Advancing Dutch Municipalities Towards Circular Asset Management

Elise Rutten

TUDelft

WAGENINGEN
UNIVERSITY & RESEARCH

SWECO

October 31st, 2024

Elise Rutten
1171429 (WUR) 4606671 (TU Delft)
Msc Metropolitan Analysis, Design and Engineering (MADE)
Delft University of Technology - Wageningen University & Research - AMS Institute

First supervisor
Prof.dr.ir. A. (Arjan) van Timmeren
TU Delft - Architecture and the Built Environment
Department of Urbanism - Section Environmental Technology & Design

Second supervisor
Dr.ir. J.N. (Jaco) Quist
TU Delft - Technology, Policy and Management
Department of Engineering Systems and Services

Organisation supervisor
Jasper Drost
Sweco
Consultant Sustainability - Circular Economy

Executive Summary

The current linear "take-make-dispose" model of production and consumption is unsustainable due to its depletion of finite natural resources, increase in waste, and environmental pollution. To foster a sustainable future, transitioning to a circular economy is essential. In line with the EU's Circular Economy Action Plan (CEAP), the Netherlands has committed to halving raw material use by 2030 and achieving full circularity by 2050. Significant progress could be made within the built environment, a sector known for its considerable environmental impact through construction, renovation, and demolition activities. Public assets offer great opportunities to advance the shift towards a circular economy since municipalities are responsible for these assets and have direct influence over decision-making.

Despite a shared understanding among many municipalities on the need to move from a linear to a circular economy, there is often a lack of actionable guidance. Municipalities need support to manage public assets in a circular way. This study aims to clarify the specific challenges Dutch municipalities face in circular asset management and explores necessary interventions to address them. Therefore, this study addresses the following research question:

> *"How can Dutch municipalities change and optimise their way of working in order to enhance circular asset management significantly?"*

Using the Multi-Level Perspective (MLP) framework, this research examines dynamics across niche, regime, and landscape levels in circular asset management, focusing on current practices, circular ambitions, critical barriers, and potential interventions. The study is qualitative research, including a literature review and in-depth interviews, with a case study of three Dutch municipalities, Amsterdam, Haarlem, and Oegstgeest, representing large, medium, and small scales.

This comparative analysis provides insights into how municipality size influences circular transitions. Larger municipalities, like Amsterdam, possess more resources and specialised staff but encounter coordination challenges due to complex structures. Smaller municipalities benefit from quicker decision-making but often lack resources and specialised expertise, which complicates implementation. Amsterdam and Haarlem show progress in circular asset management phases, while Oegstgeest is still in early stages.

The study identifies barriers across political, organisational, technological, social, economic, environmental, and legal domains. Politically, there is a lack of unified vision and prioritisation for circularity, along with an absence of clear indicators to measure progress. Organisationally, the persistence of a linear structure, compartmentalisation, unclear role assignments, poor communication, and a lack of concrete plans are significant obstacles. Technologically, limited knowledge and experience with circular processes complicate integration efforts within municipalities. Economically, municipalities face resource constraints, particularly budget, time, and expertise, and the higher costs associated with circular practices. Social barriers arise from insufficient understanding of circular principles within organisations, which leads to resistance and low engagement among stakeholders. Environmentally, implementing circular innovations in existing public spaces is challenging due to infrastructure constraints and competing stakeholder interests.

Legally, existing contracts designed for linear asset management restrict flexibility, limiting the ability to adopt circular practices.

These barriers are interlinked, often overlapping and reinforcing one another, highlighting the need for an integrated approach to circular asset management, which is crucial for a successful transition

Municipalities can make significant progress by shifting mindsets, setting clear priorities, defining goals with actionable steps, enhancing communication, supporting asset managers and optimising data management. This also involves multi-year planning and close collaboration with all stakeholders. Collaboration enables the sharing and combining of knowledge, preventing redundant efforts as all municipalities can learn from each other. Pioneering municipalities serve as role models, inspiring others toward circular asset management and enabling them to learn from established practices; however, even pioneers can benefit from learning from followers.

This research addresses the integration of circular economy principles into public space management for Dutch municipalities, helping to fill a critical knowledge gap. These findings may also support further advancements in other sectors and comparable transitions.

Keywords

Table of Contents

List of Figures

List of Abbreviations

CE:	Circular Economy
CEAP:	Circular Economy Action Plan
ECI:	Environmental Cost Indicator
EMVI:	Economisch Meest Voordelige Inschrijving (Economically Most Advantageous Tender)
EU:	European Union
KPI:	Key Performance Indicators
NPCE:	Nationaal Programma Circulaire Economie (National Circular Economy Program)
PESTEL-O:	Political Environmental Social/behavioural Technological Economic - Organisational
SOK:	Samenwerkingsovereenkomst (collaboration agreement)

INTRODUCTION

1

1. Introduction

1.1 Context

Today's society is built upon a linear economy, characterised by a "take-make-dispose" system to production and consumption. In this system, raw materials are extracted, processed into products, consumed, and eventually discarded as waste, often ending up in landfills or incinerators. This linear approach to resource management can't work in the long term, as it is not sustainable and leads to problems for future generations (Ellen MacArthur Foundation, 2013). Through the extraction of finite natural resources and the production of waste, resources are depleted, precious materials disappear and the environment is polluted. These problems are getting worse in our growth-oriented society, as the demand for raw materials increases while their availability decreases (Ness & Xing, 2017). To ensure the sustainable use of raw materials in the future, it is crucial to manage them responsibly and reuse as much as possible (Bassens et al., 2020).

To address this, a shift to a circular economy is needed. A circular economy, as defined by Stahel and Clift (2015), is *"an economy that focuses on value preservation, encompassing all activities that reduce the material input of production and extend the service-life of goods, components and materials"*. In a circular economy, natural resources are extensively used to close the loop. The transition towards a circular economy can address challenges such as CO2 reduction, biodiversity preservation, improvement of air, water, and soil quality, and the security of raw material supplies (United Nations Environment Programme & International Resource Panel, 2024).

The European Commission released a Circular Economy Action Plan (CEAP) in March 2020, a fundamental component of the European Green Deal (European Commission, 2020). The CEAP outlines strategies to advance circularity and resource efficiency in alignment with the EU's broader environmental sustainability and climate action objectives. The overarching aim of the European Green Deal is to achieve climate neutrality by 2050. As a member state of the European Union, the Netherlands must align its policies with EU initiatives and therefore has set the ambition to halve raw material usage by 2030 and achieve a fully circular economy by 2050 (Ministerie van Infrastructuur en Waterstaat, 2023).

However, the "Integrale Circulaire Economie Rapportage" (Planbureau voor de Leefomgeving, 2023) highlights that material use is increasing rather than decreasing. With the current trends, the aimed goals will not be achieved. A contributing factor is that the existing economic system is based on a linear model. The current laws and regulations are deeply rooted in this linear system and cause barriers to circular initiatives (Friant et al., 2023).

To progress towards the set goals, the transition towards a circular economy needs to accelerate. Municipal governments are essential in this transition, as developing and implementing circular economy strategies require either new governance systems or modifications to existing governance arrangements (Fratini et al., 2019). It involves rethinking the very operating system itself and requires systemic changes, encompassing various technical steps such as more efficient use of raw materials, innovative design and maintenance approaches, and enabling energy recovery. The challenge for these entities is to reinvent themselves, organise differently, and to collaborate differently with stakeholders (Geissdoerfer et al., 2017).

To increase the chances of making significant progress, the national government has decided to prioritise sectors with the highest negative environmental impact. These sectors include consumer goods, plastics, the built environment, manufacturing, and biomass & food (Ministerie van Infrastructuur en Waterstaat, 2023). Considering the built environment, it consumes 40% of the total energy, uses over 50% of raw materials, and generates 40% of indirect CO2 emissions in the Netherlands (Metabolic, 2021). A significant portion of this consumption comes from construction, renovation, and demolition activities. This is partly due to the ageing of public assets such as road infrastructure, sewers, civil engineering structures, and street furniture, which require renovation or demolition to meet modern standards (Gemeente Amsterdam, 2023).

Public assets offer great opportunities to advance the shift towards a circular economy since municipalities are responsible for these assets and have direct influence over decision-making. This responsibility allows municipalities to choose whether to maintain or replace assets in ways that prioritise circular resource use. Adopting an effective approach to asset management is crucial to ensure that these assets are maintained in a cost-effective, safe, and sustainable manner (Urquhart, 2000).

However, while public spaces and infrastructure are increasingly important to society, with over 15 billion euros spent annually on their management, the Netherlands still lacks a comprehensive asset management strategy, particularly from a sustainability perspective (Managing Public Space, 2024). The current sectoral governance model does not appear suitable to ensure the optimal and sustainable functionality and quality of public spaces (Said & Tempels, 2023). Additionally, despite significant ambitions for a circular economy and widespread recognition of its importance, there is often a gap in translating these ambitions into practical actions. Many municipalities do not have a comprehensive framework to guide the conversion of their ambitions for circular resource use into concrete measures (Metabolic, 2021). This need is reflected in the growing demand for support from consultants, such as Sweco, as municipalities seek assistance in managing public assets in a circular manner. However, to facilitate a shift towards circular asset management, it is first necessary to identify where problems lie, to understand the challenges and barriers, and to explore necessary changes (Heurkens & Dąbrowski, 2020). In this way, it is possible to articulate the demand and effectively map out the support needs.

1.2 Knowledge Gap

Although academic literature has addressed the management of public spaces to some extent, there is still a significant need for more research in this area. Most studies focus on the design, delivery, and use of these spaces, while the management of assets receives less attention. Key topics such as adapting to mid- and long-term challenges (like climate adaptation, energy transition, circular economy, urban mobility, and governance) are underexplored, as also highlighted by Duivenvoorden et al. (2021).

While some research exists on the application of circular economy principles within the built environment, it remains limited. Current studies address specific contexts or sectors such as social housing, the construction industry, construction and demolition waste management, buildings, and facades, but there is no focus on asset management. This reveals a clear gap in understanding how circular economy principles could be applied to the management of assets, as also indicated by Rahla et al. (2021).

The few existing studies on specific sectors within the built environment do discuss practices, barriers, and enablers of the circular economy. However, empirical research on circular economy practices in these areas remains minimal. Regarding asset management, no research has specifically addressed the practices, barriers, and enablers for managing assets in a circular manner.

Furthermore, there is a noticeable gap in research on how Dutch municipalities can transition to a circular economy within the built environment, particularly concerning the management of public spaces. No studies explicitly address circular asset management practices and the related barriers within this specific context.

This knowledge gap highlights the need for further research on integrating circular economy principles into public space management, with a focus on current practices, barriers, and potential interventions for Dutch municipalities.

1.3 Problem Statement

Despite consensus in many municipalities regarding the necessity of transitioning from a linear to a circular economy, there often lacks a clear perspective for action.The current system is designed for the linear economy, influencing decision making accordingly. Many municipalities lack a comprehensive framework or guidelines to convert circular ambitions into concrete measures. As a result, they cannot act efficiently enough to accelerate the transition and meet the targets set for 2030 and 2050.

This municipal challenge extends to the management of resources within the built environment, while the impact of the built environment on these objectives is substantial. The current management model seems not suitable for ensuring the functionality and quality of public spaces optimally <u>and</u> sustainably. Municipalities need support to manage public assets in a circular way. To achieve this, it is essential to first clearly identify the specific challenges they face.

1.4 Research Aim

This research aims to develop a validated inventory of current practices, barriers, needs and best practices in circular asset management within Dutch municipalities. This inventory will address the identified knowledge gap, thereby contributing to the literature. It will serve as the foundation for developing a practical decision-support tool to guide Dutch municipalities in decision-making for circular asset management. This tool is intended to help municipalities identify the barriers they face, propose interventions for these barriers, and prioritise actions. The goal is to address or mitigate these barriers and accelerate the transition from a linear to a circular approach in the maintenance and replacement of public assets.

1.5 Research Questions

To address this problem and research aim, the following research question will be explored:

"How can Dutch municipalities change and optimise their way of working in order to enhance circular asset management significantly?"

To answer the main research question, a set of sub-questions is formulated:

1. How are assets currently managed by the municipalities of Amsterdam, Haarlem and Oegstgeest?
2. What are the ambitions of the municipalities of Amsterdam, Haarlem and Oegstgeest for circular asset management?
3. What barriers are hindering circular asset management within the municipalities of Haarlem and Oegstgeest, and has Amsterdam also faced these barriers?
4. What interventions are considered to tackle these barriers in circular asset management?
5. How can Dutch municipalities be supported in applying interventions to advance to circular asset management?

In this research, *circular asset management* is defined as; the maintenance or replacement of road infrastructure, civil engineering structures, sewage systems and street furniture in a way that promotes circular resource use.

1.6 Relevance

1.6.1 Societal Relevance

Public spaces are not only functional but also play essential social roles, contributing to health, the economy, social cohesion, wellbeing, and biodiversity (Duivenvoorden et al., 2021). High-quality public spaces support these areas, and to ensure they remain effective for future generations, effective asset management is necessary, covering everything from regular maintenance to the strategic replacement of public assets. By adopting circular principles within the management of the public space, municipalities can significantly accelerate the transition to meet the ambitious environmental targets of 2030 and 2050 set by the European Union. This research aims to help municipalities in identifying and addressing barriers to circular asset management and provides practical guidance. This will enable municipalities to make informed decisions to enhance their capacity to manage public assets in a more circular way, making it societal relevant.

1.6.2 Scientific Relevance

Managing public space is inherently complex. Introducing circular economy practices within this context increases this complexity, presenting multiple challenges. Consequently, there is a need to understand circular asset management, as currently, no literature specifically addresses this topic. While limited literature discusses barriers to the circular economy transition in other sectors of the built environment, there is a notable absence of research on barriers within asset management, especially regarding Dutch municipalities. As a result, the reasons why Dutch municipalities face difficulties in implementing circular asset management are unclear, leaving ambiguity around how they can succeed in this area.

By unifying knowledge dispersed across municipalities, knowledge institutions, and consultancies, this research aims to provide empirical insights into current practices, challenges, and necessary interventions. The scientific relevance of this research lies in filling the knowledge gap on circular asset management in Dutch municipalities, providing valuable insights to researchers, municipalities, and consultants involved in similar transitions.

1.6.3 Relevance for Msc Metropolitan Analysis, Design and Engineering (MADE)

The MSc Metropolitan Analysis, Design, and Engineering (MADE) is a joint degree offered by Delft University of Technology (TU Delft) and Wageningen University & Research (WUR). It focuses on sustainable development within cities and addresses challenges related to environmental change, urban sustainability, and the quality of urban life. The program emphasises six core themes: circularity, climate resilience, food systems, urban digitalization, smart urban mobility, and energy.

This research is highly relevant to the MADE master's program as it explores metropolitan, social, and scientific dimensions with a focus on circularity, one of the core themes of the program. It aims to develop metropolitan solutions to a sustainability challenge, namely the transition to circular asset management. The process involves enhancing the understanding of metropolitan complexities, reviewing previous studies, and gathering data to refine existing assumptions. Moreover, the research aligns well with the objectives of the master's program by producing interventions and conducting research in real-life contexts. It involves various municipalities, notably Amsterdam, which is a frequent case study in the curriculum of this master's program.

1.6.4 Relevance for Sweco

Sweco (originally Swedish Consultants) is the leading architecture and engineering consultancy in Europe, based in Stockholm, Sweden. It offers a diverse range of services across various sectors, including architecture, civil engineering, urban planning, water management, and energy systems. Sweco is recognized for its commitment to making societies more sustainable. The company serves a broad range of clients, including public administrations, municipalities, and private companies.

Many municipalities have reached out to Sweco, expressing the need for assistance to translate their circular ambitions into concrete actions. Considering the growing demand from municipalities for support, and since the outcomes of this research could be used by various Dutch municipalities, this research is particularly relevant for Sweco.

1.7 Research Structure

This research comprises seven chapters. Chapter 2, "Theory", presents foundational theories and the theoretical framework, providing background information and guiding the analysis of this study's results. Chapter 3, "Research Design", outlines the scope of the research and details the methods used, including the research approach, data collection, data analysis, and the development of the decision-support tool. Chapter 4, "Results", presents results from both the literature and empirical research, covering current practices, ambitions, barriers, and interventions for circular asset management. This chapter ends with an explanation of the decision-support tool developed based on these results. Chapter 5, "Findings," provides interpretations of these results, followed by chapter 6, "Discussion," where the results are first critically examined and then reflected upon in relation to the theory from chapter 2. This chapter ends with theoretical and practical contributions, as well as the research limitations. Finally, chapter 7, "Conclusion", synthesises the insights of this research by answering the research question and proposes recommendations for future research and practical applications.

2

THEORY

2. Theory

Before diving into the research, it is essential to outline the key theories that provide the theoretical foundation for this study. These include the circular economy, the R-ladder, public asset management, sustainability transitions, the multi-level perspective (MLP), the multi-phase concept and transitionmanagement. The circular economy establishes the overarching goals and guiding principles that municipalities aim to achieve. The R-ladder complements this by outlining a hierarchy of strategies to help municipalities prioritise circular initiatives. The transition toward a circular economy aligns with the concept of sustainability transitions. The multi-level perspective (MLP) and the multi-phase concept offer structured frameworks to understand the shift from a linear to a circular economy. Transition management supplies the practical governance approach necessary for guiding this shift. Public asset management serves as the application, translating these theories into practice for managing public spaces in a circular manner. Each of these concepts is detailed in the following sections. This chapter ends with the theoretical framework, where the MLP serves as the essential lens through which the analysis is conducted.

2.1 Circular Economy

The concept of Circular Economy (CE) is gaining increasing attention from policymakers and businesses as an alternative to the social, economic, and environmental issues of the linear economy. The linear economy operates on a take-make-dispose model, where products are created, used, and then discarded (Grafström & Aasma, 2021). Circular economy therefore aims to transform current production and consumption patterns, which significantly burden the environment. It represents a practical approach to decoupling economic growth from environmental degradation (Pomponi & Moncaster, 2017). The European Commission defines the concept of CE in the Circular Economy Action Plan as: "*In a circular economy, the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste is minimised*" (European Commission, 2020). It has the potential to reduce resource depletion, pollution, and waste production while also fostering new business models and job opportunities, and enhancing resource security and resilience.

2.2.1 Circular Asset Management

According to P. Balzer (1999), asset management involves *"the management of any kind of asset by institutional and private investors in the form of real values by a manager in charge with all those tasks"* (Wojewnik-Filipkowska & Rymarzak, 2013). Davis (2007) further describes asset management as *"a continuous process-improvement strategy for improving the availability, safety, reliability, and longevity of assets, i.e., systems, facilities, equipment, and processes"*. In the context of municipalities, asset management involves the efficient and cost-effective management and maintenance of assets, such as road infrastructure, sewage systems, green spaces, civil engineering structures, and street furniture, for which municipalities are responsible. The aim of public asset management is to maximise asset lifespan, safeguard assets against loss, and maintain them in a safe, functional condition (Jolicoeur & Barrett, 2004). Therefore, balancing costs, value, and risks against the desired performance of assets is essential (Maring & Blauw, 2018).

Asset management entails a lifecycle approach where municipalities plan, acquire, operate, maintain, and eventually dispose of physical assets (Maring & Blauw, 2018), as represented in *figure 1*. The process starts with the "planning" stage, where a municipality identifies a need. Next, in the

"acquisition" stage, the necessary asset is obtained. During the "operation" phase, the asset is used until it requires maintenance. The "maintenance" stage involves repairing the asset to ensure continued use until further maintenance becomes necessary. Eventually, if ongoing maintenance becomes too costly, the asset reaches the "disposal" stage, which may lead to planning for a new asset.

Figure 1: The asset management lifecycle (own figure, adapted from Maring & Blauw, 2018)

Implementing circular economy strategies within the built environment can significantly reduce resource use and waste generation. The built environment encompasses everything people live in and around, including housing, transport infrastructure, service networks, and public spaces. According to Pomponi and Moncaster (2017), a circular built environment is one that is designed, planned, constructed, operated, maintained, and deconstructed according to circular economy principles. The lifecycle should follow a closed-loop system, ensuring that materials and components are kept at their highest possible value. A resource-efficient built environment matches asset supply with demand by using strategies from the R-ladder (discussed in the next section). In circular asset management, the traditional disposal stage (stage 5 in *figure 1*) is replaced by selecting the most suitable strategy from the R-ladder, particularly focusing on the top seven options (Davari et al., 2023).

2.2.2 R-Ladder

The R-ladder is a well-known framework that helps visualise and understand the stages of resource use and waste management in a circular economy. Each "R" in this hierarchical framework represents a strategy aimed at contributing to a circular economy. The strategies, explained in *figure 2*, include: R0 Refuse; R1 Rethink; R2 Reduce; R3 Reuse; R4 Repair; R5 Refurbish; R6 Remanufacture; R7 Repurpose; R8 Recycle; R9 Recover energy. The R-ladder indicates the degree of circularity, with higher positions corresponding to lower resource use and, thereby enhancing circularity. At the top of the ladder are strategies focused on reducing consumption and production and optimising product use. In the middle, the focus shifts to extending the life of products and components. At the bottom, the strategies involve repurposing materials that would otherwise be landfilled.

Smarter creation and use of products	R0	Refuse	Turning a product redundant by cancelling its function, or by substituting it with a radically different product.
	R1	Rethink	Intensifying product use (e.g. via product sharing or multifunctional products).
	R2	Reduce	More efficient use and/or manufacture of products through the use of fewer natural resources and materials.
Extending the lifespan of products and parts	R3	Reuse	Reuse of discarded yet still usable product, for the same purpose, by a different user.
	R4	Repair	Repair and maintenance of broken or malfunctioning product, to enable continuation of its original function.
	R5	Refurbish	Refurbishing and/or modernising an older product, so that the improved version can be used in the product's original function.
	R6	Remanu-facture	Using parts of a discarded product in a new product of the same function.
	R7	Repurpose	Using discarded products or their parts in new products with a different function.
Usefull application of materials	R8	Recycle	Processing of materials to achieve the original high-quality or reduce to low-quality.
	R9	Recover	Incineration of materials, recovering their energy.

Figure 2: The R-ladder of circularity strategies (van Buren et al., 2016)

2.3 Sustainability Transitions

According to Rotmans et al. (2000), a transition can be defined as "*a gradual, continuous process of social change, in which society (or a complex sub-system of society) structurally changes its character over a generation (+/- 25 years) or more.*" A transition involves interacting and mutually reinforcing developments at different scales. It is the result of both slow changes and fast dynamics that interfere with each other. Transitions require breaking through existing structures and system innovations and may therefore take time.

Although each transition is unique in its content and context, two types of transitions can be distinguished; evolutionary transitions and goal-oriented transitions. In evolutionary transitions, the outcome is not significantly planned. Goal-oriented transitions, on the other hand, have a specific goal or vision guiding strategic decisions and public actors (Kemp and Rotmans, 2004). Sustainability transitions are goal-oriented as they aim to tackle ongoing environmental challenges (Geels, 2011). Markard et al. (2012) define sustainability transitions as "*long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption*" (theory on socio-technical systems is provided in *Appendix A*).

2.4 Transition Theory

Transition theory encompasses two key concepts: the multi-level perspective and the multi-phase model. The multi-level perspective provides a scale lens for understanding transitions, while the multi-phase concept offers a temporal lens. Transition management is the intrinsic part of transition theory. It serves as the guiding lens for transitions by conceptualising the role of agency within them (Loorbach, 2007).

2.4.1 Multi-Level Perspective

Systemic change emerges from the interplay of diverse changes occurring across different levels and domains. These changes interact and reinforce each other, leading to a fundamental qualitative transformation within a societal system (Loorbach et al., 2017). The multi-level perspective (MLP) is a theory for understanding long-term and complex socio-technical transitions, such as the transition towards a circular economy. It conceptualises the dynamic between niches, regimes, and the socio-technical landscape at three interacting scale levels: the micro-, meso-, and macro-level (*figure 4*) (Loorbach & Rotmans, 2006).
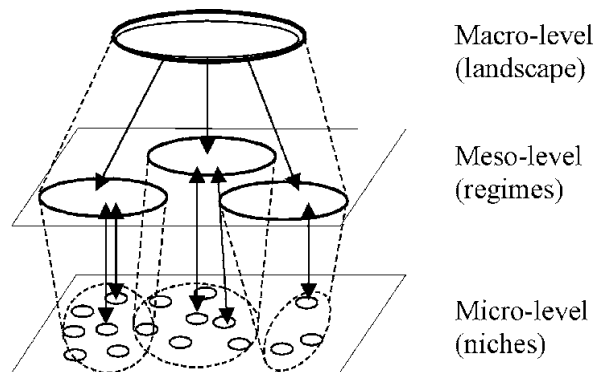
Figure 4: The three scale levels of the multi-level perspective (Loorbach & Rotmans, 2006)

Figure 5 explains the dynamics, key processes and drivers behind socio-technical transitions. At the central level is the meso-level, where the regime is situated. The regime refers to the dominant mainstream activities, structures, and rules that guide current systems, like the existing linear economy. It is "dynamically" stable. The institutionalised structures provide stability to the societal system and guide decision-making and individual behaviour of its actors. The regime is influenced by trends and changes in society, which are called landscape developments. The landscape comprises social values, political cultures, the built environment, and economic development and trends. Landscape pressures such as global climate change, resource scarcity, (international) environmental policies, and societal shifts towards sustainability drive the push towards a circular economy. Municipal governments play an important role in facilitating the transition by enacting supportive policies, providing funding for niche innovations, and setting ambitious circular economy targets. Operating on a macro-level, the landscape usually evolves autonomously, but significantly influences both the regime and the niches by defining the space and direction for change. Niche developments are new ideas such as new technologies, rules and legislation, organisations or projects, concepts or ideas that grow until they have an opportunity to challenge the existing regime. They act on the micro-level (Loorbach, 2007).
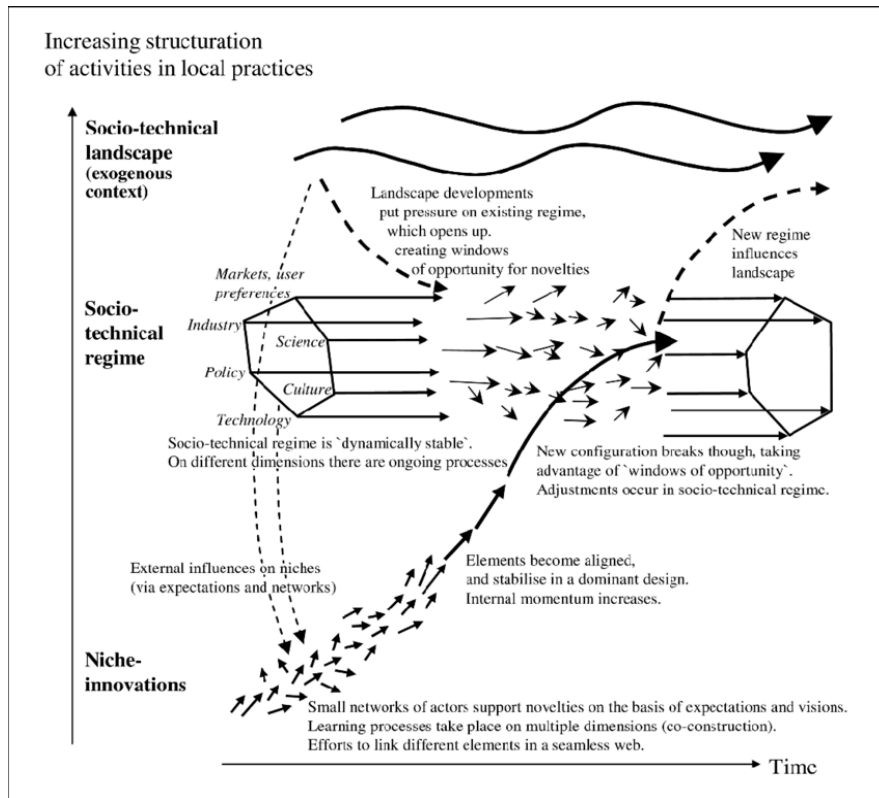
Figure 5: The multi-level perspective on socio-technical transitions (Loorbach & Rotmans, 2006)

2.4.2 Multi-Phase Concept

The multi-phase concept illustrates the non-linearity of transitions across various stages, transitioning from one dynamic equilibrium to another. This complex process is depicted by an S-shaped curve, a highly simplified model outlining the four phases of transitions (*figure 6*): the pre-development phase, the take-off phase, the acceleration phase, and the stabilisation phase. The nature and pace of change vary within each transition stage.
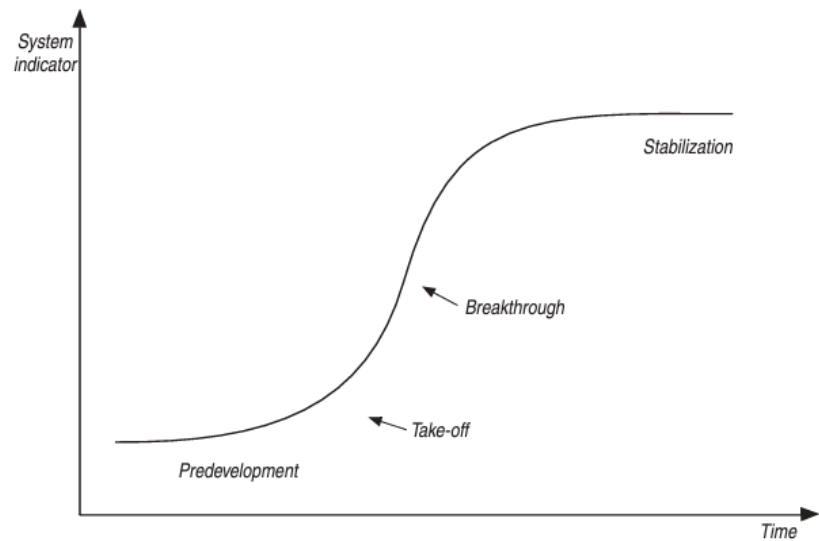
Figure 6: The S-shaped curve of the four phases of transition (Rotmans et al., 2000)

In the pre-development phase, the status quo of the system changes in the background, often hardly visible at the systemic level. However, there is a lot of experimentation going on. Moving into the take-off phase, the process of change gains momentum as the state of the system begins to shift, because of various innovations. During the acceleration phase, structural changes become visible through the accumulation and implementation of socio-cultural, economic, environmental, and institutional changes, often intertwining with one another. Finally, in the stabilisation phase, the speed of societal change decreases, leading to a new dynamic equilibrium (Loorbach & Rotmans, 2006). This concept solely illustrates the dynamics of build-up, while another simultaneous process unfolds: the breakdown of patterns. The X-curve framework of Loorbach et al (2017) visualises the transition dynamics involving processes of decline, breakdown, and phase-out, alongside the process of build-up as conceptualised in the multi-phase concept (*figure 7*). It demonstrates the interactions among these processes. This conceptual framework offers guidance for understanding and developing governance in sustainability transitions (Olsthoorn & Wieczorek, 2006). This framework is further explained in *Appendix B*.
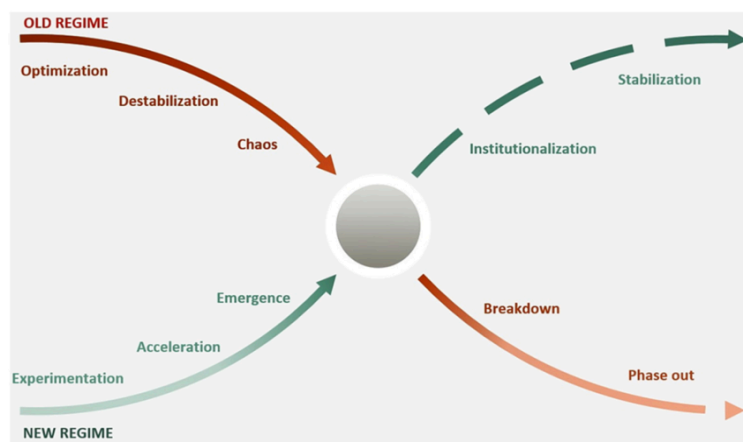
Figure 7: The X-curve of transition dynamics (adapted from Loorbach et al., 2017)

The transition to a circular economy is still in its early stages, as shown by DRIFT's analysis in *figure 8.* Most companies, consumers, governments, and organisations remain within the existing regime, the linear economy. However, the circular economy is gaining increasing attention. A small portion of these actors are engaged in the emerging circular system (niches). While the principles of a circular economy are known and being experimented with, and circular ambitions are increasingly being set, policy still mainly focuses on optimising the linear economy.
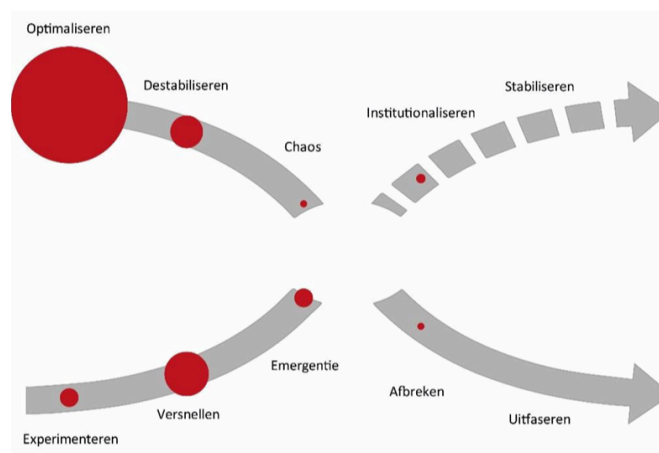
Figure 8: The state of transition to the circular economy (Lodder et al., 2017)

2.4.3 Transition Management

Transition management is a governance approach that provides strategies for guiding societal transitions across different interconnected levels: strategic, tactical, operational, and reflective (*figure 9*). It seeks to bridge the gap between short-term and long-term thinking by placing short-term policies in light of long-term ambitions (Rotmans et al., 2000). The process is iterative and cyclical, with continuous feedback loops between the levels to adapt and refine approaches as conditions evolve.
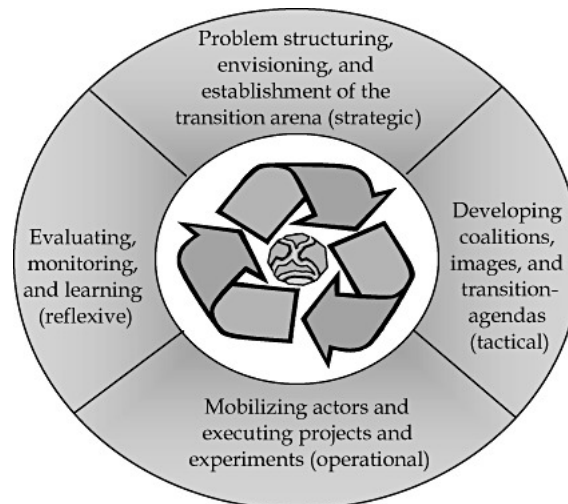
Figure 9: The transition management cycle (Loorbach, 2009)

At the strategic level, the focus is on long-term thinking. The main aim is to develop a shared understanding of the sustainability problem among various stakeholders and to define a collective vision. The goals set by the EU, as well as the ambitions of the Netherlands to halve raw material use by 2030 and achieve a fully circular economy by 2050, are part of this level. It serves as a guide for all subsequent decisions and actions in the transition process. The tactical level involves translating the strategic vision into more concrete objectives and strategies. This includes creating networks of relevant stakeholders who can influence or are affected by the transition. The operational level is the actual implementation of plans and experiments. This could include enacting supportive policies, offering tax breaks to encourage circular resource use, or implementing new technologies.The reflective level involves monitoring and evaluating the results of the strategic, tactical, and operational activities. This phase helps to learn from experiences, adjust strategies, and ensure that the transition remains aligned with the long-term vision (Loorbach, 2009).

2.5 Theoretical Framework

In this research, the Multi-Level Perspective (MLP) is used as the guiding theoretical framework. The MLP is suitable for this study as it provides a structured approach to analyse and guide the transition towards circular asset management. It illustrates how this transition is shaped by the interaction between niche innovations, established regime structures, and broader landscape pressures.

Understanding the regime's existing practices, rules, and norms within the municipality, is crucial for identifying how circular principles are—or are not—being integrated into current systems. This includes strategies, decision-making processes, and organisational structures that often resist change. Shifting towards circular asset management requires significant changes in these established practices. At the landscape level, factors such as EU regulations, sustainability trends, and global climate targets

shape the ambitions and strategies of municipalities, pushing the regime to adapt. The niche level includes emerging circular (asset management) practices (such as pilot projects, the use of sustainable materials, and new techniques), that are being experimented with and developed but have not yet been widely adopted at the regime level. These niche innovations represent potential solutions that can be scaled up if the regime becomes more receptive to change.

Integrating niche innovations into the mainstream regime often encounters barriers at various dimensions. These barriers manifest across the three levels. By employing the MLP framework, barriers to change at these different levels can be identified, which is crucial for understanding what hinders the adoption of circular asset management practices and helps in formulating interventions. The goal of these interventions is to create space for niche innovations to grow and eventually reshape the regime.

RESEARCH DESIGN

3

3. Research Design

3.1 Methodology

This research addresses five sub questions to answer the main research question. To address these questions, a qualitative approach is employed. Qualitative research is a valuable method in studying social processes (Groat & Wang, 2001). It enables in-depth exploration of complex issues and is suited for examining human experiences and behaviours, which is often essential for developing theories, strategies or models (Fossey et al., 2002). Since this research involves various stakeholders, each with their own perspectives and influences, qualitative research helps capture these diverse perspectives, providing insights into how contextual factors influence the adoption of circular economy practices. This detailed exploration of experiences, perceptions, and attitudes towards circular asset management helps in understanding the nuanced barriers that different stakeholders might face.

A popular approach within qualitative research is case study research. *"A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between the phenomenon and context are not clearly evident"*. This approach enables looking at complex interaction effects among various variables (Yin, 1994). In this study, the transition from linear to circular asset management within Dutch municipalities, is considered a complex and contemporary social phenomenon requiring changes in logistics, processes, and mindsets at multiple levels. Case studies are valuable in understanding the dynamics of change by providing a detailed contextual analysis of specific cases (Fischer, 2003). They answer 'why' and 'how' questions by tracing operational links (Yin, 1994). The aim of the case study is to explore the transition to circular asset management, discovering *why* municipalities might or might not adopt circular measures and *how* they could potentially do so. Therefore, this strategy is considered suitable. Three Dutch municipalities—Amsterdam, Haarlem, and Oegstgeest—are selected as cases for this study. Using multiple case studies increases reliability and mitigates criticisms regarding the generalisability of findings (Yin, 1994).

According to Yin (2014), case studies can be descriptive, explanatory, or exploratory. The sub-questions in this research, examined through case studies, vary in their objectives, making the case study primarily descriptive and explanatory. Sub-questions 1 and 2 investigate current asset management practices by the municipalities of Amsterdam, Haarlem, and Oegstgeest, as well as their ambitions in this area. These questions are mainly descriptive, as they provide detailed accounts of a specific context. Sub-questions 3 and 4 focus on identifying barriers to circular asset management and evaluating effective practices for addressing these barriers, making them explanatory. Explanatory studies focus on understanding the causes behind a particular phenomenon or decision (Priya, 2020), which is relevant here, as these questions seek to understand why circular asset management is not (efficiently) implemented and to evaluate different strategies used to address these challenges.

The methods applied in this case study include a literature review and in-depth interviews, which will be further elaborated on in the "Data Collection" section (3.5).

By employing a qualitative approach, a comprehensive understanding of the barriers to circular asset management is obtained. This is essential for providing targeted and effective interventions to address these barriers, which is the aim of this research. Furthermore, interviews can uncover innovative

practices and solutions (best practices) that may serve as examples or inspire similar efforts in other Dutch municipalities, thereby supporting the broader application of interventions to advance circular asset management.

3.2 Research Scope

Figure 10 illustrates the scope of this research, where the red-outlined boxes indicate the specific "route" of focus, while areas beyond these are considered outside the research scope.
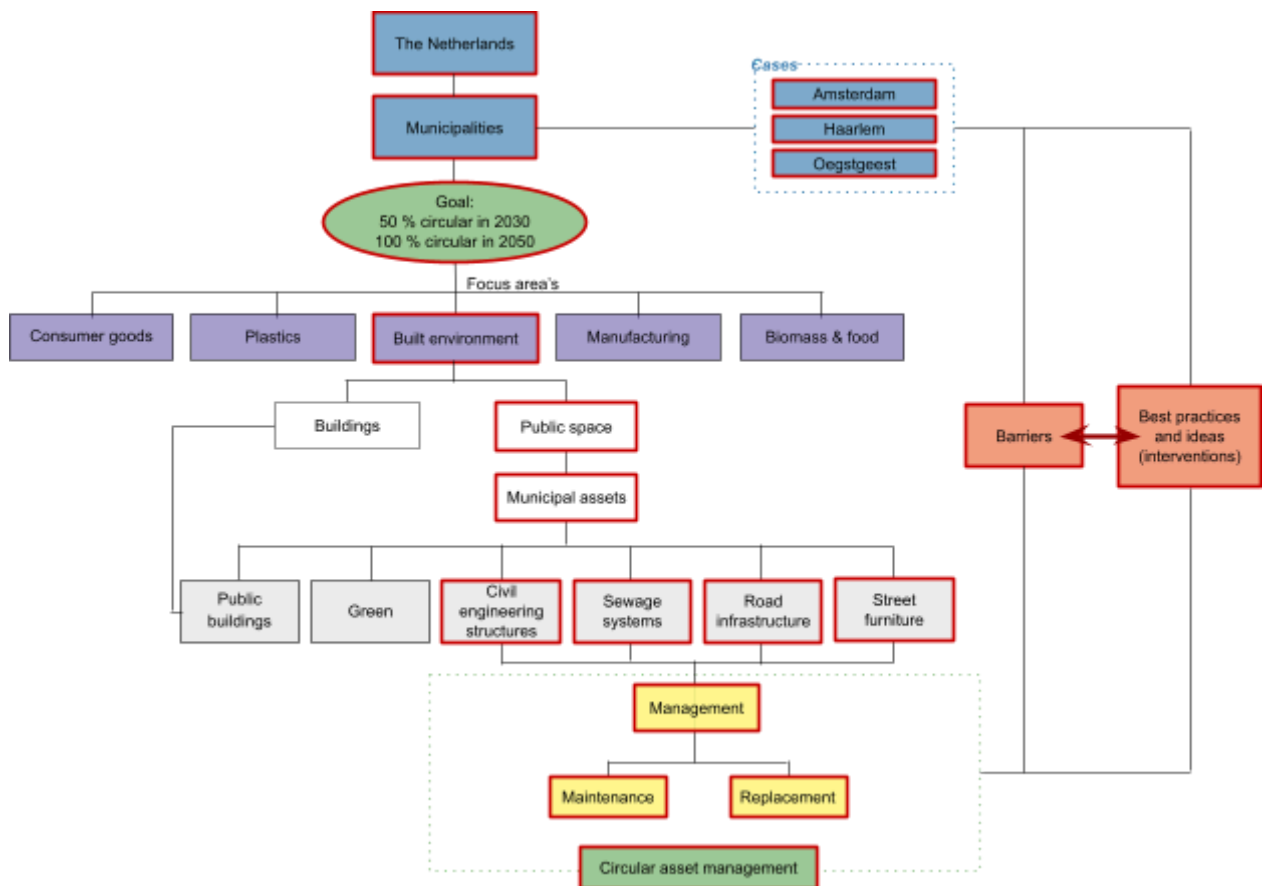
Figure 10: Scope of this research (own figure)

This study specifically targets Dutch municipalities due to Sweco's focus on Dutch clients and recognising variations in legislation across countries. To enhance the likelihood of achieving the goals of halving raw material usage by 2030 and reaching 100% circularity by 2050, sectors with the greatest environmental impact are prioritised nationally. For this research, the built environment was selected due to its significant impact and high potential for innovation and technological progress. The built environment can be roughly divided into buildings and public space. Since municipalities own and directly influence public spaces, they are responsible for implementing circular policies and practices, making public spaces a promising area for circular progress. Therefore, this research focuses on public space. Municipal assets include public buildings, green spaces, civil engineering structures, sewage systems, road infrastructure, and street furniture. This research, however, narrows down to public outdoor spaces, focusing on circularity in terms of material use. Consequently, public buildings and green spaces are excluded from the scope. The research investigates how these assets can be managed in a circular manner (to achieve the stated goals), defining "management" as the

maintenance and replacement of assets. Furthermore, to answer the main question, barriers hindering circular asset management need to be identified. Therefore, the study analyses three cases—Amsterdam, Haarlem, and Oegstgeest—examining current practices and identifying barriers, while also exploring best practices to develop interventions aimed at overcoming these challenges.

3.3 Selection of Case Studies

The cases selected for this research include three municipalities within the Netherlands: Amsterdam, Haarlem and Oegstgeest (figure 11). Among these, Amsterdam is recognised as a pioneer in circular economy initiatives, serving as a good-practice example.

The selection of case studies was based on several criteria. Firstly, each municipality had to be recognised as a Dutch municipality. Additionally, it was essential that the selected municipality had circular ambitions incorporated into its sustainability program. Municipalities were also chosen based on contact availability through Sweco, personal networks, and AMS Institute, facilitating reliable contacts and improving the likelihood of engaging multiple stakeholders, leading to more comprehensive data collection. Finally, Amsterdam, Haarlem, and Oegstgeest were chosen to represent a spectrum of municipal scales, enabling an analysis across small, medium, and large municipalities. According to the Ministerie van Sociale Zaken en Werkgelegenheid (2024), Oegstgeest is considered a small municipality, Haarlem is categorised as medium-sized, and Amsterdam as a large. *Appendix C* provides brief descriptions of these municipalities and their current contributions to the circular economy.

Municipality of Oegstgeest
7,97 km²
25.939 inhabitants (2024)
120 civil servants (2022)

Municipality of Haarlem
32,09 km²
167.763 inhabitants (2024)
1500 civil servants (2022)

Municipality of Amsterdam - Pioneer
219,32 km²
934.927 inhabitants (2024)
19.000 civil servants (2022)

Figure 11: Selection of case study, illustrating scale differences (own figure)

3.4 Research Approach

To address the main research question in a structured manner, a framework has been designed that outlines how this research was approached. This ensures a solid basis for structured work and prevents any important issues from being overlooked. This framework is illustrated in *figure 12*. Moving from top to bottom, the framework follows four stages that ultimately lead to answering the research question. The development of content progresses chronologically through these four stages,

encompassing desk research, empirical research, analysis, and tool development. In each stage, the darker-coloured box indicates the "action", the method of data collection, while the lighter-coloured box shows the "outcome," describing the purpose for which it is used. Each result from a stage serves as an input for the following stage. However, feedback loops may require revisiting an earlier stage if necessary. In the final stage, a practical decision-support tool will be developed to help Dutch municipalities advance toward circular asset management.
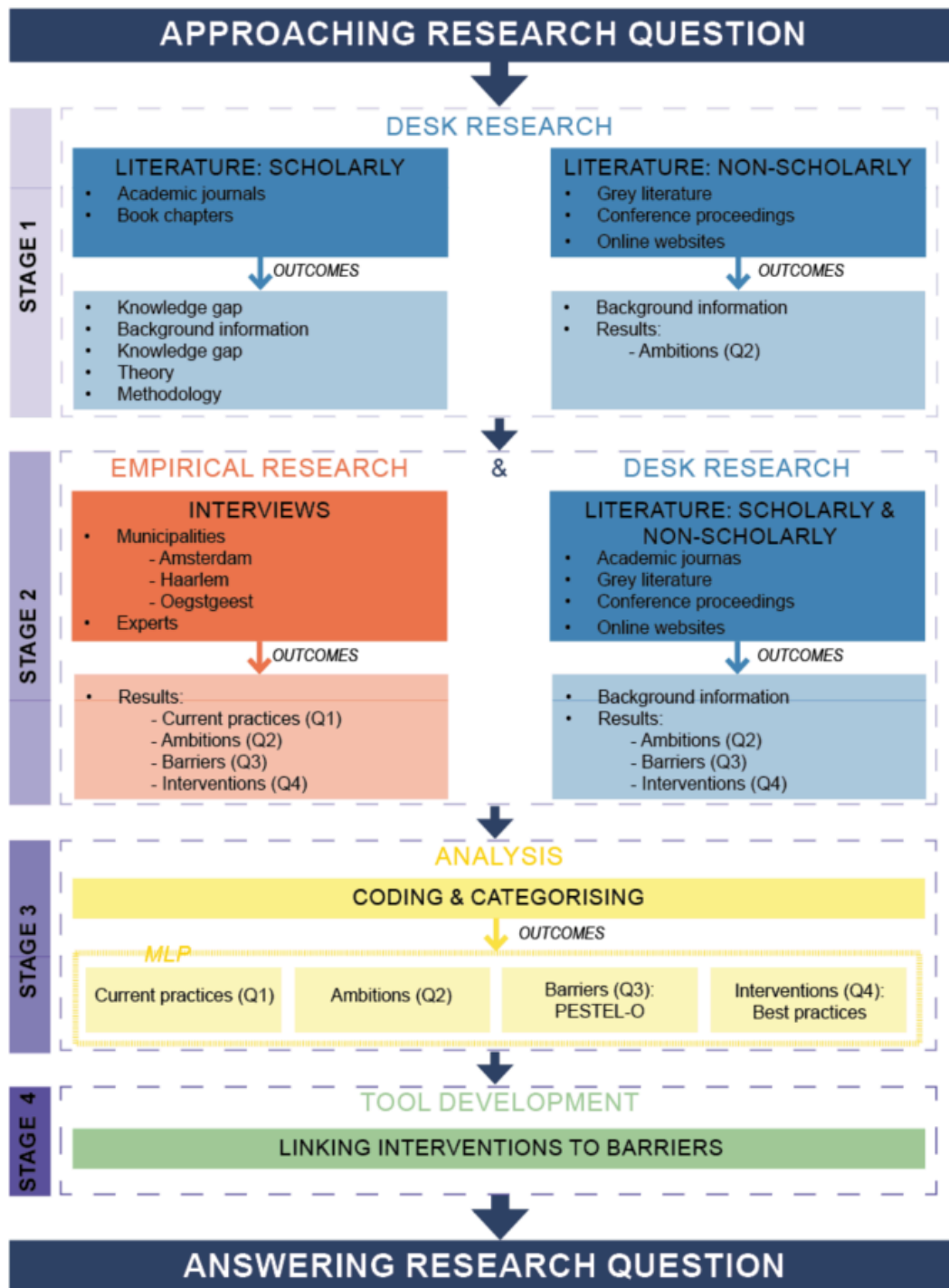

Figure 12: Research approach framework (own figure)

To structure this framework, each sub-question was examined to determine the project stage it aligns with, the data collection method to be employed, and the expected outcomes. *Appendix D* provides an overview of the process that led to the development of this final research approach framework.

3.5 Data Collection

The primary methods used for data collection were literature reviews and interviews. The literature review mainly served to gather background information, explore key theories, substantiate the methodology, and address sub-questions 2, 3, and 4, while interviews were conducted to address all sub-questions. By approaching the questions through both literature and interviews, the findings were validated, enhancing reliability.

3.5.1 Literature review

Literature reviews are essential in academic research for collecting existing knowledge and assessing the current state of a field (Kunisch et al., 2018). This desktop research encompasses both scholarly and non-scholarly platforms, including academic journals, book chapters, grey literature, conference proceedings, and online websites. Grey literature comprises reports, government publications, and other non-commercial documents (Schöpfel, 2010).

Non-scholarly sources, such as grey literature, conference proceedings, and websites, provided valuable contextual information on the three cases—Amsterdam, Haarlem, and Oegstgeest—and their strategies and ambitions, forming the foundation for the interviews. Key sources included municipal documents, (national) action programs, and consultancy reports.

The literature review through scholarly platforms was a scoping review, aimed at highlighting areas with little or no research and identifying key concepts and theories (Grant & Booth, 2009). Relevant academic journals were identified using Elsevier's Scopus and Google Scholar, with Google Scholar primarily supporting theoretical aspects and Scopus focused on addressing sub-questions. These databases were selected for their broad coverage and strict search criteria (Taiwo et al., 2023). The search keywords applied in Scopus included terms like "sustainable" OR "circular" OR "circularity" OR "circular economy" for circular, "public space" OR "built environment" OR "infrastructure" OR "public asset" OR "municipal asset" for assets, "management" OR "managing" OR "maintenance" OR "replacement" OR "renovation" for management, "barriers" OR "challenges" OR "constraints" OR "hindrance" for barriers and "solutions" OR "interventions" OR "recommendations" OR "drivers" OR "tools" OR "enablers" OR "best practices" for interventions. Given the rapid increase in academic literature on the circular economy, the focus is on recent findings from the past five years (from 2019 onward), as older works are less relevant, and the concept of a circular economy was not widely discussed in earlier literature. Based on these criteria, relevant academic papers focusing on (barriers and drivers within) the circular economy in the built environment were identified covering sectors such as construction and demolition, waste management, social housing, buildings, and facades. These papers provided insights into barriers and potential interventions within these sectors.

3.5.2 Interviews

The interviews conducted are semi-structured in-depth interviews. According to Hammarberg (2016), semi-structured in-depth interviews are an effective qualitative research technique for gathering views on a focused topic from key actors. In this research, the interviews provided insights into circular asset

management within the municipalities of Amsterdam, Haarlem, and Oegstgeest. Semi-structured in-depth interviews help to understand an experience or an event from a personal or institutional viewpoint. They are guided by an interview guide, which provides structure while allowing flexibility and a conversational approach. This guide includes predetermined open-ended questions and topics designed to encourage interviewees to express their views in their own words, resulting in more diverse data (Fossey et al., 2002).

To make a scientifically sound comparison between the different municipalities and enhance reliability and validity, a uniform questionnaire was developed. This approach was chosen to eliminate potential biases and inconsistencies that could arise from using different sets of questions or formats. The uniform interview questions allow for the collection of comparable data across all municipalities, with each interviewee responding to the same set of questions outlined in the interview guide found in *Appendix E*.

The interview questions were designed based on the research's sub-questions and theoretical framework.To ensure alignment between these interview questions and the research questions of the study, and to avoid overlooking any critical aspects, an overview was created (*Appendix F*), linking each interview question to the relevant theory, the corresponding sub-question(s), and the potential insights it might provide for the research. To provide structure to the interviews, questions were divided into several categories. The questions primarily address the current state of asset management, ambitions for circular asset management, and the barriers hindering circular asset management. However, there was room for additional questions during the interviews to follow up on interesting or unexpected topics that arose during the conversation.

As the research aimed to capture a variety of perspectives to gain a comprehensive understanding of the challenges across multiple levels, a non-random, purposive sampling approach was used to select interviewees. According to Marshall (1996), this method focuses on including the most relevant actors involved in the process being studied, in this case, circular asset management. At the end of each interview, interviewees were asked for additional participants from their network for more information, employing the snowball sampling method. This helps reach individuals who are otherwise difficult to identify or contact (Tansey, 2007).

The interviews were conducted between May and July 2024, involving a total of 15 participants with expertise in asset management or sustainability/circular economy. Interviews continued until saturation was reached. "Saturation" refers to the point at which new interviews began to repeat information already collected (Hennink & Kaiser, 2021), likely reflecting broader experiences within municipalities and supporting greater data validity. From each municipality, at least one sustainability policy officer and one asset manager were interviewed, ensuring different perspectives and allowing for cross-validation. Additionally, several external experts were interviewed to provide specialised knowledge and varied viewpoints, adding depth to the study (comparative insights and the identification of patterns) that might not be evident when focusing on a single municipality. Including external experts also helped to validate the findings. An overview of all interviewees is presented in *Appendix G*.

The interviews were conducted in Dutch, as preferred by the participants. Each interview lasted approximately 60 minutes and was conducted either in person or by video call. At the beginning of each session, participants signed a consent form (*Appendix H*), confirming their willingness to participate and granting permission for the interview to be recorded, among other terms.

3.6 Data Analysis

Based on the recorded interviews, the data was transcribed and subsequently analysed. Thematic analysis and coding were employed to identify patterns and derive insights from the data. "Coding is the strategy that moves data from diffuse and messy text to organised ideas about what is going on" (Richards and Morse, 2013). This approach helps to organise data effectively by creating categories within it, which makes comparison and identification of similarities easier. The software 'Atlas.ti 24' was used to label segments of data/quotes, describing the content of each segment. Labels such as current practices, ambitions, barriers, good practices, lessons learned, complexity, and collaboration were applied.

The identified barriers were then further categorised using the PESTEL-O model. This framework is an analytical tool used to understand factors that can impact an organisation. It is an extension of the more commonly known PESTEL model (Political, Economic, Social, Technological, Environmental, and Legal) with the addition of an "O" for organisational factors (Obersteg et al., 2019). Given the significant role of the municipality (organisation) in this research, including organisation-related barriers as a seventh category was considered essential. Consequently, sub-labels—political, economic, social, technological, environmental, legal, and organisational—were created within the "barriers" label in Atlas.ti 24.

This thematic analysis resulted in a comprehensive list of identified barriers categorised according to the PESTEL-O framework, along with lessons learned, good practices, suggestions, recommendations, and tools shared by the interviewees. These lists were analysed, and frequently mentioned topics or themes within a particular label, even if phrased differently, were merged to provide more structure and conciseness to the results. This approach allowed the barriers to be consolidated into 33 distinct barriers across the seven categories. A similar approach was applied to identify best practices, resulting in a final set of 13 interventions.

Barriers identified in the literature were also categorised according to the PESTEL-O framework. Good practices and suggestions from the literature were grouped under the label "good practice" to consolidate all relevant data. This categorization allowed for comparisons between literature-based barriers and empirical findings and enabled the formulated interventions to be substantiated or supplemented with insights from the literature.

To analyse and map the interrelationships among the barriers, each barrier was examined for potential links with every other barrier. This was done by creating a symmetric table, where each barrier's interaction with another was assessed. A connection was noted if there was either overlap between the barriers or an influence of one on the other (e.g., by triggering, reinforcing, or resulting from one another). This interrelationship was indicated in the table with 0 (no/weak relationship), 1 (moderate relationship), or 2 (significant relationship). The completed table is available in *Appendix I.* This table was subsequently converted into a chord diagram *(figure 15)* using Microsoft Power BI, an interactive tool for data visualisation. For each category, a summation of the "scores" was made to indicate the degree of cohesion.

Lastly, the MLP framework is used to structure the results, creating a clear link between the theoretical understanding of transitions and the practical aspects of implementing circular asset management. Each sub-question is positioned within different levels (landscape, regime, niche) of the MLP. This is further elaborated in chapter 4.

3.7 Development of the Decision-Support Tool

The data analysis resulted in a total of 33 comprehensive barriers to circular asset management and 13 potential interventions to address these barriers. These barriers and interventions form the foundation of the decision-support tool designed to assist municipalities in prioritising interventions for advancing circular asset management.

Each barrier is matched with one or more interventions aimed at addressing or mitigating it, based on insights from interviews and literature. This information is organised into a table, where columns represent barriers and rows list interventions. Each cell where an intervention is relevant to a barrier is highlighted in green, providing a clear overview of the relationships between barriers and interventions *(figure 17),* and indicating which interventions may be implemented for each barrier.

To make this overview practical, an Excel tool was developed to assist users in identifying priority barriers. The tool starts by analysing the current situation by identifying existing barriers. To facilitate this, an Excel-based questionnaire with 70 statements was created, derived from the identified barriers (with some barriers containing multiple statements) (see *Appendix J*). The questionnaire uses a Likert scale from "strongly disagree" to "strongly agree," with responses scored from 5 to 1 in Excel. By marking an "X" in the relevant cell, Excel calculates the score; for instance, a "strongly disagree" response yields a score of 5. For barriers represented by multiple statements, an average score is calculated. Finally, Excel generates a radar pie chart that automatically visualises the scores, with a score of 5 displayed in red and a score of 1 in green. This chart provides a clear view of the municipality's most significant barriers and their intensity (see *figure 18* for an example), enhancing the overview's effectiveness by prioritising the barriers.

4

RESULTS

4. Results

In this chapter, the MLP framework is used to structure the results, creating a clear link between the theoretical understanding of transitions and the practical aspects of implementing circular asset management. Each section is positioned within different levels of the MLP, enhancing the understanding of the dynamics involved in this transition. This is illustrated in *figure 13*.

The first section (4.1), the current practice of asset management, reflects the existing regime by describing the current structures and organisational practices within asset management. It sets the stage for understanding why circular principles have not yet been (fully) integrated into the existing system. The findings in this section are based on conducted interviews.

The second section (4.2), circular asset management ambitions, is linked to the landscape level, showing how landscape pressures create momentum for circular ambitions. This section explores the circular ambitions of the three different municipalities (Amsterdam, Haarlem, Oegstgeest) and their alignment with(inter) national policies. It serves as a foundation for the next section, which describes the initial steps of translating these ambitions into practice. The findings of this section are based on interviews and desk research.

Section 4.3, current circular asset management practices, focuses on how circular asset management practices (niche) are being developed by the three municipalities and the extent to which they are influencing regime-level changes. The findings are based on interviews.

Section 4.4, barriers of circular asset management, identifies and discusses barriers that hinder the adoption of circular asset management. It shows where the regime is resistant to change. These barriers emerge across all three MLP levels, depending on their type (political, environmental, social, technological, economic, legal, and organisational). This section also discusses how these barriers interact and reinforce each other. The findings are based on interviews and are compared in 4.4.2 to the literature.

Finally, 4.5, interventions for implementation of circular asset management, outlines interventions to facilitate the transition towards circular asset management. These interventions span multiple levels (niche, regime, and landscape) and aim to address existing barriers, thereby creating enabling conditions for the integration of circular principles into mainstream practices. The findings are based on interviews, supplemented by a literature review and personal perspective.
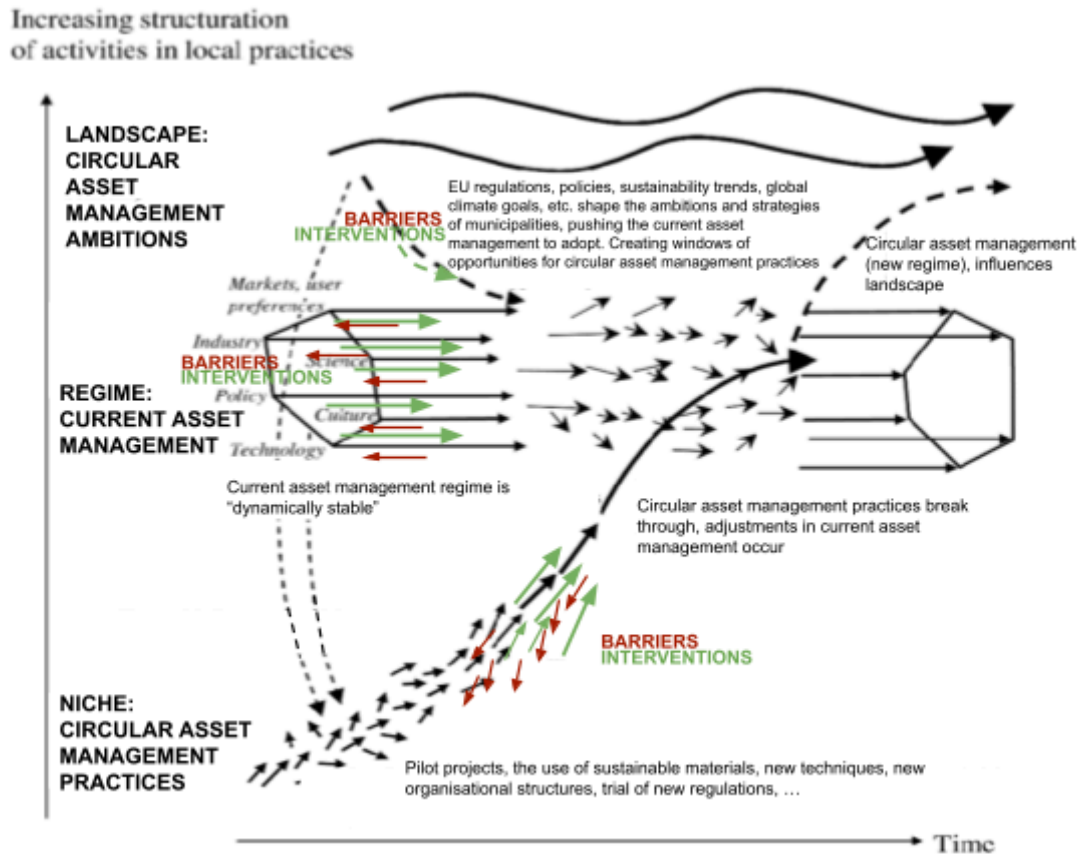
Figure 13: MLP framework for the transition to circular asset management (adapted from Loorbach & Rotmans, 2006)

4.1 The Current Practice of Asset Management

The current practice of asset management reflects the existing regime. It provides insights into the processes that shape decision-making and operations within municipalities. According to the MLP, regimes are characterised by elements that provide stability to systems. Due to these features, the regime is considered 'dynamically stable', meaning it can adapt to minor changes without losing its core structure and function. These stabilising elements include regulations and standards (widely accepted by the actors within the system), organisational structures, social and cultural practices, as well as market dynamics, business models, and financial structures. The current practice of asset management in municipalities is a clear representation of a regime, as it is characterised by its structured organisation (organised into the categories of 'policy', 'project', and 'management'), its compartmentalisation of assets, its standardised approach based on maintenance cycle (implementation, maintenance, replacement after specific lifespan, monitoring and evaluation), and the financial considerations that influence decision-making.

Organisation and approach
In public spaces, assets are developed, maintained, and replaced according to their intended use, as outlined in the asset management lifecycle *(figure 1)*. This process requires careful management. Changes in societal demands also lead to changes in repair and maintenance strategies. To preserve the value of assets, timely management and maintenance are essential. The responsibility for managing public spaces typically falls to municipal governments, with most municipalities following

31

a similar approach to asset management. The overall goal is to create a safe, functional, and attractive environment for both residents and visitors, while keeping costs and risks manageable.

Asset management covers various assets such as greenery, road infrastructure, civil engineering structures, sewage systems, and street furniture. Each asset type usually has a dedicated team responsible for its management. In most municipalities, asset management is organised into the categories of 'policy', 'project' and 'management' (terminology may vary by municipality). Each level has its own set of responsibilities and decision-making processes, contributing to an effective management process.

The policy level creates plans for the design and use of public spaces, documented in resources like the "Handboek Openbare Ruimte". The project level focuses on implementing specific redevelopment and maintenance projects, ranging from small replacement projects to major redevelopments. At the start of a project, the municipality sets the framework, outlining the objectives and expected outcomes. During the project, the municipality takes on a guiding role, which gradually transitions into a supervisory role. The management level deals with daily maintenance and handling complaints and reports from the municipality or residents. This includes both daily and preventive maintenance, such as cleaning roads, repairing street furniture, pruning trees, and minor maintenance of infrastructure like lighting and roads. Additionally, corrective maintenance is undertaken when an asset unexpectedly breaks down or is damaged and requires immediate attention.

Once maintenance and replacement activities are performed, a monitoring and evaluation process follows to ensure that the work meets the required quality standards. This involves documenting the work performed so that it can be integrated into the asset management system.

Decision making

Decisions regarding major maintenance and replacement interventions are based on technical inspections carried out according to national standards. Therefore, periodic inspections are scheduled to determine what maintenance measures are needed and when they should be executed. Major maintenance involves extensive work required to keep an asset in good condition and must be performed regularly to ensure its desired lifespan. Replacement occurs when an asset has reached the end of its technical lifespan. Many above-ground public spaces, such as greenery, roads, traffic, and lighting, have a maintenance cycle of 40 years. For civil engineering structures, the cycle is typically longer, around 100 years. However, there are small variations between municipalities.

The management of public assets requires significant investments. Therefore, municipalities set annual budgets. Financial considerations play a major role in the maintenance and replacement of assets. These considerations include the investment value, the current value of the asset, and the maintenance costs.

"Maintenance and replacement should be seen as opportunities to achieve municipal goals rather than as financial burdens" (Task-oriented Asset Manager, Municipality of Haarlem)

Case study: differences in practice of asset management between Amsterdam, Haarlem, and Oegstgeest

For this research, it is important to highlight two notable differences in asset management between the municipalities of Amsterdam, Haarlem, and Oegstgeest.

The first difference concerns the organisational structure, which is influenced by the size of each municipality's civil service. Oegstgeest, as a smaller municipality, only has the capacity to form teams, while larger municipalities such as Amsterdam and Haarlem have more complex organisational structures with multiple departments made up of various teams.

The second difference lies in the use of cooperation agreements with external parties. While Amsterdam and Haarlem make use of these agreements, Oegstgeest does not. Haarlem employs a "control model", where projects in public spaces are outsourced to "raamcontract partners" such as engineering and construction services. This is based on their belief that the necessary expertise is predominantly found in the market rather than internally, leading to a reliance on external specialists. Amsterdam uses the "SOK (samenwerkingsovereenkomst)"; a multi-year cooperation agreement with a fixed group of contractors. They see the advantage of not having to make new agreements for each project but instead having consistent, structural agreements that can be applied across all projects. Both municipalities have chosen this approach with sustainability as a key consideration. Through these contracts, circularity requirements, such as the reuse of materials, can be established and adhered to.

4.2 Circular Economy Ambitions

The stability of the existing regime makes large-scale transitions difficult to achieve without pressures from above. Therefore, to shift from traditional asset management to a new regime of circular asset management, landscape pressures and niche developments play an important role. In the MLP framework, the landscape acts as an overarching structure that shapes the direction and speed of transitions by exerting pressures or creating opportunities for change within regimes and niches. It sets the context in which regimes and niches operate, defining the broader "rules of the game" and influencing which innovations are viable or desirable. Goals and strategies can push regimes to adopt circular economy principles. Circular ambitions set by municipalities are often shaped by the broader landscape, such as national government policies, which are, in turn, influenced by the European Commision. These ambitions are part of the landscape because they act as forces, defining the socio-political context, setting the agenda for long-term change, and shaping the environment within which regimes and niches operate. This creates a consistent backdrop for regime actors in their planning and decision-making. This positioning aligns with the MLP framework, where the landscape shapes, but does not directly control, the dynamics of regimes and niches.

(Inter)national ambitions for a circular economy within the built environment
Global, national, and regional developments and decisions challenge municipalities to approach transitions with great ambition. In 2020, the European Commission introduced the "European Green Deal", a roadmap aimed at making Europe climate-neutral by 2050. A key component of this initiative is the EU's "Circular Economy Action Plan (CEAP)", which promotes circular processes, encourages sustainable consumption, and aims to reduce waste. The goal is to improve resource efficiency and reduce the impact on the climate, including in the built environment, by integrating circularity principles into every stage of the life cycle (European Commission, 2020).

In 2016, the Netherlands became one of the first countries in the world to translate its ambition for a circular economy into policy through the program "Nederland Circulair in 2050". This program set the goal of reducing the use of primary abiotic resources by 50% by 2030 and achieving full circularity by 2050, aligning with broader European objectives (Ministerie van Infrastructuur en Waterstaat, 2023).

The "Nationaal Programma Circulaire Economie 2023-2030 (NPCE)" further elaborates on these ambitions. The NPCE serves as a directive from the government to accelerate the transition to a circular economy. It focuses on four strategies for promoting circular resource use: reducing resource use ("narrow the loop"), substituting resources, extending product lifespan ("slow the loop"), and high-quality processing ("close the loop"). These strategies are derived from the R-ladder model (*figure 2*).

For the built environment, the NPCE focuses on the development, use, and reuse of buildings, infrastructure, and areas without depleting natural resources, or harming ecosystems. This involves selecting materials and products based on their minimal environmental impact throughout their entire lifecycle: from production and use to maintenance, end-of-life, and reuse. The government has set a goal of reducing the environmental impact of infrastructure by 50% by 2030 compared to 2019. To achieve this, the government is focusing on circular construction and sustainable management and maintenance. The main objectives for each strategy are (Ministerie van Infrastructuur en Waterstaat, 2023):

1. Reducing resource use: By 2030, all new and replacement projects must undergo an integrated assessment of circularity, aiming to minimise environmental impact by building more efficiently with fewer primary materials.
2. Substitution of resources: By 2030, alternative materials with lower environmental impact must be used, such as environmentally friendly, secondary, and renewable materials. Additionally, at least 95% of the recovered asphalt must be recycled at a high quality, and alternative materials (at least 10% binders and 20% other resources) must be applied.
3. Extending product lifespan: By 2025, new structures must be designed to be future-proof, ensuring they are adaptive, flexible, or robust and can adapt to changing use requirements. From 2030, existing infrastructure must meet or exceed their intended technical lifespan through proper and circular maintenance. New structures must be designed such that their technical and functional lifespans are aligned to prevent premature replacement. Circular management and maintenance of asphalt roads should be fully implemented by 2026, with asphalt layers extending their lifespan by two years by 2030.
4. High-quality processing: By 2030, high-quality reuse will be mandatory for all existing infrastructure, and materials that cannot be reused must be recycled at a high-quality level of at least 80%. Concrete bridges and viaducts set for demolition must be dismantled in a circular way, and 95% of recovered asphalt should be recycled at a high-quality standard. By 2050, incineration of recyclable materials should be fully eliminated.

Case study: differences in circular ambitions between Amsterdam, Haarlem, and Oegstgeest
All three municipalities aim to fully transition to a circular economy by 2050, in line with national objectives, using the four strategies introduced in the NPCE . However, the extent to which their plans are developed and their approaches vary significantly. Both Amsterdam and Haarlem have dedicated action programs for the circular economy, with a focus on the built environment, though their strategies and specific actions differ.

For instance, Amsterdam's key goals for the built environment by 2025 include (Gemeente Amsterdam, 2023):

- Ensuring all new designs for area development and public spaces meet circular criteria.

- Conducting 50% of renovations and public space management (both above and below ground) based on circular principles.
- Applying circular and social criteria to activities in public spaces, such as procurement, tenders, and land allocations.

Key actions include:

- Developing (digital) standards and circular criteria.
- Creating enforceable policies to guarantee circular principles.
- Stimulating the reuse of materials in public spaces, following the "Hergebruik, tenzij…" (Reuse, unless…) principle (elaborated in the next section).
- Developing a system to track the progress of circular initiatives.
- Investing in technologies to optimise material management.
- Contributing to regional, national, and international knowledge platforms.

Haarlem, with its proactive and progressive municipal council, has set even more ambitious sustainability targets, aiming for full circularity by 2040, ahead of the national goal. The interim goals for 2025 for the built environment are (Gemeente Haarlem, 2023):

- 50% of procurement to be circular (100% by 2030).
- 50% of civil engineering projects to be circular (100% by 2030).
- Tracking material flows for 50% of external construction projects.
- Establishing a resource hub in collaboration with maintenance partners.
- Developing a circular construction market in partnership with regional entrepreneurs.

To support these goals, Haarlem has set nine Key Performance Indicators (KPIs), with four specifically focused on circularity:

- Reducing the total environmental impact by 50% compared to 2017 levels.
- Decreasing the use of new raw materials by 50%.
- Providing all projects with a material passport.
- Contributing to a circular hub and providing insight into its mass percentage reduction of primary raw materials, as well as its reduction in ECI and CO_2 equivalents.

Additionally, Haarlem is committed to transparent and measurable reporting on the progress of these sustainability goals.

In contrast, Oegstgeest has a less extensive policy on circularity. The municipality focuses on sustainability in its ambition document, but the circular economy is only a small part of it. There is no specific action plan for circularity, and no concrete goals have been formulated for the built environment or public spaces. Consequently, Oegstgeest's ambitions are limited. Their focus is on promoting the reduction of raw material use, material substitution, extending the lifespan of products, and high-quality processing (in line with the four NPCE strategies). They also emphasise socially responsible procurement, where not only price but also environmental and social impacts are considered during tenders. Their long-term goal is to gradually integrate circularity into daily operations (Gemeente Oegstgeest, 2020).

In summary, the municipalities of Amsterdam and Haarlem are leading with ambitious action programs and goals for transitioning to a circular economy. Oegstgeest, on the other hand, has a more general focus on sustainability, with limited specific actions related to circularity.

4.3 The Current Practices of Circular Asset Management

Circular asset management practices are currently considered niche as they embody innovative approaches and solutions still positioned outside the mainstream. These practices focus on new methods of managing resources, reducing waste, and organising systems that challenge the linear models typical of the existing regime. These circular initiatives aim to challenge and ultimately replace the current approach to asset management.

Case study: current circular asset management practices in Amsterdam, Haarlem, and Oegstgeest
Amsterdam is implementing various measures to accelerate the transition to a circular economy. One such measure involves an organisational shift within the municipality, where a "circularity booster" has been appointed in each department involved in public space management. This role is responsible for promoting circular initiatives, such as using materials more consciously, reducing the Environmental Cost Indicator (ECI), and achieving other circular goals.

A major step since 2024 has been the introduction of the "Duurzaam, tenzij…" (Sustainable, unless…) guideline. While the previous focus was primarily on cost-efficiency, the new approach establishes that circularity and reuse should become the norm. This change requires a mindset shift, where sustainability is no longer seen as an exception but as a fundamental principle. Additionally, the municipality has signed a cooperation agreement ("SOK") with market parties selected for their ability to work "smart and sustainably," reuse materials, and apply innovative solutions.

Regarding material use, the focus is on extending lifespans and making conscious material choices based on the ECI. For example, concrete is only used when absolutely necessary due to its relatively short lifespan, while wood is being used more frequently. A first protocol for material reuse has also been developed, outlining criteria and conditions for reuse. To further stimulate reuse, a special depot has been established to temporarily store materials for future projects.

Haarlem has outlined a clear path for circular measures with its "Duurzaamheidsmanagementplan". This plan includes nine KPIs, such as the goal to reduce the ECI by 50%. By applying the ECI instrument more frequently, the municipality can better compare the environmental impact of material choices and make more sustainable decisions.

Haarlem has also introduced an obligation to report progress annually. Every year, sustainability performance is reviewed in relation to projects, goals, and EMVI (Economically Most Advantageous Tender) criteria. Significant progress is already being made, with the first report expected by the end of this year. In parallel, the municipality is developing a dashboard where results for each project are documented uniformly, ensuring greater transparency and insight into achievements.

Additionally, the municipality is working on a resource hub where surplus materials are registered in a material passport and stored for reuse in other projects.

Oegstgeest is currently in an exploratory phase, seeking ways to integrate circularity into policy and practice. The municipality is investigating possibilities and exploring new market initiatives. Their

focus is mainly on extending the lifespan of existing elements through optimisation. If replacement is necessary, materials of higher quality and longer lifespan are considered, as this is also more cost-effective. Where possible, Oegstgeest aims to preserve existing materials and assets, following the "Leidse Ladder" guideline, which promotes the reuse of materials and the preservation of structures.

Circular asset management is an emerging practice that is still at the niche level, as it has not yet become the dominant regime. The extent to which circularity is being integrated varies between municipalities. Differences between municipalities illustrate how the regime is starting to adapt to niche innovations. Larger municipalities with more resources, such as Amsterdam and Haarlem, can integrate these innovations more quickly, whereas smaller municipalities, like Oegstgeest, are slower to adopt them. Initiatives within municipalities like Haarlem and Amsterdam, such as using ECI instrumentation, establishing material hubs, and implementing Amsterdam's "Duurzaam, tenzij" guideline, demonstrate how niche innovations are being tested within the existing regime. Meanwhile, Oegstgeest's early-stage efforts in circular asset management highlight how smaller municipalities, with fewer resources, are still in the exploratory phase.

4.4 Barriers of Circular Asset Management

In the MLP, barriers to changing the existing regime arise from interactions between the three levels: niches (micro-level), regimes (meso-level), and the landscape (macro-level). These barriers typically stem from a misalignment between the regime's current structures and the changes required by landscape pressures and niche innovations. Changing the regime is challenging because it resists transformation through stabilising mechanisms, creating a "lock-in" effect. As a result, existing systems, practices, and regulations become so deeply entrenched that introducing (major) changes, such as adopting circular economy principles, becomes difficult. Niche innovations struggle to scale up and go mainstream. This dynamic creates different types of barriers across various MLP levels that hinder change. For instance, political barriers typically arise at the landscape level, referring to broader pressures that force a regime to adapt or change. Organisational barriers are often linked to the current regime, describing structural and operational barriers within organisations (such as municipalities) that hinder transitions. Technological barriers often emerge at the niche level, highlighting challenges in integrating innovative technologies or practices into existing systems.

4.4.1 PESTEL-O

Interviews with experts and municipalities revealed multiple barriers, which were categorised using the PESTEL-O framework (Political, Environmental, Social, Technological, Economic, Legal, and Organisational). Here "political" primarily refers to decision-making processes, "environmental" to the complexity of the existing environment, "social" to the behaviour of individuals or groups, "technological" to a lack of knowledge on how to address certain tasks, "economic" to insufficient resources needed for the transition, and "organisational" to the established structures within the organisation.

Figure 14 presents a bar chart illustrating the frequency with which each specific barrier was mentioned, ranging from 0 to 15 mentions. The chart clearly shows that the "organisational" category is the most frequently mentioned, indicating that organisational barriers have a significant impact. It also highlights the prominence of social and technological barriers, with several barriers reaching high values. This suggests that stakeholder behaviour and technological challenges are substantial barriers.

Additionally, the lack of resources and increased costs associated with the transition were frequently cited.
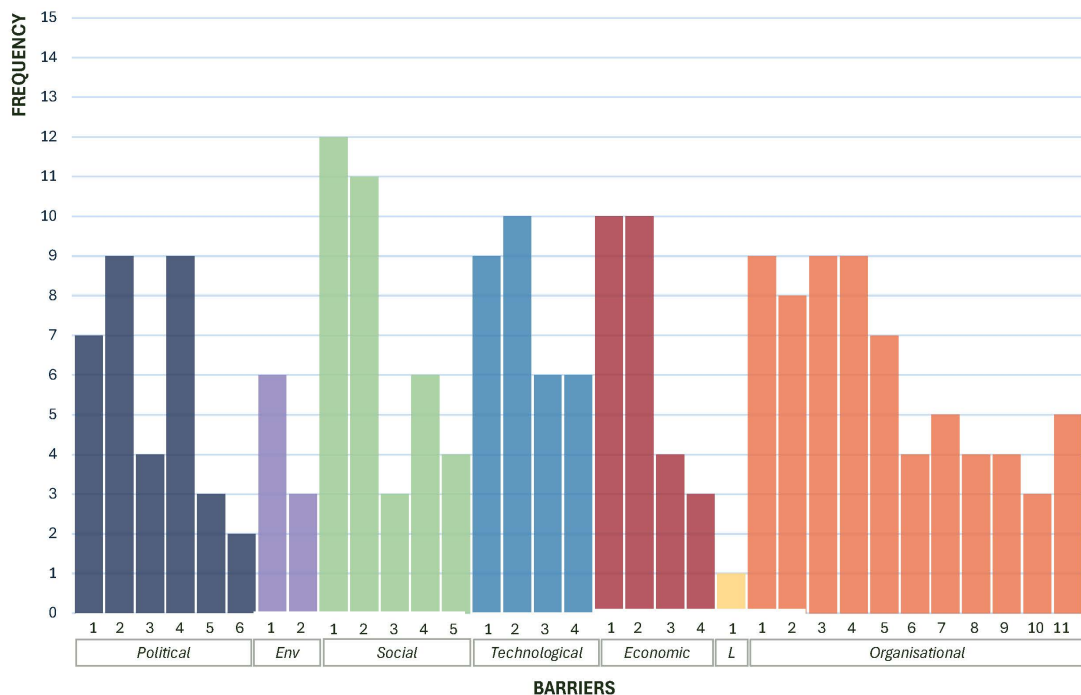
Figure 14: Frequency of mentioned barriers (own figure)

4.4.1.1 Political

Political barriers involve governance structures, political priorities, and the alignment of perspectives among municipalities on circular asset management. The absence of political guidance and coordination results in a lack of clarity regarding vision, prioritisation, and assessment, ultimately hindering effective implementation. The specific barriers within this category are outlined below.

P1. Lack of a clear and unified vision or definition of circularity
There is no nationally recognised or coordinated understanding of what "circular" means or key themes associated with it. This lack of clarity results in an unclear starting point and insufficient support. Without a shared vision and a uniform framework of definitions, the parties involved in the process have different interpretations, resulting in them not effectively working towards the exact same goal. This problem occurs within municipalities, between municipalities, and between municipalities, provinces, and the national government. It complicates policy development and hinders cooperation.

"What exactly does a circular society look like?" (Policy advisor, Municipality of Oegstgeest)
"What does it involve, and which themes are associated with it?" (Policymaker circular built environment, Municipality of Amsterdam)

P2. Lack of clear prioritisation
There is a lack of prioritisation by government and politics (national, provincial, and municipal levels). As a result, many municipalities lack a clear prioritisation of sustainability objectives, let alone circular objectives. Making well-considered choices requires administrative courage (Director future-proof assets, Municipality of Amsterdam). The lack of prioritisation results in fragmented

responsibilities, budgets, and implementation. Sustainability goals compete with each other and with other policy goals, making it hard for executive officials to set the right priorities.

"What has priority, and what do you start with?" (Policy advisor, Municipality of Oegstgeest)
"What is the most important thing that yields the most results?" (Task-oriented manager, Municipality of Haarlem)

P3. Action programmes do not specifically focus on circular management of the public space
While many municipalities have sustainability programmes, they are often broadly defined and do not focus specifically on circularity or public space management. As a result, critical topics such as reuse do not receive sufficient attention.

"We do have a Sustainability Roadmap, but nothing concrete for circularity yet" (Asset manager, Municipality of Oegstgeest)

"We have quite a few ambitions, but not everything is directly linked to public space from the Circular Action Program because it was developed from the perspective of Economy" (Policy advisor circular economy, Municipality of Haarlem)

P4. Lack of a framework to assess the results of transition efforts in the field of circularity
The absence of a clear vision, a coherent set of concepts, and well-defined priorities makes it difficult to create a consistent assessment framework. Without proper guidelines, setting specific indicators or defining the value to be achieved becomes unclear. Compliance criteria remain vague, complicating the development of concrete requirements. As a result, evaluating the effectiveness of efforts and comparing results becomes more challenging, limiting the ability to identify and share best practices.

"What does it have to comply with? There are no real guidelines yet." (Task oriented manager, Municipality of Haarlem)
"How do you define the value you want to achieve?" (Director of future-proof assets, Municipality of Amsterdam)

"We hear that we need to use 50% fewer abiotic raw materials, but no one knows what that means. What exactly does it mean? Which indicator corresponds to that? I don't know." (Senior policy officer for sustainability, Municipality of Haarlem)

P5. The governance model is based on a four-year cycle, which usually does not align with the time needed to achieve demonstrable results

P6. Lack of collaboration (among municipalities)
There is no obligation for municipalities to collaborate on sustainability or circularity. Some municipalities prefer to execute their sustainability agendas independently, believing it to be more efficient. Others fear that their interests will not be adequately represented in wider cooperation. Moreover, there is often no one to take the initiative to promote collaboration.

4.4.1.2 Environmental

Environmental barriers refer to the (physical) environment and its constraints, which impact the transition to circular asset management. The public space is particularly complex due to its existing infrastructure and the diverse vested interests of various stakeholders.

ENV1. The existing public space is already developed and has vested interests, limiting or complicating opportunities for intervention or redesign

The existing public space contains complex infrastructure that is intensively used by residents, businesses, and other stakeholders. These groups have an interest in its current state and wish to be involved in decision-making processes regarding potential redevelopment. Any changes to the layout could disrupt these interests. Moreover, space constraints in existing public areas put further pressure on technical realisation.

"The longer you operate, the more established interests there are, and the more established interests, the harder it becomes to incorporate new things." (Senior advisor public space management, Rijkswaterstaat).

"In new developments, you have a lot of options and possibilities. In existing areas, there is participation; everyone wants a say, and before you know it, years have passed before any changes are implemented". (Asset manager, Municipality of Oegstgeest).

ENV2. Residents and users of the public space may resist the circular transition because they do not understand how distinctions are made when considering new and reuse
Traditionally, residents and users have been accustomed to worn-out or outdated assets being replaced with new ones. When these assets lose their technical or functional qualities and reach the end of their lifespan, replacement is usually the standard approach. However, the philosophy of circular asset management differs: careful consideration is given between reuse or replacement, often favouring reuse. This can create confusion for residents, who may not understand why reuse is chosen in one neighbourhood while replacement with new assets is preferred in another (Advisor future-proof assets, Municipality of Amsterdam). This can lead to frustration and feelings of disadvantage among residents.

"Some residents get irritated by this and immediately bring up concerns about their tax money". (Area asset manager, Municipality of Amsterdam)

4.4.1.3 Social/behavioural

Social barriers relate to the behaviour and engagement of stakeholders, which affect the adoption of circular practices. The novelty of the topic, combined with insufficient communication, leads to a limited understanding of stakeholders' interests. This can result in uncertainty, resistance, or a lack of motivation to engage in circular initiatives.

S1. Lack of understanding of each other's interests within the organisation due to inadequate communication
Within the organisation, there are various functions and departments, each with its own interests that need to be represented. Asset managers, for instance, often set strict requirements because they are responsible for the execution. The diversity of interests sometimes leads to clashes, making it difficult to achieve optimal outcomes.

"There are so many different interests that sometimes clash, leading to a lot of work and discussions, making it not always easy to achieve the best result." (Process manager for sustainability, Municipality of Haarlem)

Additionally, these interests are not always effectively communicated across the organisation, leading to misunderstandings of each other's perspectives and working alongside each other. This often results in inefficiency and frustration.

"People are rarely asked during the implementation process, 'What are you struggling with? How can I help you?'" (Future-proof assets director, Municipality of Amsterdam)

S2. Insufficient motivation and/or willingness among participants

Not all participants required to change and contribute to achieving transition objectives are sufficiently motivated. This lack of motivation may stem from ignorance, poor communication, conservatism, fear of losing status, routine, or disinterest.The influence of unmotivated employees and managers can significantly impact projects and the team members involved (Advisor future-proof assets, Municipality of Amsterdam).

"It's a bit of traditional thinking, and asset managers don't always dare to take action either. If we come up with a very nice new solution that turns out not to work, like cracks appearing in the pavement, they are held accountable for it. So it's also a form of self-protection" (Process manager for sustainability, Municipality of Haarlem)

S3. Initiatives are not sufficiently followed (up)

Although many initiatives are launched and set in motion, the effort often fades over time because the goals are not well known or embedded, or simply because there is no time or a designated person in charge. If a municipality is not actively engaged in following up or using these initiatives, they risk being left unused, which can lead to their quiet failure without it being actively noticed.

"Many things are set up, but it often doesn't work because there is insufficient capacity to keep up with it, and it's unclear who is responsible for keeping it up-to-date." (Director future-proof assets, Municipality of Amsterdam)

"All those tools and methodologies, if a municipality is not actively involved, it will just remain unused" (Sustainability advisor, Managing Public Space)

S4. Unfamiliarity of the topic has a negative impact on readiness for change

For many employees, the circular transition is an abstract topic for which it is unclear what the consequences of (lack of) action will be. This lack of familiarity leads to a lack of urgency and, consequently, a low willingness to change. Due to this knowledge gap, employees tend to stick to familiar ways of working to maintain a sense of security.

S5. Fear of making major changes or decisions due to potential negative reactions

Unfamiliarity with the subject matter and the complexity of related issues force employees to step out of their "comfort zone." The uncertainty of whether their proposals will be valued or criticised by colleagues, superiors, and suppliers makes them hesitant to take actions.

4.4.1.4 Technological

Technological barriers refer to the knowledge and management of technological resources needed for circular asset management. Many aspects of circular asset management are still unknown and unresolved. There is uncertainty about practical implementation, such as the use of reused materials and the management and collection of data.

T1. The municipality and, in particular, the asset manager is tasked with a job for which they lack the necessary knowledge and experience to execute properly and efficiently

There is a lack of knowledge in various areas, such as how to operationalise circular processes and develop appropriate policies. Circular asset management introduces a new way of working for many,

with limited prior experience in this field. As a result, some individuals are unsure how to implement these processes and may hesitate to cooperate, hindering the implementation of circular initiatives.

"Many people say: 'I don't know how, so I won't do it'." (Director future-proof assets, Municipality of Amsterdam).
"It's a new way of working for people that they have no experience with" (Advisor future-proof assets, Municipality of Amsterdam)

Furthermore, knowledge from institutions, such as research centres, does not sufficiently make its way into everyday practice. This disconnect between theory and application, means that valuable insights fail to reach asset managers in the field, leaving a gap between the knowledge available and its practical use.

"The translation to practise, so the implementation of all that knowledge, is a really tricky thing". (Senior program manager public space, Managing Public Space)

T2. The lack of effective data management hinders the ability to measure and report results accurately

Currently, data management practices are insufficient due to unclear guidelines on how to measure, collect, store, share, and use data effectively for reporting purposes. There is a lack of knowledge regarding data processes, while data is crucial to measure and compare the results of efforts. The absence of standardised agreements and protocols for data measurement, definitions, storage, sharing and use, leads to a lack of reliable quantitative insights. It is unclear whether targets are being met or to what extent they have been achieved, as the necessary data is missing, making it difficult to demonstrate what is having an impact. Additionally, roles and responsibilities related to providing this information are not well-defined. This hampers proper documentation of data, which is essential to guide the transition process and to communicate results clearly, which in turn increases support.

"How do we provide that information? How do we create a suitable format? How can we make this possible? How will it be processed and who is responsible?" (Task-oriented manager, Municipality of Haarlem)

"If you ask now whether we are meeting our targets and what percentage we are achieving, we can't really answer that because we don't have clear data. We just don't know where we are, so we can't demonstrate what makes an impact" (Task-oriented manager, Municipality of Haarlem)

T3. Integrating circular processes into current public spaces (including supply chains and infrastructure) is complex

Reuse is often part of a broader (production) chain primarily based on using new materials. Integrating reused materials poses challenges because existing infrastructure and public spaces were not designed with reuse in mind. The original design did not consider the possibility of circular applications, complicating their integration.

T4. Technical knowledge gaps regarding the application of reuse

Although there are generic ideas about reusing materials, many technical uncertainties or limitations remain, such as the fact that not all materials are currently suitable for reuse (Area asset manager, Municipality of Amsterdam). Additionally, there is great diversity in materials. The lack of detailed information complicates the development of concrete policies and specific standards.

"You need to know what quality you have available. That's often not entirely clear" (Senior advisor public space management, Rijkswaterstaat)

Economic barriers address the financial constraints and resource limitations that impact the feasibility of transitioning to circular asset management. Essential resources, such as money, time, and expertise, are often lacking or insufficient, and current financial systems are not prohibitive to the implementation of circular asset management.

ECO1. Lack of resources such as money, time and expertise
Municipalities experience a shortage of resources throughout the organisation to optimally manage the transition. The lack of resources manifests itself particularly in shortages of financial resources, time and expertise (manpower). This shortage affects both primary execution and the identification and incorporation of "lessons learned".

"Financially, that is quite a challenge" "we have relatively few people" (Task-oriented manager, Municipality of Haarlem)
"There is a budget constraint; you have to do it with the available budget." (Asset manager, Municipality of Oegstgeest)
"Training people, bringing them on board, and integrating a new generation into a specific area also takes years". (Sustainability advisor, Managing Public Space)

ECO2. The transition can be cost-prohibitive and may lead to the decision not to opt for circular solutions
Adopting new ways of working and investing can result in substantially higher costs.
"The maintenance cycle must be changed, and that has financial consequences." (Sustainability manager, Sweco)
Politicians and/or budget holders face a dilemma as to whether they want these investments to come at the expense of other important, non-transition-related topics. As a result, circular options are not always selected.

"Sustainability in general, or at least circular asset management, often costs money, and it's always a challenge to get everyone on board for it." (Process manager for sustainability, Municipality of Haarlem)

"We have policies that require pursuing certain objectives, but if that comes at the expense of quality, resulting in more daily maintenance needs, which entail more costs and effort, you have to justify that clearly" (Process manager for sustainability, Municipality of Haarlem)

ECO3. Insufficient clarity on budget responsibility
In many municipalities, there is still no clear allocation of the budget for the transition, and it is unclear which official is responsible for managing the budget for the transition project. Often, the available budget is fragmented across existing assets, departments, and projects, putting pressure on the prioritisation of transition objectives.

ECO4.The (power) position of the executing (market) parties
On the suppliers' side, revenue models are primarily focused on the use of new materials as well as existing requirements and conditions. Project proposals and quotes are tailored accordingly. Suppliers have sufficient expertise to meet these requirements. This contrasts with many municipalities, which often cannot challenge the traditional proposals from suppliers due to a lack of expertise.

4.4.1.6 Legal

Legal factors involve the existing laws, regulations, and contractual agreements. Legal barriers often emerge during the implementation phase, affecting flexibility and decision-making.

L1. Existing contracts limit freedom of action
Many municipalities are bound by contractual agreements from the past that continue to run for a longer period, which limits their freedom of choice.

4.4.1.7 Organisational

Organisational barriers focus on internal municipal structures, internal and external communication, and processes that influence circular asset management. The complexity arises from existing linear systems, undefined roles, compartmentalisation within the organisation, poor communication, and a lack of concrete action plans.

O1. Current systems are linearly set up and/or not aligned with sustainability and circularity
Current systems are linearly set up, with little emphasis on alternative, circular methods. Municipal systems, such as financial models, purchasing systems, and depreciation methods, are aligned with this linear setup.

"Asset managers are assessed on costs and efficiency, so they are essentially forced into this siloed way of thinking by all kinds of financial systems." (Senior program manager public space, Managing Public Space)

Such systems are generally not aligned with the aspects crucial to the transition, such as reusing materials instead of using new materials or making long-term investments that support circularity. Financial models do not account for certain benefits of the circular model.

"In the current cost calculation model, there is no room to include these certainly economic benefits of such circular applications because they also take place in the future." (Consortium manager future-proof living environment, AMS Institute)

"Nobody realises what that cost reduction or what the environmental impact is, while that is super important" (Policymaker circular built environment, Municipality of Amsterdam)

As a result, these models frequently lead asset managers and procurement teams to opt for new materials over reusing existing ones. Furthermore, in current project teams, decision-making authority typically rests with the process manager, who often bases decisions primarily on financial-economic considerations (Senior policy officer for sustainability, Municipality of Haarlem).

O2. Lack of role definitions, experts and "new generation" employees
The circular transition requires specific expertise and clearly assigned responsibilities. As new processes and methods are introduced, additional knowledge is needed to manage them effectively.

"With each theme you add, you actually need extra expertise." (Senior advisor public space management, Rijkswaterstaat)

However, circular expertise is often insufficiently available, and there is a lack of clear role definitions. This creates ambiguity about who is responsible for certain tasks, leading to the risk of them being overlooked, especially when they don't align with regular duties and employees are

already handling heavy workloads.Sometimes this is due to a shortage of people (FTEs); other times, it just concerns properly defining and assigning roles to the current workforce.

"It's easier that it gets left behind, because people just have lots of other things to do and this doesn't belong in their normal everyday tasks" (Policymaker circular built environment, Municipality of Amsterdam)

Finally, there is often an experienced but ageing execution organisation, resulting in too few employees of the new generation being trained and given a position.

O3. The organisation is compartmentalised, hindering communication between departments
While the transition to circular asset management requires an integrated approach, everyone currently functions independently from their department or asset with limited coordination. This hinders cohesion within projects and effective collaboration.

"It often proves difficult to coordinate optimally between all departments within a municipality" (Task-oriented manager, Municipality of Haarlem)

"Everyone is kind of designing their own thing on their own island" (Senior program manager public space, Managing Public Space)

"It's nice to design something, but if we get to manage it and we can't maintain it, then within two years your design is done" (Area Asset Manager, Municipality of Amsterdam)

Moreover, communication between employees is insufficient, preventing the exchange of critical information about overarching project goals. There is minimal engagement between colleagues, resulting in inefficient and unfocused teamwork throughout all stages of a project; before, during, and after completion.

"Engaging with each other happens too little." (Senior program manager public space, Managing Public Space)

O4. Strategic and tactical goals are not translated into concrete actions
While circularity is in full development, the objectives often remain at the level of vision and strategy, without being translated into concrete actions. There is a lack of clarity on how to achieve these goals..

"We know we have to meet the Paris Climate Agreement, but the biggest hurdle is moving into implementation" (Director future-proof assets, Municipality of Amsterdam)

It is essential to translate these strategies into concrete actions to support implementation. These operational objectives should primarily address the question of how the transition can be realised, such as determining the approach in which materials can be reused.

"Ambitions and goals are formulated in such a way that we have to be circular by 2050, but how to achieve that, no idea" (Advisor future-proof assets, Municipality of Amsterdam)
"In what form should we reuse? As far as I know, there is still no clarity about that. It is certainly not clear to me what exactly we mean by it and how we should translate it into practice." (Task-oriented manager, Municipality of Haarlem)

O5. Inadequate communication of objectives and results
The communication of objectives is lacking both internally and externally. Internally, this ensures that not all employees have the same view of the goals to be achieved and the necessary efforts.

Externally, better communication could help raise public awareness. Also, (positive) results are not optimally shared, which is essential to show the impact of the transition and create more understanding.

"There are reports, but whether anything is done with them? I don't think so". (Task-oriented manager, Municipality of Haarlem)

Moreover, communication is currently not sufficiently tailored to specific target groups, resulting in information not being well received. Best practices are also insufficiently shared with other municipalities.

"How do you communicate this to other municipalities, and how do you learn from each other? We obviously do that far too little" (Advisor future-proof assets, Municipality of Amsterdam)

O6. Communication lines are poorly set up
Poorly designed lines of communication hinder the exchange of information on vision, goals, plans, and results. Knowledge is spread out, making it unclear where relevant information is stored. Additionally, it is unclear which information is important, or to whom it should be communicated. This applies to both the sender and the receiver.

"Information is increasingly being documented digitally, but it's not clear where that information is digitally located." (Task-oriented manager, Municipality of Haarlem)

"Knowledge is spread out; it's housed in many different institutions" (Sustainability manager, Sweco)

O7. Insufficient (central) retention of knowledge and experience
The civil servant population is dynamic; employees come and go within the organisation. Much of the knowledge and experiences is not consistently documented, leading to gaps when employees leave. The inadequate or incomplete documentation and transfer of information within departments results in repeated efforts to rediscover or recreate valuable knowledge. There is no central information point where knowledge is secured.

"Knowledge resides in people's heads, and several people have already left" (Task-oriented manager, Municipality of Haarlem)

O8. Unclear (physical) layout and role assignment complicate integrated working
The size of the municipality makes the organisation less transparent, as the allocation of functions and responsibilities is not always clear. This makes it harder to find the right person for specific tasks. This problem is exacerbated by the physical flexibilisation of workplaces. This particularly negatively impacts projects and tasks where integrated working is a prerequisite for success.

"In the past, we knew who was responsible for what function; we had a building with fixed workplaces, and you knew exactly where to be for which person. That's less clear now because of flexible workplaces and distance" (Process manager for sustainability, Municipality of Haarlem)

O9. Fragmentation of responsibilities hampers the decision-making process
In the current organisation, responsibilities for the transition to circular asset management are allocated within a structure designed for linear processes and compartmentalised tasks. Circular asset management, however, requires a more integrated approach. This creates fragmentation of responsibilities, with numerous officers holding small, partial roles in the decision-making process,

making it slower and less efficient. Additionally, the officials responsible for circularity often have other, more significant duties, meaning the topic must compete with other priorities. Responsibilities within current systems are often historically determined and hinder integrated working.

An additional complication is that larger and more established departments often have more influence (Senior advisor public space management, Rijkswaterstaat).

"Circularity is just one of the themes, so someone else comes in for energy, and another for climate adaptation, and these themes compete with each other. In our case, the energy transition is handled by a team of 40 or 50 people that has been active for a long time, so they often get priority" (Policymaker circular built environment, Municipality of Amsterdam)

O10. The impact of the transition on the (execution) organisation is unknown
The topic of circular asset management is relatively new. The visions and strategic, tactical, and operational objectives are still evolving and are certainly not yet fully developed. As a result, the expected impact on the organisation is unclear. It remains uncertain what impact the transition will have on the various parts of the organisation.

"We also don't yet know what the ultimate consequences will be for the municipality. What consequences will it have within the organisation? Will it also affect certain people's work? Will it perhaps be more work? Will it require more money or less? Those are uncertain questions". (Sustainability policy advisor, Municipality of Oegstgeest)

O11. The transition to circularity must be integrated into other public space management to ensure efficiency
Municipalities face the challenge of transitioning to circular asset management while maintaining efficiency to avoid wasting resources and minimise inconvenience to residents. The infrastructure of public spaces, both above-ground and underground, is complex and robust. This robustness can conflict with the flexibility needed to implement transitions effectively (Senior program manager public space, Managing Public Space).The main challenge is coordinating various activities to ensure the transition is as seamless as possible.

"The biggest challenge is to do it as efficiently as possible. You want to do as much as possible at the same time in the same year, at the same moment, in the same area, to minimise inconvenience and spend your money as efficiently as possible" (Process manager for sustainability, Municipality of Haarlem)

4.4.2 Comparison with the Literature

In this section, the barriers identified in the interviews (4.4.1) are compared with those found in the literature. Given the limited literature on circular asset management in the Netherlands, this research explored related sectors, such as circular construction and demolition, circular social housing, and circular buildings and facades. These sectors reveal considerable overlap in the barriers to adopting a circular economy within the built environment. This overlap is particularly strong in the circular social housing sector, possibly due to this sector's position within the public domain. Barriers identified in both literature and empirical research are analysed to highlight commonalities and identify any differences between the two sources.

The empirical research identifies several barriers to circular asset management across political, environmental, social, technological, economic, legal, and organisational dimensions. Key challenges include the predominance of linear systems, insufficient knowledge and experience, inadequate communication, high costs, limited resources, and data management difficulties. Frequently cited

clusters of barriers in the literature (financial, sectoral, business, technical, social/cultural, regulatory, organisational, and knowledge) align closely with these empirical findings.

A prominent barrier in the empirical findings is the lack of a unified vision for circularity, absence of frameworks for progress assessment, and challenges in translating strategic goals into actionable steps (P1, P4, O4). The literature (Abdulai et al., 2024; Hossain et al., 2020; Hart et al., 2019; Zaman et al., 2023; Mahpour, 2019; Ancapi, 2021; Guerra & Leite, 2021; Çetin et al., 2021) supports these findings, emphasising the absence of clear indicators, guidelines, and a cohesive definition of circularity. Both sources highlight the challenges stakeholders face in developing practical guidelines. However, the literature also notes the lack of international standards and regulations, which empirical findings did not cover, possibly due to a national rather than international focus.

Another significant barrier is the linear nature of existing systems, complicating the integration of circular approaches (O1). Municipalities often operate within financial and governance models that favour short-term, cost-efficient decision-making. Similarly, the construction sector follows a linear, hierarchical structure that emphasises capital expenditure and short-term profitability over long-term sustainability (Hart et al., 2019; Çetin et al., 2021; Guerra & Leite, 2021).

Organisational compartmentalisation also emerged as a common barrier, where poor communication between departments hinders collaboration towards circular goals (O3 and S1). Literature (Abdulai et al., 2024; Hossain et al., 2020; Hart et al., 2019; Çetin et al., 2021) discusses how siloed departments within businesses and institutions lead to poor coordination and misalignment around common objectives. Additionally, fragmented supply chains and split incentives in the built environment complicate accountability and decision-making processes (aligning with O9). Competing policy goals further complicate these challenges, highlighting a need for clearer prioritisation of circular objectives, which aligns with barriers P2 and P3.

High costs associated with adopting circular alternatives and limited resources are common barriers (ECO1 and ECO2) in both interviews and literature (Abdulai et al., 2024; Hart et al., 2019; Zaman et al., 2023; Mahpour, 2019; Guerra & Leite, 2021; Çetin et al., 2021; Hartwell et al., 2021; Shooshtarian et al., 2021). Lack of incentives, limited funding, budget constraints, time-consuming processes, and high upfront investment costs present significant challenges to adopting circular strategies in the construction sector. The literature specifically mentions the absence of financial incentives, like tax benefits or subsidies, which were only rarely noted in the interviews.

A significant barrier is a lack of awareness, engagement, and motivation among stakeholders (S2). The literature (Abdulai et al., 2024; Hossain et al., 2020; Hart et al., 2019; Zaman et al., 2023; Mahpour, 2019; Guerra & Leite, 2021; Çetin et al., 2021; Hartwell et al., 2021; Shooshtarian et al., 2021) views this as one of the most critical barriers to circular economy implementation. Empirical research frequently references conservatism and traditional thinking, with asset managers being risk-averse due to possible negative outcomes. The literature echoes this, noting that conservatism in the building sector often leads to resistance to change. It also highlights a lack of interest in end-of-life design due to insufficient knowledge. Unfamiliarity with circular concepts reduces readiness for change (S4), leading to fear of disruption and uncertainty, as described in the literature and observed in barrier S5. Unlike the interviews, the literature points to a lack of rewards, which further reduces enthusiasm for circular practices.

A lack of expertise, knowledge, and skills to effectively execute circular tasks (O2, T1) is emphasised in both literature (Abdulai et al., 2024; Hossain et al., 2020; Hart et al., 2019; Mahpour, 2019; Guerra & Leite, 2021; Çetin et al., 2021; Hartwell et al., 2021; Shooshtarian et al., 2021) and empirical research. Limited education, insufficient training, and lack of experience in circular processes hinder implementation. The literature calls for increased training and awareness but does not specifically note the need for new employees, whereas interviews suggest the ageing workforce isn't adequately prepared for future circular tasks and needs "new generation" employees.

Another barrier is the difficulty of retaining and sharing knowledge (O6, O7). Unstructured communication channels and documentation make it difficult to retain institutional knowledge in circular asset management. Both empirical research and literature (Hossain et al., 2020; Mahpour, 2019; Çetin et al., 2021; Zaman et al., 2023) stress the need for better information exchange and data management. A point particularly noted in interviews and not mentioned in the literature is that due to staff changes, knowledge and experience are often poorly documented and transferred within departments, leading to repetitive work.

Resistance to circular interventions from residents and other users of the public space is another barrier (ENV1 and ENV2). These groups have established interests in the existing infrastructure and are sceptical about changes. The literature (Hossain et al., 2020; Hartwell et al., 2021; Çetin et al., 2021; Zaman et al., 2023) highlights the social and cultural complexity of transitioning to circular practices in the built environment, emphasising aesthetic and cultural norms that favour newness. Empirical research describes how existing public spaces complicate the integration of circular processes, as these are not designed with reuse in mind (T3), a point less emphasised in the literature.

Barriers to material reuse are more prominent in literature (Hossain et al., 2020; Hart et al., 2019; Shooshtarian et al., 2021; Hartwell et al., 2021) than in empirical findings. Both sources highlight the lack of technical knowledge (T4) on reusing materials, including gaps in understanding material quality and suitability and the absence of clear guidelines or standards, whether in terms of data management or specifications for recycled materials. Literature addresses specific barriers such as the lack of information about the recycled content of materials and limited research on material recovery. It also discusses economic challenges posed by low virgin material prices, high costs of recycled materials, and uncertainty about the future value of reused materials.

Overall, the most frequently cited barriers in the literature include a lack of awareness and engagement, lack of incentives, lack of knowledge, and the absence of a clear vision, indicators, and guidelines. While the literature tends to frame these barriers from a design perspective, the empirical findings bring attention to organisational challenges. Inadequate communication of objectives and results, both internally and externally, as well as data management challenges, were more prominent in empirical research than in the literature, where these aspects were less frequently mentioned.

It is essential not only to understand the additional barriers identified in circular asset management compared to other sectors but also to consider barriers from these other sectors, as they may also arise in circular asset management or already exist without being explicitly mentioned.

4.4.3 The Interconnectedness of Barriers

The categorisation of barriers using the PESTEL-O model is useful for identifying key areas where progress is needed to advance towards circular asset management. However, assigning barriers to

specific categories is not always straightforward, as some barriers may fit into multiple categories. In this research, each barrier has been placed in the category that aligns most closely. For example, barrier O5 (inadequate communication of objectives and results) is categorised as an organisational barrier, though it could also be considered a social/behavioural barrier. This categorisation choice reflects that it concerns not only insufficient communication but also how communication is executed. It is important to recognise that certain barriers span multiple categories and are not strictly confined to one.

Moreover, understanding the barriers that hinder the transition towards circular asset management requires acknowledging that they do not exist in isolation but form an interconnected web. Each barrier may *overlap* with or (directly) *influence* another (e.g., by triggering, reinforcing, or resulting from one another). For example, there is an *overlap* between barriers ECO1 and ECO2: the lack of resources (ECO1) drives decision-makers towards more affordable options, as the transition to circular practices can be cost-prohibitive (ECO2). Similarly, limited resources (money, time, and expertise) (ECO1) *overlap* with O2, which involves a lack of defined roles, experts, and "new generation" employees.

An example of barriers *influencing* each other is found in the relationship between T2, O5, and S2. Here, the lack of effective data management hinders the ability to measure and report results accurately (T2), leading to inadequate communication of objectives and results (O5). In turn, this reduces motivation and willingness among participants (S2). Without clear communication, employees may not understand why changes are needed, reducing their willingness to act. Another example of *influence* is the lack of a clear, unified vision for circularity (P1), which affects prioritisation (P2). Without a clear vision, setting specific priorities is challenging, which can lead to broadly defined action programs (P3) and a lack of clear indicators for evaluating results (P4). This prevents the development of concrete action plans (O4), leaving asset managers uncertain about what and how to implement circular principles (T1).

Figure 15 illustrates the interconnections within each PESTEL-O category. This chord diagram builds on the one shown in *figure 16*. Although both diagrams express similar insights, *figure 15* provides an immediate overview of which categories heavily influence others. *Figure 16*, based on the table in *Appendix* I (explained in section 3.7), highlights connections between individual barriers and shows the extensive relationships among the various barriers. In *Appendix K*, the effects of each category are further detailed. The chord diagram in *figure 15* reveals significant flows to and from the "organisational" category, indicating strong interconnections with political, social, technological, and economic factors, as well as internal organisational influences. This suggests that addressing organisational barriers could significantly impact other categories.
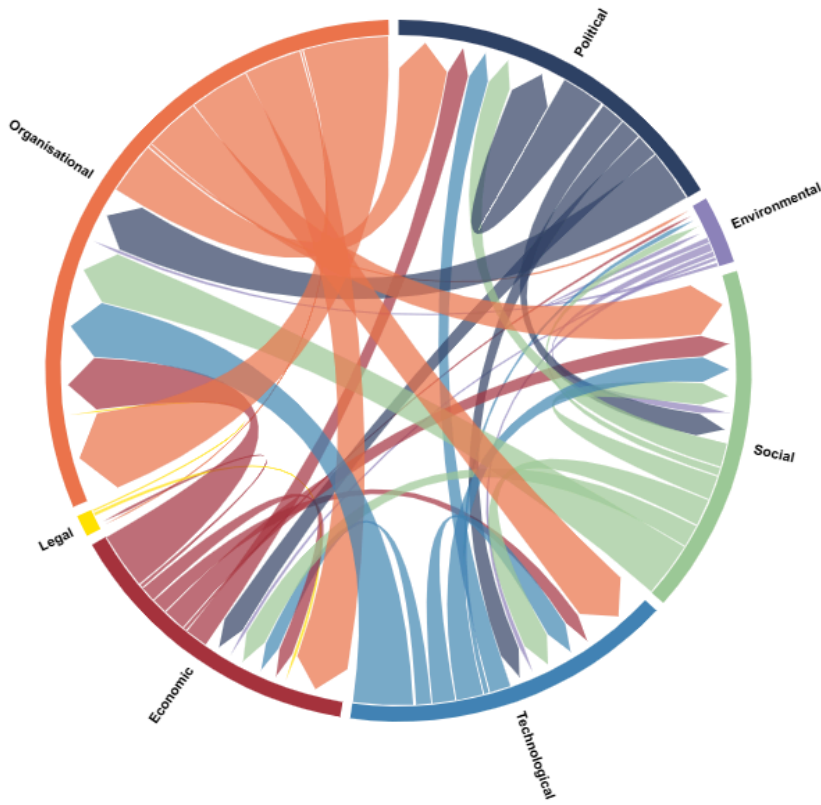
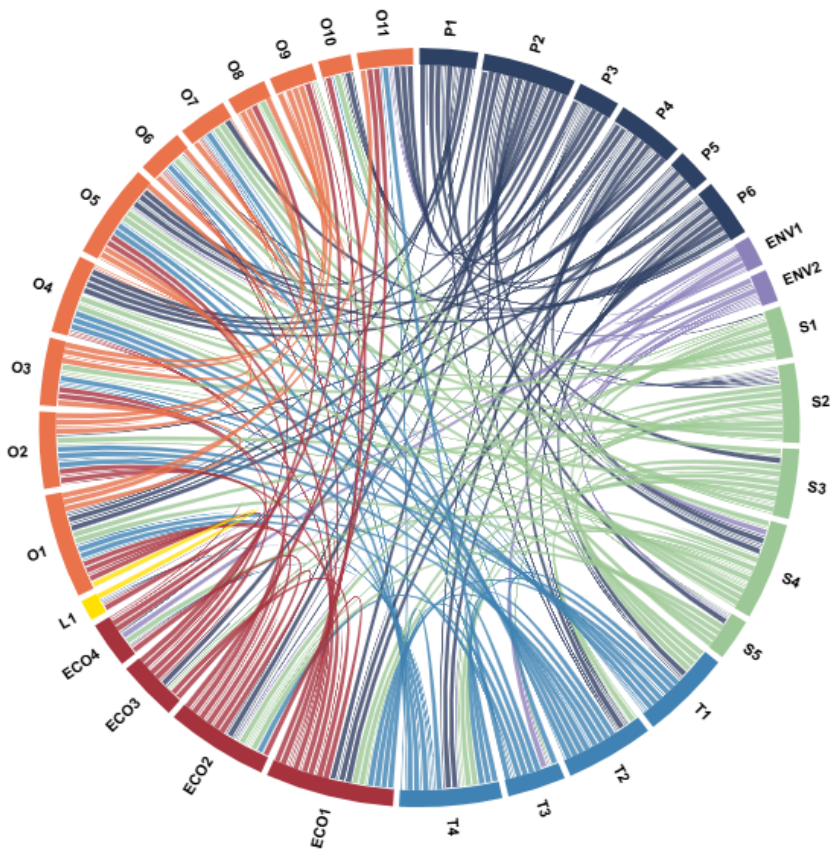*Figure 15: Interconnections within each PESTEL-O category (own figure)*

Figure 16: Interconnections between individual barriers (own figure)

The interconnectedness of barriers demonstrates that no single barrier can be fully addressed without considering (its effects on) others. Recognising the interplay among barriers allows for a more comprehensive approach to developing interventions for advancing towards circular asset management. Understanding the links between barriers helps target interventions at the root causes and enables interventions that tackle multiple barriers simultaneously.

4.5 Interventions for Advancing Circular Asset Management

Interventions target the existing regime to reduce barriers and enable niche innovations to become mainstream. These interventions occur at several levels. At the niche level, interventions focus on early-stage innovations, experiments, and the development of new tools and methods that challenge existing norms, paving the way for broader adoption. At the regime level, interventions involve changes to organisational structures, roles, responsibilities, and processes to integrate circularity into mainstream asset management practices. At the landscape level, interventions aim to influence broader political and societal trends through lobbying and collaboration, creating a supportive environment for circular transitions.

This section outlines 13 interventions to tackle the identified barriers to circular asset management. These interventions are based on best practices and ideas from literature in related sectors (circular construction and demolition, circular social housing, and circular buildings and facades), as well as insights from interviews with the three municipalities and experts. Additionally, (own) ideas derived from the specific needs expressed in these interviews, supported by literature, are included. The interventions are intended for municipalities (policymakers, advisors, asset managers, designers, project leaders, etc.), external consultants like Sweco, and other stakeholders, such as suppliers. For example, interventions 1, 6, and 8 are directed towards municipal action, while interventions 3, 5, and 9 are typical interventions consulting firms could assist municipalities with.

The interventions are organised into "what," "why," and "how & tools." The "what" describes the content of the intervention, "why" provides the reasoning and importance, and "how & tools" outlines the approach, practical tools, and methods for implementing the interventions.

1. **Working with a different mindset: circularity as standard**

What: Shifting to a different mindset where circularity and reuse are prioritised over cost-efficiency. The Municipality of Amsterdam has implemented the principle of "Duurzaam, Tenzij…" ("Sustainable, unless...") as a standard approach since January 2024. Whereas previously the focus was often on the most cost-efficient solutions, the new guideline explicitly states that circularity and reuse should be the norm. This strategy shows how transforming the mission into a widely supported political guideline can accelerate the transition by providing clear direction for decision-making. It forces decision-makers to apply circular principles in all projects, encouraging the reuse of materials and promoting long-term sustainability over short-term cost savings. The guideline includes a "comply or explain" principle, where implementers are required to justify any deviations from circular standards due to practical constraints (e.g., existing contracts) and indicate when compliance with the guideline will be feasible. The "explain" clause builds understanding for deviation and fosters transparency in circular efforts and decision-making. It also offers valuable insights for improving future processes.

Why: Research by De Los Rios and Charnley (2016) and Mahpour (2018) shows that accelerating the transition to a circular economy requires radical innovation and disruptive change. Effective transitions ask placing high priority on circularity within the organisation (Çetin et al., 2021). Without strong internal commitment to circularity, progress will remain slow. By making circularity the norm, municipalities ensure that all decisions align with long-term goals. Moreover, studies by Abdulai et al. (2024) and Shooshtarian et al. (2021) emphasise the importance of enforcement and pressure in driving change.

How & tools:
Open dialogue: Early and open communication among stakeholders (e.g., sustainability coordinators and project managers) is critical. Discussions should focus on what must be guaranteed within the project, including circular and project-specific requirements. Measures to be included and possible obstacles are considered. Note: It is important here that there is a uniform understanding of what is considered 'circular'.

Checklist: Amsterdam employs a checklist that outlines the sustainability criteria for projects. This checklist, supported by the tools listed below, helps assess whether project goals are realistic and identifies any obstacles. Any barriers encountered are discussed, and alternatives are considered. The results of the checklist can then be communicated and incorporated into the design or program of requirements.

Tools:
- Quickscan Circular: Serves as a project-specific guide for selecting sustainable materials and reuse options.
- Materials Quickscan: Helps evaluate which materials can be repurposed either within the same project or for other municipal projects. It offers designers insights into incorporating second-hand materials.
- DuboCalc: Calculates the environmental costs (ECI) of different design options, optimising sustainability by focusing on areas with the highest environmental impact.

2. A. Clarity, priorities and "low-hanging fruit"

What: A unified national understanding of the circular economy should be developed, accompanied by clear ambitions and priorities. It is crucial to communicate this effectively to all relevant stakeholders, ensuring that everyone understands the objectives. Priorities must be set based on feasibility and potential impact. Action plans should be organised around these priorities, beginning with "low-hanging fruit" tasks that are easily achievable and provide visible short-term results. These early successes create momentum and set the stage for tackling more complex, long-term goals.

Why: The current transition to circular asset management often faces ambiguity, unfamiliarity, and a lack of structure. It is important to clearly define the vision, ambitions, and actionable steps, as research (Hart et al., 2019) also shows that clarity and prioritisation are essential to translating circular economy principles into practical results. Once priorities are defined, implementing the circular economy becomes more straightforward and impactful (Hossain et al., 2020). By focusing on achievable tasks first, tangible progress can be demonstrated, motivating all involved. A well-structured action plan that aligns with these priorities enhances understanding and support among

stakeholders, facilitating the transition (Policymaker circular built environment, Municipality of Amsterdam).

How & tools:
National agreements: Decision-makers must be familiar with circular economy concepts (Mahpour, 2019). National agreements on the circular economy should be established (Çetin et al., 2021) and national action plans need to clearly define goals, targets, and visions for advancing towards a circular economy (Mahpour, 2019).

Clear communication: Clearly communicate goals to all relevant stakeholders. Use simple, memorable frameworks like the "4 V's" (Voorkomen, Vervangen, Verlengen, Verwaarden—Prevent, Replace, Extend, Valorise) to make complex concepts more engaging and easier to understand (Policymaker circular built environment, Municipality of Amsterdam).

Quick wins & small steps: Taking small steps is the best approach within a large transition. Focus on short-term, manageable goals to build confidence. Demonstrating success through "quick wins" motivates stakeholders (Hart et al., 2019). Municipalities like Amsterdam, Haarlem, and Oegstgeest, as well as various experts (Sweco, AMS Institute, MPS) are convinced that small steps lead to larger changes.

"It starts with small steps. These steps are necessary to move towards bigger steps" (Director future-proof assets, Municipality of Amsterdam)

Tools:
-   Ambition web and the "Omgevingswijzer": Help set priorities and visualise ambition levels, helping in the identification of focus areas and communicating these priorities to stakeholders.
-   CROW's value monitor: Helps assess the integration of circular economy principles into asset management practices.

B. "Agile" working
What: Municipalities are encouraged to explore whether the agile working method can increase the chances of a successful transition. Agile working is a dynamic approach where temporary, cross-functional teams are formed, made up of intrinsically motivated individuals with relevant skills, experiences, and expertise. These teams set (sub)goals and deliver tangible results through short, iterative cycles known as "sprints" (typically two weeks). Each sprint leads to partial outcomes, and through continuous assessment and adaptation, the final result is achieved.

Why: Agile working fosters an integrated approach, which is key for addressing complex transitions such as the shift to circular asset management. This approach increases motivation through regular short-term results, and can be integrated into a traditional organisational structure. Successful modern companies, like Spotify (a pioneer in this field), have adopted this method to manage large-scale projects in complex environments. In such cases, an integrated approach is more effective than a siloed approach. Agile working is particularly suitable for projects with some uncertainty where rapid response to change is essential.

How & tools:
Form teams: Create temporary teams of (6 to 8) intrinsically motivated individuals with the relevant skills and expertise. Ensure these individuals are empowered to work towards shared goals.

Set clear goals: Define clear goals and desired outcomes. Break these down into short-term, actionable tasks that can be achieved in two-week sprints. Each sprint should aim to deliver concrete results that contribute to the larger project.

Evaluate and adapt: After each sprint, conduct evaluation sessions evaluating what is going well and what could be improved. Review plans and adjust based on new insights.

3. **Providing insight into the impact on the organisation**

What: Develop a clear overview that provides municipalities with advance insight into the potential impact of integrating circular economy practices within their organisation. This overview should outline how circular practices may influence ongoing municipal operations, staffing levels, time allocation, and budget distribution. The goal is to provide municipalities with the information they need to understand how such changes could affect their daily functioning.

Why: Municipalities, particularly smaller ones with limited budgets, often have insufficient staffing for thematic projects. Even normal fluctuations, such as holidays, can significantly impact the organisation's execution capacity. As a result, municipalities often do not dare to take on additional themes because the impact on available resources is unpredictable or unknown. There is a concern that focusing on these themes could disrupt normal citizen services. However, at the same time, there is a strong desire and intention to contribute to valuable themes. Clear insights into the organisational impacts of adopting circular approaches can reduce this hesitation (Policy advisor, Municipality of Oegstgeest), making it easier for municipalities to take action.

How & tools: The overview should be detailed yet accessible, highlighting the effects of circular practices on various aspects, such as organisational structure, budgetary implications, required expertise, project timelines, and potential disruptions on current municipal activities. This can be best communicated through visuals and graphical representations such as flowcharts and infographics. The municipalities of Haarlem and Amsterdam recognise that these forms of communication work effectively.

4. **Defining new roles and appointing an ambassador**

What: Define new roles within the organisation. A key role is appointing an ambassador, also referred to as a booster or catalyst, to drive the transition to circular asset management.
This person focuses on raising awareness, promoting a shift in mindset, and prioritising circular management themes in a department (such as reuse, conscious use of materials, minimisation of the ECI, etc.) to maximise the chances of success. Both the Municipality of Amsterdam and Haarlem stress the importance of this role as a coordinator and facilitator.

In addition to this role, other stakeholders should be engaged and assigned specific responsibilities to move towards a circular economy (Mahpour, 2019). Victar et al. (2023) also highlight the need for other essential positions focused on cost control, measurement, feasibility studies, innovation, and risk management. Support teams with the necessary knowledge and experience can help departments.

Why: The transition to circular asset management is a relatively unknown territory for the involved execution organisation and its environment. The current organisational setup is not yet designed to tackle this complex, integrated issue. Organisations are often operating from traditional mindsets, with existing processes and a conventional organisational setup, which is not optimal for achieving success

in a disruptive transition. Departments often work in silos, with unclear responsibilities and budget allocations, which creates confusion and slows progress. Introducing new roles can reduce this fragmentation, clarify responsibilities, and ensure that circularity becomes a priority. However, since restructuring the entire organisation might not always be feasible, a support team with relevant expertise can help integrate circular asset management into existing structures.

Additionally, clear political direction is often lacking, and action programs are not yet focused on the transition to circular asset management. Appointing an ambassador and establishing support teams can bring the necessary leadership to drive the transition, as strong leadership is crucial in achieving disruptive transformations (Hart et al., 2019).

How/tools:
Appointing the ambassador: Choose someone from within the department who is intrinsically motivated and in a position to move the transition forward. This responsibility should be embedded within the department itself, rather than being delegated to a central circularity team, so that ownership is felt, and progress can be effectively organised by those with a direct understanding of daily practices (Advisor future-proof assets, Municipality of Amsterdam).

Defining responsibilities: Clearly define and communicate the new roles and their impact across the organisation. New positions do not necessarily require adding more staff; existing employees can be reassigned with new responsibilities by reshaping their current roles to integrate circular asset management practices. Key roles include experts in circular asset management and officials responsible for measuring, monitoring, communicating, and managing data and results. Ideally, these individuals would also become budget holders or report to a budget holder responsible for achieving the transition.

Training & support: Providing circular economy training, education, and workshops is critical to building a well-informed organisational ecosystem (Çetin et al., 2021). Therefore training and education should be provided to ensure that all team members understand their new roles and responsibilities. Support teams with the necessary expertise can help departments translate strategic goals into actionable steps and provide ongoing guidance, as advised by the Municipality of Amsterdam and the sustainability advisor of Managing Public Space.

5. Defining, collecting, storing, monitoring, analysing and reporting data

What: Municipalities need to gather empirical evidence through data collection and analysis to demonstrate the tangible impacts of circular initiatives. Therefore, robust systems for collecting, monitoring, and reporting data on circularity initiatives must be established. Defining clear KPIs will help municipalities build an assessment framework, enabling objective tracking of progress and transparent reporting to stakeholders. Data across municipalities and stakeholders should be standardised and unified, making it easily accessible and understandable for all involved. Additionally, municipalities should document learning experiences thoroughly and share them with other municipalities.

"This way, you can eventually demonstrate that what we are doing is actually making an impact, and substantiate and justify the choices being made" (Task-oriented manager, Municipality of Haarlem)

Why: The shift from traditional to circular asset management promises positive effects for the environment and may even prove more cost-effective in the long term. However, a lack of empirical

evidence has led to scepticism, making it challenging to secure support or funding. Providing a solid evidence base is essential (Hart et al., 2019). Data is essential for demonstrating the success of circular initiatives and securing continued support. Without clear, measurable evidence of progress, municipalities may struggle to justify their investments in circular projects. The process of monitoring captures learning experiences, helping to refine approaches and ensure effective implementation. Sharing learning experiences prevents ineffective implementations and costly mistakes across municipalities. Data-driven decision-making enables better strategy evaluation, clearer communication with stakeholders, and the ability to adjust approaches as needed.

How/tools:
Assessment framework: Develop a framework with well-defined indicators and specific thresholds to measure progress. Specifications for reuse and for recycled materials should be included (Hossain et al., 2020; Shooshtarian et al., 2020).

Measurement: Start with a baseline measurement as early as possible to establish a reference point for future progress. This is crucial to demonstrate impact from the outset and build trust.

Monitoring: Continuous monitoring helps identify what works and what doesn't. Data from this process can provide valuable feedback to adapt strategies.

Managing data & sharing: As the transition project progresses, more and more data will become available.Municipalities must ensure that this data is systematically analysed and shared. Reports should be well-substantiated, informing different target groups objectively. This data must be managed systematically to avoid fragmentation and inaccessibility. It is crucial to appoint responsible persons to shape the management.

Collaboration: Municipalities should work together to standardise data collection and reporting practices. Standardising practices across municipalities will ensure consistency and comparability in data collection and reporting. Learning experiences should be documented thoroughly and shared, as incorrect implementations can be costly. Centralised databases should be established to track, store, and report data. A unified platform where data and knowledge can be easily accessed and understood by everyone should be developed. These systems should include robust platforms accessible to all stakeholders, simplifying the translation of technical data into actionable insights. Communicating the existence and use of these databases is essential.

"There should be some platform where everyone knows that knowledge can be found here" (Senior program manager public space, Managing Public Space)

Organisational change: Moving towards a data-centric strategy will significantly impact working practices across civil services, requiring substantial organisational changes. Developing this data landscape requires not only methodological and technical efforts but also organisational adjustments within municipalities. Roles and responsibilities must be clearly defined and budgets allocated to support this data-centric strategy. Appointing data managers or administrators to oversee the implementation is critical for maintaining structure and preventing data fragmentation.

6. **Revising cooperation agreements with suppliers**
What: Municipalities should revise their cooperation agreements with market partners to facilitate the integration of circular practices. These agreements must include clear sustainability objectives and

specific circular economy requirements. Suppliers will have a contractual obligation to meet these objectives, with the flexibility to innovate and adjust their processes over time. By embedding circularity into long-term contracts, municipalities foster partnerships where suppliers can transition gradually to more sustainable operations, minimising friction and resistance. Early consultations between municipalities and suppliers are essential for aligning expectations and ensuring both parties are prepared for the transition.

Why: Transitioning to circular practices often requires significant changes across the supply chain, which can cause disruptions if suppliers are not adequately prepared. Without early collaboration and clear contractual agreements, suppliers may face challenges in meeting circular requirements, potentially delaying the transition. Revising these agreements to include circular goals gives suppliers the necessary time and support to adjust their business models, aligning them with the municipality's sustainability demands. Research by Hart et al. (2019) shows that long-term partnerships promote better collaboration towards shared goals, reducing adversarial interactions. By establishing shared responsibility for circular objectives, municipalities and suppliers work together to integrate circular activities into their operations (Shooshtarian et al., 2020). This collaborative approach not only facilitates a smoother transition but also promotes sustainability throughout the supply chain.

How & tools:
Early consultations: For existing contracts, municipalities should engage in discussions with suppliers as early as possible to minimise disruptions. The aim is to jointly define and contractually establish new sustainable cooperation agreements.

Cooperation agreements: When entering new contracts, municipalities can use Amsterdam's example of cooperation agreements ("SOK") with selected market parties. These agreements prioritise suppliers based on the sustainability plans they submit. By embedding these cooperation agreements within the organisations and consistently working with a set group of partners, sustainability goals are standardised in all projects. This reduces the need for new agreements for each project, streamlining processes and saving time.

Financial incentives: Municipalities can incorporate financial incentives within these contracts to encourage suppliers to meet or exceed circular goals (see intervention 7).

7. Circular award criteria and financial incentives
What: One of the most effective ways to guide suppliers towards circular practices is by establishing sustainable and circular award criteria. Municipalities can integrate these criteria into their procurement processes by including specific requirements in tenders that evaluate suppliers on more than just cost. These criteria determine whether a supplier qualifies for contracts, considering factors such as environmental impact, life cycle analysis (LCA), material usage (with emphasis on how materials and resources can be reused at the end of their lifecycle), and cost-benefit analysis. These requirements help assess the sustainability of a project to select the most suitable option. By setting such criteria, municipalities encourage suppliers to adopt circular practices, ensuring that materials and resources are designed for reuse at the end of their lifecycle.

To further encourage this shift, municipalities should provide incentives for suppliers that meet or exceed these criteria. This could include rewards such as subsidies, tax breaks, or bonuses for achieving specific circular targets. Research shows that financial incentives (Abdulai et al., 2024;

Hossain et al., 2020) and policies like carbon taxes or landfill restrictions (Guerra and Leite, 2021) can motivate suppliers to invest in sustainable innovations.

Why: Shifting procurement criteria towards circular goals signals to the market that sustainable and circular solutions are a priority. Research indicates that "encouragement actions" are significantly effective in transitions (Shooshtarian et al., 2020). By incorporating circular criteria in procurement, municipalities encourage suppliers to innovate and adopt circular practices. Combining circular procurement standards with financial rewards creates a compelling business case for suppliers, offering clear financial benefits and competitive advantages for meeting these criteria. This not only encourages innovation but also fosters a market where sustainable practices become the norm.

How & tools:
Assessment framework & minimum requirements: Developing a clear assessment framework is important to objectively measure, report, and evaluate supplier performance, both internally and between the municipality and the supplier. As award criteria accumulate, it is necessary to set a minimum level that suppliers must meet to be considered for contracts. While circular standards are critical, price and other factors will also influence the overall evaluation.

Collaboration among municipalities: Collaboration between municipalities to create a unified assessment framework is very useful and even necessary. Standardised assessment methods will allow for better comparison of supplier performance across municipalities, improve communication, and promote transparency.

Incentives: To maximise sustainable returns, the Municipality of Amsterdam recommends increasing the reward for suppliers the more requirements above the minimum level are realised. For instance, suppliers with lower ECI-scores could be ranked higher in tenders, so they are not assessed purely based on financial criteria (Policymaker circular built environment, Municipality of Amsterdam). Additional financial incentives such as tax breaks or subsidies for using secondary materials (Çetin et al., 2021; Hossain et al., 2020) can encourage suppliers to exceed basic requirements.

Communicating benefits: It is recommended to continuously motivate suppliers by showing them the benefits of circular practices through examples from other projects. Highlighting the positive environmental and financial impact of successful circular initiatives can inspire further engagement and commitment.

Tools:
- Environmental Cost Indicator (ECI) and the Economically Most Advantageous Tender (EMVI) model: Parameters that provide useful guidelines for assessment.

"We are now experimenting with setting threshold values, such as an ECI ceiling, that bidders must not exceed." (Policymaker circular built environment, Municipality of Amsterdam)

- Leidse Ladder: Assesses minimum requirements, focusing on questions about demolition, reuse of objects, material use, and circular design. Suppliers must meet a minimum score to proceed with their tender.
- CO2 Performance Ladder: Ranks suppliers based on their efforts to reduce their carbon footprint. A similar tool could be developed to assess circularity initiatives, rewarding suppliers who apply circular strategies.

- Dashboard Monitoring (CROW): Designed to track progress towards sustainability goals. This dashboard provides insight into performance metrics such as ECI, circularity, and lifespan. It offers a uniform monitoring method, allowing for easy comparison across municipalities and showcasing the most effective circular practices.

8. Involving circularity and asset management from the project initiation phase

What: The municipalities of Amsterdam and Haarlem recommend integrating circular principles and asset management early in the project lifecycle. Asset managers should assess whether existing public assets can be repaired or reused, rather than replaced entirely. By involving asset managers from the project initiation phase, options for extending the life cycle of assets can be explored, promoting more circular outcomes.

Why: Circularity is often introduced too late in the project process, leading to missed opportunities for material reuse and for circular asset management. Early integration allows municipalities to explore ways to extend asset life cycles, resulting in more sustainable and resource-efficient projects. By embedding circular principles from the start, municipalities can make better material decisions, avoid unnecessary replacements, and improve the long-term sustainability of public spaces (Consortium manager future-proof living environment, AMS Institute). Engaging asset managers early ensures circular principles guide the project from planning to execution.

"Can we postpone replacement? Can we avoid replacement? The functional life of objects is often longer than planned, so assets can remain in use longer than initially anticipated. At least asking that question is important at the start" (Consortium manager future-proof living environment, AMS Institute)

How & tools:

Collaboration and stakeholder engagement: A collaborative approach is essential, as circular asset management adds complexity (e.g., not all materials fit into an effective management process). Planning becomes more intricate, and material choices more important. Successful implementation relies on collaboration and effective communication among all stakeholders (designers, suppliers, asset managers, policymakers etc.) (Shooshtarian et al., 2020). Regular dialogues are necessary to ensure that all viewpoints, conditions, interests, and motivations are considered, leading to clear responsibilities and better decision-making throughout the project (Mahpour, 2019; Advisor future-proof assets, Municipality of Amsterdam). Additionally, commitment from top management is crucial to driving the project forward, as their support significantly influences the project's direction (Director future-proof assets, Municipality of Amsterdam; Çetin et al., 2021).

Material reuse and circular considerations from the start: Material reuse should be prioritised from the outset. By considering durability and the potential for repurposing elements early, project teams can make informed decisions that align with circular principles (Hartwell et al., 2021; Hossain et al., 2020). The Municipality of Amsterdam recommends incorporating material reuse practices into public space design guidelines, such as the "Handboek Inrichting Openbare Ruimte".

Early asset management considerations: It is essential to ensure that managers can manage and maintain the asset effectively. The "management acceptance process" (2019) used by the Municipality of Amsterdam ensures that projects are transferred from the development phase to the asset management organisation in a controlled manner. This process includes multiple touchpoints where asset managers can provide input, ensuring the final design meets their requirements. Project

execution only begins once all stakeholders, including asset managers, have approved the final design. This guarantees that projects are manageable and sustainable once handed over.

Continuous evaluation: Continuous evaluation of the project (before, during, and after) with the entire team is necessary, more so than in traditional asset management. This involves ongoing discussions with stakeholders to align interests and motivations, allowing flexibility and adaptability to challenges during the project (Advisor future-proof assets, Municipality of Amsterdam). Post-tender meetings to review and operationalize targets are also recommended (Shooshtarian et al., 2020).

Tools:
- Quickscan Circular: A tool for identifying opportunities for reuse and sustainable material choices.
- Digital Material Hub, Materials Quickscan and "Inspectierapport & Straatwerkplan" (Municipality of Amsterdam): Digital tools used at the start of a project to map available materials for reuse. "Materials released from other projects should be considered early on in the design" (Process manager for sustainability, Municipality of Haarlem).
- "Materials tool" (Municipality of Amsterdam): A tool in development to help designers assess the environmental impact of material choices, promoting informed decisions in the circular design process (Policymaker circular built environment, Municipality of Amsterdam).

The use of such tools is recommended to facilitate circular design and support both asset managers and designers in making and justifying material choices.

9. A manual for the asset manager

What: Municipalities should provide detailed manuals, step-by-step protocols, and training programs to guide asset managers in integrating circular principles into their daily operations. These manuals should cover everything from selecting sustainable materials to managing public assets in a way that maximises their lifecycle and minimises environmental impact. With the right knowledge and tools, asset managers can smoothly transition from traditional to circular asset management.

Why: Many asset managers have extensive experience with traditional asset management methods. Transitioning to circular practices requires new skills and knowledge, making structured guidance essential. Without proper support, implementing circular principles can be challenging. Detailed manuals and training programs offer the necessary step-by-step instructions for asset managers to adapt while maintaining the high standards of asset management municipalities rely on. Additionally, this approach ensures consistent practices across different municipal projects.

How & tools:
Guides: Municipalities should provide practical, easy-to-follow guides that outline strategies for implementing circular asset management. These should include step-by-step plans, checklists, or protocols for integrating circular practices. Instructions may include the requirements, process organisation, and do's and don'ts for successful implementation (Consortium manager future-proof living environment, AMS Institute). These documents could also be co-developed by external experts.

Training programs: Municipalities can organise courses on circularity, as suggested by the Municipality of Oegstgeest. These programs should build asset managers' expertise in circular operations, combining theory with hands-on workshops that explain the manuals and offer practical experience.

Continuous guidance: Ongoing support is crucial, especially during the early stages of implementation. Continuous guidance ensures asset managers become comfortable using the manuals and applying circular principles effectively as they adjust to new responsibilities.

Good practices and knowledge sharing: The Municipality of Amsterdam and other experts (Managing Public Space, AMS institute) emphasise the importance of (creating) a portfolio of solutions and inspiring projects with detailed descriptions of working methods. This portfolio should be included in the manual, shared widely, and updated regularly with contributions from other municipalities. This encourages collaboration and knowledge exchange, enabling asset managers to learn from each other's experiences and avoid common pitfalls.

Tools:
- Materials trade-off matrix (Municipality of Haarlem): A decision-making tool to help select the most sustainable materials for each project, balancing performance and environmental impact.
- Overview of sustainable material options: Asset managers may need guidance on unfamiliar materials used in circular asset management. An overview of sustainable material options, along with their application methods, can support informed decision-making.
- Materials factsheet: A factsheet currently being developed by the Municipality of Amsterdam that provides information on materials with a high environmental impact, such as concrete, wood, plastic, composite, and steel, and suggests sustainable alternatives for use in projects.

10. "Bridging the gap"

What: Fostering stronger collaboration and communication between policymakers and asset managers, to better understand each other and align long-term circular goals with practical implementation. This collaboration ensures that circular policies are not only ambitious but also feasible (considering the practical challenges of implementing these policies faced by asset managers). Structured dialogues, regular meetings, and joint planning sessions can help foster this alignment. Emphasis should be placed on identifying challenges, sharing knowledge, and developing innovative, practical solutions. Encouraging policymakers to experience the daily operations of asset managers will further promote an integrated approach to circularity.

"There is really a great need for those parties to talk to each other about their work" (Senior program manager public space, Managing Public Space)

Why: Policymakers and asset managers often have differing perspectives due to their roles. While policymakers tend to focus on long-term goals and political directives, asset managers deal with the practical challenges of implementing these policies. Misalignment can lead to tensions, misunderstandings, inefficiencies, and delays in transitioning to circular asset management. Bridging this gap is essential for smoother transitions, better mutual understanding, and creating policies that are both ambitious and realistic.

How & tools:
Structured dialogues: Managing Public Space proposes activities such as regular structured meetings and "masterclasses" where asset managers, policymakers, and scientists collaborate to openly discuss challenges, share insights, and develop solutions. These sessions foster mutual understanding and promote dialogue across different perspectives (Task-oriented asset manager, Municipality of

Haarlem). Addressing critical questions like "What are the frustrations between these groups?" helps uncover underlying issues and promotes empathy and cooperation (Senior program manager public space, Managing Public Space).

Work alongside asset managers: Policymakers should spend time in the field with asset managers, gaining firsthand experience of the operational challenges in circular asset management (recommendation from the Municipality of Amsterdam). This practice allows policymakers to better understand practical limitations and possibilities, enriching their theoretical understandings with practical insights, enabling them to develop more realistic policies that align with on-the-ground realities (Director of future-proof Assets, Municipality of Amsterdam). Furthermore, these interactions create natural opportunities for knowledge transfer and communication, where new insights can be shared and tested.

"You encounter different things when you actually experience it." (Director of future-proof assets, Municipality of Amsterdam)

Early involvement of asset managers: Asset managers should be engaged early in the policy development process. Their input ensures that policies are practical, realistic, and aligned with operational capabilities. Early involvement helps to secure greater support from asset managers, leading to more successful implementation.

Education: Developing educational programs aligned with circular asset management practices is crucial. These should include training for current asset managers on resource-efficient methods, as well as programs to equip new generation asset managers with future-focused circular asset management skills. While asset managers are often viewed as conservative, they have a wealth of experience. Targeted training helps overcome conservatism, while preserving their valuable expertise (Shooshtarian et al., 2020). Encouraging collaboration between younger and more experienced asset managers can facilitate knowledge sharing and a cultural shift towards circularity.

11. **Communicating and celebrating successes**

What: Municipalities should actively highlight and share the successes of their circular initiatives, both internally (within the municipality) and externally (with the public and other stakeholders). By showcasing positive outcomes clearly, they can build trust, inspire stakeholders, and sustain momentum for future efforts. KPIs related to circularity should be measured and communicated regularly through reports, dashboards, and public platforms. Celebrating both large and small achievements is essential, with an emphasis on how these efforts contribute to broader sustainability goals, supported by concrete data. Frequent communication of milestones and achievements keeps stakeholders engaged and demonstrates that circular initiatives are making a tangible impact.

Why: Clear and consistent communication of successes is crucial for gaining widespread support for circular transitions. It builds trust, fosters transparency, and increases stakeholder motivation. Effective communication ensures that stakeholders are informed of the tangible benefits of circular initiatives and reinforces the value of investing in these transitions. Sharing measurable, verifiable results is essential to demonstrate the effective use of public resources and ensure continued support.

"Everything needs explanation. The civil servant is responsible for public money, so it is important to show that the money being spent actually contributes to the goals" (Task-oriented asset manager, Municipality of Haarlem)

How & tools:
Sharing results: Transparent and positive communication is key to building trust and maintaining engagement. Regular updates through newsletters, dashboards, and social media keep both the public and internal teams informed of progress. The Municipality of Haarlem highlights the importance of linking efforts and results directly to specific objectives. Sharing interim results or milestones more frequently allows for easier and more consistent communication of successes, rather than waiting for a final outcome. Regardless of the audience, it is important to communicate in positive terms, even when facing setbacks (Task-oriented asset manager, Municipality of Haarlem).

Measurement tools: It is recommended to develop or use tools that provide objective measurement of results over time and compare them to established objectives. It is important to start sharing results early, even if measurement tools are still being refined.
The municipalities of Haarlem and Amsterdam stress the importance of using verifiable data. All information shared should be credible and comparable to maintain trust.

Targeted communication: Communication should be tailored to different audiences, as internal teams, the public, and policymakers require varying levels of detail and messaging. Target group-specific communication is most effective. Tools should be designed to make information accessible to each group, with direct stakeholders needing more detailed information than the general public.

Celebrating success: Celebrating both small and large successes helps maintain momentum and strengthens commitment to long-term sustainability goals. For example, small wins can be acknowledged through internal newsletters, while significant achievements can be shared with the public through press releases or social media updates.Highlighting tangible benefits, such as cost savings, environmental impact reductions, or increased resource efficiency, keeps progress visible and enthusiasm high, especially in the early stages when external recognition may be limited.

Tools:
- Visuals: Infographics, graphs, and other visual tools make data easier to understand for all stakeholders, helping them grasp the tangible impact of circular initiatives. Comparing key metrics visually is particularly effective for showing progress.
- KPIs and assessment frameworks: Measurable indicators to enable tracking progress towards circularity goals.
- Dashboards and report: Tools for regularly sharing progress, ensuring the impact of circular initiatives is clear to all stakeholders.

12. Developing a multi-year plan
What: Creating detailed multi-year plans for circular asset management. These plans establish long-term sustainability and circularity goals, providing a clear roadmap to achieve these objectives over time. A multi-year plan coordinates various projects to align with circular goals, ensures efficient use of resources, and avoids ad-hoc interventions (Hossain et al., 2020). This allows for combining necessary interventions so that, for example, the underground only needs to be opened once instead of multiple times. From this overarching plan, specific action steps are developed for each neighbourhood, ensuring all activities are coordinated. Early communication of these plans to residents helps manage expectations and reduces frustration by providing a clear timeline of expected disruptions.

Why: Managing public spaces is a complex task influenced by factors such as space constraints, existing infrastructure (both above and underground), resident concerns, accessibility, and environmental impacts like noise and pollution. Introducing circular principles into asset management adds further complexity, as traditional timelines for asset renewal (based on fixed depreciation schedules) shift towards more flexible approaches focused on minimising or preventing interventions. Without coordinated planning, there's a risk of disjointed interventions, inefficient use of resources, resident dissatisfaction due to frequent disruptions, and higher costs. A well-structured multi-year plan helps coordinate various projects, reducing costs, streamlining resources, minimising interventions, and ensuring alignment with circular goals. Additionally, it allows municipalities to clearly communicate with residents in advance, reducing frustrations.

How & tools:
Integrated approach: Combine as many projects as possible to minimise disruptions, optimise budgets, and ensure cost efficiency. Integrating efforts and resources across different departments helps achieve this goal (Task-oriented manager, Municipality of Haarlem).

Consultation: Regular consultations with stakeholders are essential. Engaging stakeholders early and consistently helps prevent misalignment and ensures circular objectives are integrated into all projects. Involving these parties early in the planning process allows for alignment of needs and goals, reducing conflicts during execution. Feedback loops should be incorporated, with updates to the multi-year plan based on circular KPIs and stakeholder input.

Plans should be communicated well in advance to residents, suppliers, project teams, and other stakeholders to reduce frustration and ensure smooth execution.

Tools:
- Digital material hub (Municipality of Amsterdam): A digital tool to track and manage reusable materials across projects, coordinating material availability with project timelines to maximise reuse opportunities.
- Physical material hub (Municipality of Haarlem): A physical space to store materials for reuse in future projects. This facilitates the circular use of materials across multiple projects.

13. A. Collaboration between municipalities
What: Form structured partnerships between municipalities to foster collaboration in circular asset management. These collaborations would facilitate the sharing of knowledge, pooling of resources, development of common frameworks, standardisation of tools, and alignment of efforts to address common challenges.

Why: Circular asset management is still a relatively new field, lacking fixed definitions, standardised tools, and clear assessment criteria. It is noted that the exchange of knowledge and experiences between municipalities remains limited, resulting in each municipality often reinventing the wheel on its own. This results in a wide variation in definitions, standards, and instruments, complicating dialogue and comparability and wastes unnecessary resources. Working in isolation can lead to inefficiency, duplicated efforts, and slow progress. Collaboration can significantly accelerate the shift towards a circular economy (Abdulai et al., 2024). Municipalities often benefit from cooperation, a point underlined by many municipalities themselves. It is essential for municipalities to collaborate as they face similar challenges when implementing circular principles. Working together fosters shared learning, co-development of standards and tools, and motivates municipalities to reach their circular

goals more quickly (Policy advisor circular economy, Municipality of Haarlem). This collaborative approach encourages innovation, accelerates progress, and ensures that successful practices are shared and widely adopted.

How & tools:
Consultation sessions: Organise consultation sessions where municipalities work together to develop a unified conceptual framework and approach to circularity. These sessions can focus on key themes and work towards shared definitions and interpretations, potentially creating a general assessment framework with predefined indicators and thresholds.

"A clear goal provides focus and direction. It connects to achieve the desired result" (Sustainability advisor, Managing Public Space)

Best practice sharing: Plan regular meetings for municipalities to exchange updates, best practices, and experiences (Director future-proof assets, Municipality of Amsterdam).
Best practice examples are seen as important enablers (Çetin et al., 2021) and sharing successful strategies encourages continuous learning and motivates municipalities to achieve their circular objectives, fostering innovation and wider adoption of these practices.

Central information point: Create a central information point where all relevant knowledge is easily accessible (Hossain et al., 2020). This will save time and resources currently wasted on searching for information.

Organisations: Provinces, the national government, or organisations such as the Association of Dutch Municipalities (VNG) could play a facilitating role in organising collaborations.

Tools:
- Standardised materials passport : A document providing detailed information about the materials used in an asset, including composition, origin, and lifecycle characteristics. This would facilitate material reuse across municipalities (Abdulai et al., 2024).
- Digital marketplaces for secondary material: A platform where municipalities and stakeholders can trade secondary materials and components, promoting material reuse (Çetin et al., 2021).
- CircuLaw60: A forum for municipalities to share legal best practices and guidelines. These forums help local governments learn from each other's experiences and adopt legal frameworks that support circular asset management (Municipality of Amsterdam).

B. Lobbying for political support
What: Municipalities need to lobby together for stronger political support to facilitate the transition to circular asset management. A unified approach to lobbying can help municipalities advocate for clearer policies, increased funding, and stronger incentives for circular transitions (Mahpour, 2019). Municipalities can increase pressure on political leaders to provide more guidance and the necessary resources to support these initiatives.

Why: Circular transitions require clear policies, sufficient funding, and strong political backing to succeed. It is primarily the responsibility of the politicians to make this direction clear and provide the necessary resources. So far, this has been insufficient, while they are the ones given municipalities the task of implementing the transition. Municipalities could gain significant advantages by collaborating

more closely in lobbying efforts towards politicians, provincial authorities, and the national government (Çetin et al., 2021).

How & tools: By presenting a strong, united voice, municipalities can help increase the urgency for removing these barriers and securing the necessary support.

Note: A letter from the House of Representatives (2e Kamer) to the Amsterdam municipality calling for progress on circularity has acted as a strong catalyst, illustrating the significant influence politics can have on the process.

"In a transition, you need urgency, and without urgency, people are not going to change" (Advisor future-proof assets, Municipality of Amsterdam)

4.6 Decision-Support Tool for a Circular Way of Working

To enable practical application of the proposed interventions, a decision-support tool has been developed. This tool aims to support municipalities in decision-making by helping to prioritise interventions for advancing circular asset management. This is achieved by first analysing the current situation and identifying existing barriers. Based on this analysis, interventions can be selected that are specifically tailored to the context of the respective municipality. These interventions can then be implemented, with the support of external experts or consultants if needed, to address or mitigate barriers to circular asset management.

Tool benefits:
Barrier identification: Maps and visualises barriers, showing the extent of each one to determine which ones require prioritisation.
Intervention selection: Assists in selecting targeted interventions for specific barriers.
Integrated approach: Highlights barriers that could be addressed simultaneously, promoting an integrated approach.
Targeted support: Municipalities can leverage the tool's insights to request more specific support from political entities, external experts, or consultants.
Growing knowledge base: By sharing experiences, challenges, and effective strategies, through this tool, users contribute to an expanding knowledge base accessible to all.

For who: This tool is primarily intended for municipalities (policymakers, asset managers, project leaders, advisors, etc.) and external consultants.

When: The decision-support tool is especially valuable in the orientation phase, as it helps anticipate potential barriers and proactively address them.

How to use the tool:
The tool is organised in an Excel file with four tabs. A step-by-step guide is provided in the first tab (also detailed in *Appendix L)*. The second tab contains a questionnaire (also provided in *Appendix M),* the third tab displays questionnaire results, and the final tab links the 33 barriers (section 4.4) to the 13 interventions (section 4.5) in an overview, as shown in *figure 17*.

The tool works as follows: Users complete a questionnaire in Excel that contains 70 "statements". They are asked to evaluate these statements on a Likert scale (strongly disagree – strongly agree).

After completion, the user is directed to the next tab, where a "radar pie chart" of the results is automatically generated (see example in *figure 18*). This chart visually maps the municipality's relevant barriers and indicates their intensity. Large red-coloured sections highlight the most significant barriers, while smaller green sections indicate weaker barriers. This visualisation clarifies which barriers require prioritisation. Users then move to the last tab, which directly links barriers to interventions. In this tab, an overview is presented. Suitable interventions can be quickly identified by searching on high-priority barriers shown in the radar pie chart. Since barriers are interconnected, some interventions may apply to multiple barriers. The overview also shows how different barriers can be addressed simultaneously for an integrated approach. An example demonstrating the tool's application is provided in *Appendix O*.
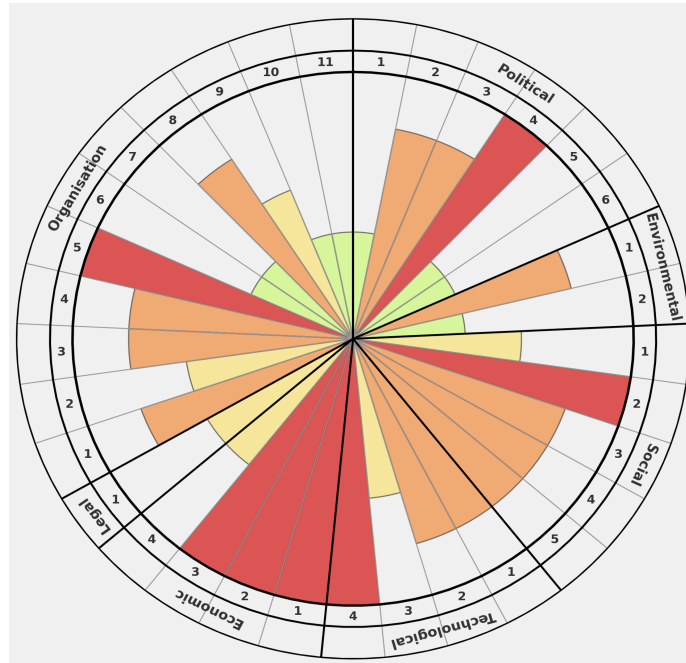
Figure 18: An example of a radar pie chart from the decision-support tool (own figure)

Next steps:

As a "living document," this tool is designed to evolve continuously, adapting to new insights and experiences gathered from municipalities over time. These updates may include newly identified barriers, best practices, feedback from practical applications, and lessons learned. With each update, incorporating fresh data and reflecting the latest findings, the tool becomes progressively accurate and relevant to municipalities' needs. Keeping it up-to-date is therefore essential, with municipalities responsible for this maintenance (new role definition). This iterative process not only optimises the tool but also strengthens connections and collaboration among municipalities, enabling them to address shared challenges.

Category	#	Barrier	1	2	3	4	5	6	7	8	9	10	11	12	13
O(rganisational)	11	The transition to circularity must be integrated into other public space management to ensure efficiency												X	
	10	The impact of the transition on the (execution) organisation is unknown			X										
	9	Fragmentation of responsibilities hampers the decision-making process	X			X			X						
	8	Unclear (physical) layout and role assignment complicate integrated working				X									
	7	Insufficient (central) retention of knowledge and experience					X								X
	6	Communication lines are poorly set up					X						X		X
	5	Inadequate communication of objectives and results		X		X		X					X		
	4	Strategic and tactical goals are not translated into concrete actions				X					X	X		X	
	3	The organisation is compartmentalised, hindering communication between departments		X						X		X		X	
	2	Lack of role definitions, experts and "new generation" employees			X									X	
	1	Current systems are linearly set up and/or not aligned with sustainability and circularity						X	X	X					
L(egal)	1	Existing contracts limit freedom of action													
E(conomical)	4	The (power) position of the executing (market) parties	X					X	X						
	3	Insufficient clarity on budget responsibility			X	X									
	2	The transition can be cost-prohibitive and may lead to the decision not to opt for circular solutions						X						X	
	1	Lack of resources such as money, time and expertise													X
T(echnological)	4	Technical knowledge gaps regarding the application of reuse					X				X				X
	3	Integrating circular processes into current public spaces (including supply chains and infrastructure) is complex								X					
	2	The lack of effective data management hinders the ability to measure and report results accurately					X								
	1	The municipality and, in particular, the asset manager is tasked with a job for which they lack the necessary knowledge and experience to execute properly and efficiently					X				X				X
S(ocial)	5	Fear of making major changes or decisions due to potential negative reactions	X												X
	4	Unfamiliarity of the topic has a negative impact on readiness for change					X				X	X	X		X
	3	Initiatives are not sufficiently followed (up)					X								
	2	Insufficient motivation and/or willingness among participants		X			X	X					X		
	1	Lack of understanding of each other's interests within the organisation due to inadequate communication								X		X			
E(nvironmental)	2	Residents and users of the public space may resist the circular transition because they do not understand the basis on which distinctions are made when considering new and reuse												X	
	1	The existing public space is already developed and has vested interests, limiting or complicating opportunities for intervention or redesign								X		X		X	
P(olitical)	6	Lack of collaboration (among municipalities)						X			X				X
	5	The governance model is based on a four-year cycle, which usually does not align with the time needed to achieve demonstrable results													
	4	Lack of a framework to assess the results of transition efforts in the field of circularity					X								X
	3	Action programmes do not specifically focus on circular management of the public space	X							X					
	2	Lack of clear prioritisation	X	X				X							
	1	Lack of a clear and unified vision or definition of circularity		X											X

Intervention

1. Working with a different mindset: circularity as standard
2. A. Clarity, priorities and "low-hanging fruit"
   B. "Agile" working
3. Providing insight into the impact on the organization
4. Defining new roles and appointing an ambassador
5. Defining, collecting, storing, monitoring, analysing and reporting data
6. "Circular" as award criteria
7. Revising cooperation agreements with suppliers
8. Involving circularity and asset management in the initiation phase of a proje
9. A manual for the asset manager
10. "Bridging the gap"
11. Objectifying, communicating, and celebrating successes
12. Developing a multi-year plan
13. A. Collaboration between municipalities
    B. Lobbying for political support

5

FINDINGS

5. Findings

Based on the results provided in the previous chapter, several interpretations have been drawn. These include interpretations regarding the potential as well as the complexity of circular asset management, the importance of an integrated approach and the benefits of collaboration and insights in differences between municipalities. This chapter elaborates on these findings.

5.1 The Potential of Public Space for the Circular Economy

Public space offers significant opportunities for circular asset management. Firstly, municipalities are generally responsible for managing public space and therefore, have direct influence. They are the ones responsible for implementing policies and practices that support circular asset management, such as establishing guidelines for material reuse or incorporating circular criteria into procurement processes. Secondly, public space covers a large part of urban infrastructure and since existing urban areas are much larger than those yet to be developed, circular asset management can make a substantial contribution to circular economy goals. Thirdly, an advantage of applying circular measures in public space is the relatively low risk. Unlike area development and large-scale redevelopment projects, which often involve higher risks and require complex decision-making, asset management offers a more manageable and less risky environment for testing and adopting circular practices. Public spaces also provide an opportunity to achieve small-scale successes that can demonstrate the benefits to stakeholders and users. Additionally, since public space maintenance is an ongoing process, there are continuous opportunities to implement and refine circular methods. Furthermore, in the long term, circular asset management can lead to cost savings, for example, through the reuse of materials and extending the lifespan of existing materials. Lastly, successful circular practices can often be easily replicated across municipalities, facilitating the scaling or adaptation of initiatives and potentially leading to broader impact at regional and national levels.

5.2 The Complexity of Asset Management

Despite the significant potential that public spaces hold for implementing circular practices, managing them remains challenging due to continual changes and the predominantly technical approach applied. Typically, assets are replaced as soon as they no longer meet requirements or have reached the end of their defined lifespan. Often, asset management is approached on a per-asset basis without considering their interrelationships. This complicates the coordination of different maintenance rhythms within a city, such as sewage systems with a maintenance cycle of 50-60 years, daily maintenance work, or street lighting with a cycle of about 10 years, as well as other above-ground and underground activities. Moreover, emerging themes like mobility changes, demographic shifts, biodiversity, circularity, climate adaptation, and developments in data and ICT are playing an increasingly important role in asset management. Each of these transitions is significant and cannot be ignored. At the same time, social issues such as economic aspects and the perception of space must also be taken into account. The complexity of managing public spaces lies in the need to address multiple aspects simultaneously; coherence is essential. It can be concluded that the complexity of asset management is further increased by the need for flexibility due to constant changes, which conflicts with the robust and fixed systems in use. Moreover, all of this must be managed within an existing public space with diverse interests.

5.3 Integrated Approach

The transition towards a circular economy deeply affects the existing system and cannot be approached in isolation. Therefore, transitioning to circular asset management is a multifaceted challenge that cannot be tackled with a single approach. The various barriers that slow down the transition cannot be viewed separately; rather, they are interconnected.. This means that addressing one barrier often affects other barriers and that an isolated approach will ultimately not be sufficient to achieve the desired change. A successful transition requires an integrated approach, often involving multi-year planning and close collaboration with all stakeholders (e.g., suppliers must be given time to prepare for new requirements). This means that all stakeholders—from policymakers to implementers, from residents to external market parties, and municipalities—must work together on a shared vision, clear communication, and effective collaboration.

5.4 Scale Differences

The size of a municipality significantly impacts the complexity and feasibility of transitioning to circular asset management. While both large and small municipalities ultimately face the same objectives, their effectiveness is highly influenced by scale-related factors. Larger municipalities often have a larger and more specialised civil service. This offers clear advantages in developing and implementing policies related to circular asset management. A larger workforce offers more knowledge and experience, and the financial resources of large municipalities enable them to develop and implement more comprehensive programs. However, this strength also comes with significant challenges. In large municipalities, there is often a more complex organisational structure. Responsibilities are more fragmented, and coordination between different departments is more difficult. This can lead to confusion about who is responsible for what tasks. As a result, it can be harder to maintain personal contacts and collaborate effectively, slowing down decision-making and implementation.

Smaller municipalities, on the other hand, can benefit from simpler coordination and faster decision-making but face more resource limitations. The limited number of stakeholders and the smaller organisation make it easier to make quick decisions and take concrete steps. There are fewer layers of decision-making, which benefits flexibility and speed. However, these advantages also come with limitations. Smaller municipalities often have fewer financial resources and (therefore) less access to specialised knowledge, making it more challenging to develop and implement strategic plans.

5.5 Pioneer Function

Pioneering municipalities can inspire and influence other municipalities and organisations to also take steps towards circular asset management. They act as role models, supporting a broader transition and preventing other municipalities from "reinventing the wheel", thereby allowing them to learn from good practices. Being a pioneer offers opportunities but also involves risks and challenges. One advantage is that exploring new possibilities fosters high commitment and a steep learning curve among involved civil servants. Additionally, pioneering municipalities can establish standards that fit their specific context, which others can later adopt. Innovative municipalities are also often eligible for grants, funds, and collaborations, which can ease financial burdens and provide access to additional expertise. Finally, pioneering municipalities often gain a positive image and reputation.

However, pioneering also has drawbacks. It requires significant resource commitment since "the wheel has to be (partially) invented". Developing and implementing new circular methods and techniques can be expensive initially, requiring investments in research, development, and new systems. Given the lack of existing examples, there is more uncertainty about what will work. This can lead to experiments that are not always successful, which may feel like a waste of time and resources. Pioneers also have fewer opportunities to learn from others, as they are often ahead in many areas. As leaders, they lack established best practices or examples in this transition, which means limited guidance in policy-making, operational execution, and monitoring. Internal resistance to change can also present an obstacle; employees may need to be convinced of the necessity and benefits of circular asset management, requiring additional effort.

Pioneer municipalities, however, can learn a lot from similar transitions, such as the energy transition, the protein transition and the COVID-19 pandemic. Although these transitions differ in content, they often go through similar phases—from a sense of desperation to a "new normal"—and bring comparable challenges and learning experiences. By analysing these phases, pioneering municipalities can gain valuable insights to support them in transitioning to circular asset management. This includes best practices for raising awareness and urgency, experimenting and innovating, and scaling up initiatives. Municipalities can, for example, learn how to expand successful pilot projects to broader applications, collaborate effectively with other municipalities, businesses, and knowledge institutions, standardise processes, create a supportive policy framework, and embed new practices in policy and culture.

5.6 Collaboration

Collaboration within regions, between municipalities, and with other organisations can positively impact circular asset management. However, this cooperation also adds extra complexity due to its larger scale.

By collaborating, municipalities can work more uniformly towards a circular economy, aligning policy objectives and regulations to national and even international ambitions. Collaboration also offers opportunities to share and combine knowledge, by transferring best practices, experiences and lessons learned, allowing municipalities to learn from each other. Additionally, (in the long term) municipalities and organisations could pool their resources, such as financial resources and human capacity, which enables them to take on larger projects that might otherwise be unfeasible.

To effectively implement circular asset management, support from higher government levels, such as the national government or even the European Union, is essential. This ensures that policy is appropriately translated and implemented at the provincial and municipal levels. However, currently this translation to local governments is often misaligned; while the national government has good intentions and tools, implementation at the municipal level remains a challenge. Municipalities could strengthen their lobbying efforts by collaborating more intensively, presenting a unified voice that creates greater urgency for the support and resources needed.

6

DISCUSSION

6. Discussion

6.1 Critical Look at Results

The role of the organisation in a transition
When conducting interviews with municipalities, there was the "silent" assumption that Amsterdam could serve as an example for other municipalities. This was based on desk research indicating Amsterdam's leading role in the transition to circular asset management. However, the interviews revealed that the organisational context of a municipality—especially influenced by size and complexity—plays an equally important role in the potential success of the transition. Both large and small municipalities can learn from each other in this regard.

Advantages and disadvantages of the pioneering role
When conducting interviews, it was assumed that the pioneering role brings both advantages and disadvantages. On the one hand, the pioneer role requires intensive involvement from participants, where all options must be thoroughly explored. This leads to a steep learning curve within the civil organisation and creates support. On the other hand, many options are explored that ultimately turn out to be unfeasible, which incurs costs, and there is limited use of best practices. This assumption was confirmed during the interviews.

Pitfall of "pioneer arrogance"
Amsterdam is generally seen as a pioneer, both by other following municipalities and by Amsterdam itself. Because this image is constantly confirmed, there is a risk that the municipality of Amsterdam considers itself more developed than all other municipalities and (un)consciously assumes that nothing can be learned from them. However, it has emerged that learning from the experiences of other municipalities can indeed be valuable to pioneers.

The critical size of the municipality
For this case study, a distinction was made between small (Oegstgeest), medium-sized (Haarlem), and large municipalities (Amsterdam). It is noteworthy that both Haarlem and Amsterdam succeed in putting the transition topic on the municipal agenda, assigning a supporting organisation to this theme, developing initial guidelines, and taking the first steps towards implementation. Oegstgeest, as a small municipality, however, does not have the capacity to achieve similar outcomes. What stands out here is that the difference in population and size of the civil service between Amsterdam (934,927 inhabitants in 2024 (Gemeente Amsterdam, 2024), 19,000 civil servants in 2022 (Bureau Integriteit Gemeente Amsterdam, 2023)) and Haarlem (167,763 inhabitants in 2024 (Gemeente Haarlem, 2024), 1,500 civil servants in 2022 (Gemeente Haarlem, 2022)) is about as large as between Haarlem and Oegstgeest (25,939 inhabitants in 2024, 120 civil servants in 2022 (Gemeente Oegstgeest, 2022)). This suggests that a certain critical mass of resources and staff is needed to successfully address themes such as transition and that smaller municipalities like Oegstgeest fall below this threshold.

The difference in perspective within the transition
It was initially assumed that municipal employees would present a unified voice regarding the transition. However, during the interviews, it became clear that there are differences in how the transition is experienced, mainly due to an employee's role and function within the transition. These differences are more noticeable in larger municipalities, where the organisation is more compartmentalised.

The gap between policymakers and asset managers
Both policymakers and asset managers note that there is little mutual understanding and knowledge of each other's perspectives. Managers are often labelled as conservative, while policymakers are seen as civil servants disconnected from complex day-to-day practices. Interestingly, there are few initiatives aimed at bridging this gap.

Paradox of "open-mindedness"
Policymakers often believe asset managers should be more open-minded. They criticise them for being too rigid in existing practices and want them to be more open to new ideas, changes, and policy initiatives. The paradox arises because by stating that managers should be more open-minded, policymakers imply that they themselves are already open-minded and know what is best. However, this attitude suggests that they are holding on to their own perspectives and beliefs. This points to a lack of open-mindedness on their part, as they are not fully open to the perspectives of asset managers or do not acknowledge that their own vision may also have limitations. While policymakers advocate for more openness among asset managers, they could, in fact, reflect on their own level of open-mindedness.

A new generation of asset managers
Interviews frequently reveal that asset managers are conservative in their way of working. They rely on traditional methods, which forms a barrier to circular asset management. There is a direct call for a "new generation of asset managers" rather than exploring the possibility of retraining the current group of asset managers to adopt new, circular ways of working. It is also noticeable that there are no ongoing initiatives or actions aimed at addressing this problem.

Initiative to collaborate
Interviews show that all municipalities are open to more collaboration. At the same time, it is noticeable that no fixed or structured forms of collaboration have been established and that there is no clear party taking the initiative to organise or coordinate these collaborations.

The interaction between national governments and municipalities
The national government has set ambitious goals for the circular transition and expects municipalities to play an active role by developing policies and taking measures that contribute to a circular economy. Although this responsibility is clearly assigned to the municipalities, they often lack the necessary resources, such as sufficient financial support, to actually achieve these goals. This reveals a gap between the high expectations set by politicians and the actual capacity of municipalities to meet those expectations. The national government set ambitious demands but, in practice, provides insufficient help to create the necessary conditions and resources that would enable municipalities to operate successfully.

6.2 Theoretical Reflections

This section provides a reflection on the theory presented in Chapter 2, comparing the results and findings to the theoretical insights. It begins with the Multi-Level Perspective (MLP), as this framework serves as the guiding theoretical approach.

6.2.1 Multi-Level Perspective & Multi-Phase Concept

The Multi-Level Perspective

The MLP explains how changes at the landscape (macro), regime (meso), and niche (micro) levels interact to create opportunities for transformative change. For a successful transition to a circular economy, it is important to support niche developments, adapt existing regimes, and leverage landscape pressures. This ultimately leads to sustainable, long-term transformations, such as circular asset management.

In this context, the macro level, or landscape, encompasses pressures such as ambitions (e.g., NPCE), regulations, and incentives from municipal, national, and European authorities. The landscape significantly influences both regimes and niches by setting the stage and direction for change. Political action frequently responds to societal pressures, as shown by European and national goals encouraging policymakers to rethink existing paradigms. An example from practice is the open letter from the Dutch Parliament to the Municipality of Amsterdam, urging them to take sustainability more seriously and incorporate explicit objectives. Such pressure creates a sense of urgency to set objectives and related regulations aimed at shifting the current linear regime of asset management. This research shows a growing (political) awareness of the urgency for circular economy practices, with several municipalities beginning to focus on circular asset management. However, there is still a lack of clear political direction, as ambitious objectives often lack practical implementation guidelines.

At the meso level, the regime represents the established linear economy (and the current practice of asset management), characterised by institutionalised structures that provide stability and shape decision-making. In practice, a conservative adherence to existing regulations often leads to resistance to change. For example, asset managers often face pressure to prioritise efficiency and cost-effectiveness, which may discourage the adoption of circular practices in public space management, as these are generally more time-intensive due to limited experience and established processes. This preference for established practices slows the transition to circular asset management.

The micro level, or niche, involves circular asset management practices, including the development of new ideas, technologies, regulations, organisational structures, and pilot projects that challenge the existing regime. These niches often emerge from pioneers, such as Amsterdam, which introduces innovative concepts that gain traction over time. The research emphasises that new regulations and technological advancements play a significant role in fostering niche development. However, the theory often overlooks the critical role of individuals with a positive or passionate attitude toward circular management. In the early stages of niche development, dedicated employees who believe in the new regime are essential for driving broader systemic change.

The MLP illustrates the dynamics between these different levels and how they influence each other in the pursuit of a new regime. However, in practice, the transition faces numerous barriers that impact its effectiveness. These barriers often stem from a misalignment between the regime's existing structures and the changes required by landscape pressures and niche innovations. Barriers emerge across all three MLP levels, indicating that interventions must be implemented at each level to steer the transition in the right direction. However, the MLP model does not explicitly illustrate where these barriers and interventions can occur.

The multi-phase concept
The multi-phase concept emphasises the non-linear progression of transitions, highlighting different phases from pre-development to stabilisation and illustrating both the build-up and breakdown processes that shape new systems. Typically, transitions begin slowly, followed by a sudden

acceleration after reaching a "tipping point," then flatten out as they enter the maturity phase. This process is commonly depicted by an S-shaped curve (*figure 6*). In practice, however, development often progresses with more disruptions and less uniformity than the S-curve suggests.

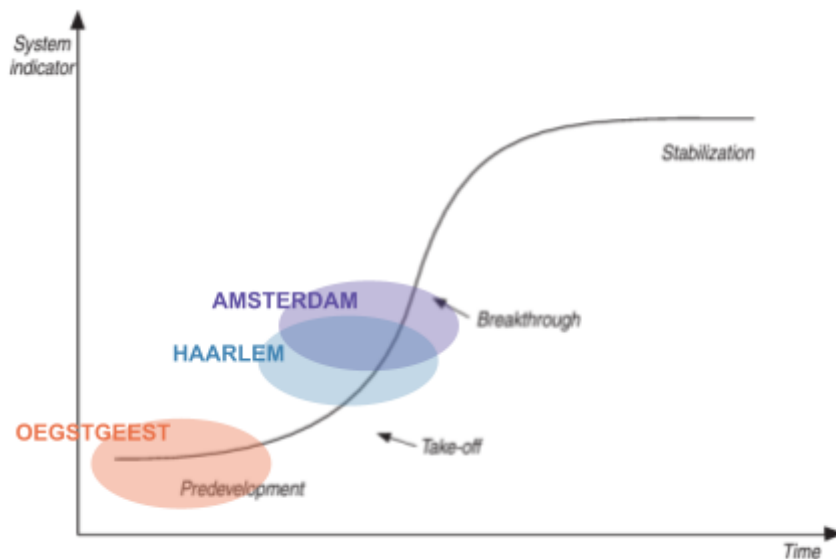*Figure 19* shows the position of each municipality in the case study along the curve, elaborated below.

Figure 19: The position of the three municipalities on the S-Curve

The slow start to the transition is partly due to the presence of many supporters of the traditional, linear economy. Oegstgeest, is still at the starting point and needs time to align internal perspectives. Although the topic is on their agenda, budget constraints lead them to prioritise traditional concerns. A small group of early adopters must invest substantial effort in convincing an unaware majority and sceptics, which, according to interviews, leads to frustration.

At a certain point, a sense of urgency triggers a critical mass, initiating experimentation within niches. This study underscores the importance of making niche developments visible and supporting them. Recognising and rewarding these niches while encouraging competition is essential. This requires an approach to mitigate risks and offset the extra costs for niche practices, which would otherwise struggle to compete with linear practices benefiting from established structures.

Following this phase, upscaling occurs and acceleration can then take place rapidly. During upscaling, having a clear action plan becomes critical, ensuring stakeholders understand necessary actions, even when they conflict with standard practices. A thorough analysis of barriers to upscaling across various domains, as conducted in this research, helps define approaches. The rise of the new regime mirrors the decline of the old system, depicted in an inverse S-shaped curve (*figure 7*). The decline starts slowly but accelerates past the tipping point, leading to disorder, uncertainty, and competing interests. During this phase, officials may face confusion and chaos. Early adopters operate within the new paradigm, while many stakeholders continue working from traditional values and norms, resulting in conflicts. A common example from the research highlights the tension between policymakers who have embraced new values and asset managers still operating within the old system.

The progression towards circular asset management by the municipalities of Haarlem and Amsterdam illustrates these phases well. Initially, it was challenging to make circular asset management a priority. However, with committed politicians, civil servants, and stakeholders, as well as pressure from the national government (e.g., the open letter from the Dutch Parliament), Amsterdam felt an urgency to shift from the traditional linear approach to a circular one, viewing assets from a circular perspective rather than focusing on renewal after depreciation. This change in mindset has transformed the system's perspective, allowing Amsterdam to reach a breakthrough stage. Amsterdam's approach demonstrates they are no longer operating within the take-make-dispose model. Similar developments are evident in Haarlem, where there is a growing consensus and acceleration, with increasing experimentation and adoption of circular principles signalling a gradual shift away from the linear model. Haarlem is closely following in Amsterdam's footsteps.

After the chaos phase, the existing system enters the breakdown phase, involving partial or complete failure of existing systems, structures, or processes. Significant restructuring or transformation becomes necessary. In the cases of Amsterdam and Haarlem, the first signs of this theory can be observed. Officials engaged in innovation are increasingly vocal about the need to adapt the organisation, criticising siloed approaches and advocating for a more integrated perspective. Meanwhile, other officials see organisational changes as potential sources of major disruptions.

The analysis by Lodder et al. (2017), which suggested that the circular economy is still in its early stages and that policy primarily focuses on optimising the linear economy despite increasing circular ambitions, can therefore be considered outdated for Amsterdam and Haarlem.

The MLP and the multi-phase concept help municipalities understand that transitioning to a circular economy isn't a quick fix. It is a long-term, iterative process that involves shifting norms, regulations, and practices.

6.2.2 Circular Asset Management & the R-Ladder

Public asset management focuses on the efficient and effective management of physical assets that municipalities are responsible for, aiming to balance costs, value, and risks while ensuring that these assets remain safe and functional. Circular asset management goes a step further by extending the service life of materials and components, emphasising the continuous reuse and regeneration of materials. This approach ensures that assets are managed in a way that supports long-term sustainability and resource efficiency. While both traditional and circular asset management aim to maintain assets in a safe and functional condition, the paths they take differ significantly. In the traditional model, similar assets are treated uniformly according to standard methods, resulting in efficient bulk logistics and maintenance. However, this also leads to the disposal of individual assets that may still be of good quality. The circular approach, on the other hand, requires a more tailored strategy for similar assets, leading to more complex and costly assessments and logistics, but ultimately maximises the lifespan of each individual asset. Ideally, disposal is minimised or avoided altogether.

Municipalities face the challenge of transitioning towards a circular approach, preferably by following the "4 V's" strategy (Voorkomen, Vervangen, Verlengen, Verwaarden—Prevent, Replace, Extend, Valorise) of the NPCE, which is similar to the steps of the R-ladder. However, the complexity of the environment means that some steps are too ambitious to implement within current systems, as their impact is too disruptive. As a result, municipalities often opt for simpler solutions or "low-hanging

fruit," rather than more complex circular strategies. In practice, this means that municipalities remain focused on levels (of the R-ladder/4 "V"'s) that are more compatible with traditional systems, mainly engaging in refusal or renewal rather than fully embracing more advanced circular strategies.

6.2.3 Socio-Technical Systems

According to the theory, complex systems are characterised by the interplay of interconnected elements, hierarchical organisation, and adaptive behaviour. Elements are nested within subsystems, which, in turn, are part of larger systems. Each subsystem self-regulates and organises itself while remaining connected to its broader system context. The transition to a circular economy arises from interactions between these interconnected elements. The definition of (sub)systems depends on the perspective taken when analysing the system. From a macro perspective, municipalities and provinces can be seen as subbersystems, while the national government functions as a subsystem within the broader European system.

Municipalities function as socio-technical systems, where social elements (e.g., human behaviour and governance) and technical elements (e.g., infrastructure and technology) co-evolve. Research clearly shows that barriers exist across the entire organisation and are often interconnected. Technical barriers often result in behavioural resistance, making it challenging for both the system and individual behaviours to evolve in parallel. This confirms the nature of municipalities as socio-technical systems. Through intensive communication and fostering mutual understanding, both system structures and behaviours can adapt to align with a new environment. For example, in the municipality of Amsterdam, circular asset management is increasingly accepted, and municipal decisions are becoming more aligned with this ambition. Observations indicate that municipalities indeed behave as socio-technical systems, where the system's efficiency depends on how well its elements are designed to meet each other's demands and those of the environment, as well as how effectively they are integrated and managed. This research further confirms that the system becomes ineffective when its design does not align with its operational context. For example, the absence of a clear vision results in officials being hesitant in making decisions that could accelerate the transition. As a result, they often resort to traditional methods to maintain a sense of certainty and control. One such method is the use of current depreciation systems, which complicates the transition, as it forces municipalities to prioritise renewal over reuse, illustrating a misalignment that hinders the adoption of circular asset management practices.

6.2.4 Sustainability Transitions

Transitions occur through interactions at various levels and are the result of both slow and rapid dynamics that influence each other. They require breaking down existing structures and implementing systemic innovations, which can be time-consuming. A significant barrier identified in research is that current systems are designed with a linear approach, which does not align with sustainability or circularity objectives. Other organisational barriers, such as compartmentalised departments, further hinder progress. These barriers suggest that the sustainability transition is not yet advancing optimally. To accelerate this process, existing structures need to be reformed.
According to the theory, two types of transitions can be distinguished: evolutionary transitions and goal-oriented transitions. In evolutionary transitions, outcomes are not explicitly planned, whereas in goal-oriented transitions, a clear vision or objective guides the decisions of strategic and public actors. Sustainability transitions fall under goal-oriented transitions as they focus on addressing environmental challenges. According to municipal officials, clear political ambitions and objectives

are essential to drive the transition forward. By setting clear visions and goals, the transition process can become more structured. However, despite these efforts, many aspects still resemble an evolutionary transition, with different elements progressing at varying rates (e.g., policymakers versus asset managers), creating ambiguity, making it challenging to adopt effective strategies..

6.2.5 Transition Management

Transition management is a governance approach that provides strategies for guiding societal transitions across different interconnected levels: strategic, tactical, operational, and reflective. Since managing the transition occurs on these levels, it is not surprising that barriers are also encountered at these levels in practice, as research has shown.

Political barriers are typically aligned with the strategic level, where the primary objective is to develop a shared understanding of the sustainability challenge among diverse stakeholders and to define a collective vision. The tactical level involves translating the strategic vision into concrete objectives and actionable strategies. This level is linked to identified organisational barriers, which stem from political ones (e.g., O4 and P4). The operational level focuses on the actual implementation of plans and experiments. This level can be associated with technological barriers, where municipalities lack the necessary knowledge and experience to execute their tasks properly and efficiently. At the reflective level, municipalities indicate that there are still significant steps to be taken. These steps mainly relate to technological and organisational barriers, such as organisational structures, communication, and effective data management, which hinder the ability to measure and report results accurately.

Since barriers exist at every level, it can be argued that transition management is not yet fully effective and remains an ongoing process. However, it is evident that different municipalities experience more barriers at certain levels than others. For instance, smaller municipalities encounter fewer barriers at the reflective level because they have not yet reached that stage. In contrast, larger municipalities report significant challenges related to communication and effective data management at this level.

6.3 Contribution

6.3.1 Theoretical Contribution

This research significantly contributes to the body of knowledge on circular economy practices within asset management. While existing literature has focused on sectors in the built environment such as construction and housing, this study brings new insights into the integration of circular principles specifically within asset management. It enriches academic discourse on circular transitions in the public space, particularly within the context of Dutch municipalities.

By employing the MLP framework, this research enhances the understanding of the dynamics between niche, regime, and landscape levels in the context of circular asset management. The study explores current practices, circular ambitions, critical barriers, and potential interventions for circular asset management, highlighting how circular practices can disrupt or transform existing linear systems under external pressures and through the adoption of new practices. It demonstrates the applicability of the MLP framework to circular asset management, extending its use beyond other types of transitions.

The empirical approach of this study bridges the gap between theory and practice by exploring how municipalities perceive and apply circularity in asset management. This approach uncovers dynamics that cannot be detected through theoretical research alone, which is crucial for designing interventions that address underlying causes.

This research identifies effective interventions, either already employed or with the potential to overcome barriers, tailoring solutions to the specific context of Dutch municipalities. Given the lack of empirical research specifically focused on circular asset management in the Dutch context, this study fills a critical gap and serves as a valuable reference for future research.

By examining small, medium-sized, and large municipalities, this research provides comparative insights into how different scales affect the potential for circular transitions.
It reflects the complexities and particularities of different (-sized) municipalities, offering theoretical insights into how organisational factors influence transition outcomes.

The introduction of the PESTEL-O framework offers a systematic categorisation of barriers that hinder the transition to circular asset management. This categorisation not only provides structure to the various barriers but also serves as a foundation for future studies to refine, expand, or apply this framework in other contexts or sectors. The analysis of how these barriers interact and reinforce one another reveals the systemic nature of these challenges and the complexity of disrupting the current regime.

Additionally, this research demonstrates how specific interventions can support the implementation of circular practices in asset management. By linking identified barriers to targeted interventions at different MLP levels, it proposes a framework that can serve as a model for researchers studying circular transitions.

The literature review draws parallels between sectors within the built environment, revealing that other sectors face comparable challenges when transitioning from linear to circular models. This comparative analysis highlights recurring themes and barriers that are also present in circular asset management, suggesting that many of these challenges are not unique to a single sector but reflect broader patterns in transitioning to circular models. Reviewing literature on interventions in other sectors provides a rich source of innovative strategies and solutions that can be adapted for circular transitions in asset management. Understanding how barriers have been addressed in other sectors sheds light on potential strategies for overcoming similar challenges in asset management. By exploring practices, barriers, and interventions across different sectors, this research emphasises the opportunity for cross-sectoral learning. Consequently, the findings from this study can inform research in other sectors, reinforcing the theory around circular economy transitions and providing valuable contributions to the academic literature.

Overall, this study strengthens and expands the understanding of existing practices, identifies barriers hindering the transition towards circular asset management, and outlines how circular economy principles can be integrated into asset management for Dutch municipalities.

6.3.2 Contribution to Practice

Along with its theoretical contributions, this research offers several practical implications for policymakers, asset managers, and other stakeholders involved in the transition to circular asset management. It provides municipalities with possible interventions to effectively implement circular principles in their asset management practices.

The Excel-based tool developed as part of this research facilitates the identification of critical barriers and highlights areas requiring priority intervention, making it easier for municipalities to strategically plan their transition to circular asset management.

The research outlines interventions that can be used to overcome specific barriers and implement circular principles within asset management, to effectively accelerate the circular economy transition.The development of a framework that links identified barriers to specific interventions offers municipalities clear guidance on which interventions are most effective for particular challenges. This structured approach supports strategy development, decision-making, and the implementation of circular principles in municipal asset management.

The empirical nature of the study provides evidence-based interventions, enhancing the likelihood of acceptance and support from decision-makers who value proven effectiveness.

Furthermore, this study highlights the importance of inter-municipal collaboration and the sharing of best practices. It encourages municipalities to establish networks, partnerships, and knowledge-sharing platforms to leverage collective knowledge, pool resources, and increase lobbying power for national support. Such collaboration can significantly accelerate the transition, especially for smaller municipalities that may lack the capacity and resources to independently drive circular initiatives.

The findings are also relevant for consulting firms like Sweco, which can use this research to support municipalities in their transition to circular asset management. The framework and tool developed in this study enable consulting firms to offer more targeted advisory services, thereby enhancing their role as facilitators of the circular transition for municipalities across the Netherlands.

Overall, this research equips municipalities, consulting firms, and other stakeholders with the practical tools and insights to successfully shift from a linear to a circular approach in asset management.

6.4 Limitations

While the qualitative case study approach used in this research provides insights into the barriers and best practices in circular asset management within Dutch municipalities, several limitations must be acknowledged. These limitations are considered when interpreting the results and formulating recommendations. This section discusses scope limitations, methodological limitations and data analysis limitations.

6.4.1 Scope Limitations

This research employs a case study approach focusing on three municipalities: Amsterdam, Haarlem, and Oegstgeest. While these cases provide valuable insights into different approaches to circular asset

management, they may not fully represent the diversity of challenges and practices across all Dutch municipalities.

Oegstgeest, as a smaller municipality, differs significantly from Haarlem (medium-large) and Amsterdam (large), which share greater similarities. A gap exists in the research since no municipality was included that falls between Oegstgeest and Haarlem in terms of size and capacity.

6.4.2 Methodological Limitations

Although the study includes a range of stakeholders involved in circular asset management, it primarily focuses on the perspectives of municipalities and experts. This focus may overlook other important stakeholders, such as contractors. Additionally, due to time constraints, the number of interviewees per municipality was limited, potentially resulting in an incomplete representation of all relevant perspectives.

The number of interviewees also varied across municipalities: four were interviewed in both Amsterdam and Haarlem, while only two were interviewed in Oegstgeest due to limited contact availability. As a smaller municipality, Oegstgeest may be underrepresented in the data, potentially leading to an underreporting of the specific challenges faced by smaller municipalities in adopting circular asset management practices.

Moreover, policymakers and advisors formed a significant portion of the interviewees, as they were more willing to participate. This introduces a risk of over-representing their perspectives, which may influence the findings, such as an overemphasis on certain barriers.

6.4.3 Data Analysis Limitations

Qualitative data analysis involves a level of subjectivity in interpreting responses and identifying themes, patterns, and insights. Although efforts were made to enhance reliability through a uniform interview guide and systematic coding procedures, the analysis is still influenced by the researchers' perspectives and interpretations.

The composition of municipalities and interviewees in the study has led to overrepresentation and underrepresentation. Since all interviewees' inputs were given equal weight in the data analysis, barriers relevant to underrepresented groups may be mentioned less frequently and, as a result, appear less significant.

In qualitative research, counting the frequency of arguments presented by interviewees can provide an indication of the importance of a barrier. However, this method does not consider the different levels of importance or emphasis that interviewees may place on a particular argument. Therefore, while frequency counts help identify commonly mentioned barriers, they may not fully capture the intensity or significance of each perspective.

The 33 barriers identified in this study are formulated qualitatively, leading to variations in their specificity. Some barriers are defined broadly, while others are more narrowly described. Broadly defined barriers may appear more prominent simply because they capture more responses, which can make these barriers appear more prominent than those defined more narrowly.

The proposed interventions are not the only possible solutions for addressing the identified barriers; alternative or additional approaches may also be effective. Furthermore, this research focuses on the identification of interventions. As a result, some interventions are described in broad terms or emphasise what should be achieved (e.g., defining indicators), without providing detailed steps for implementation.

Lastly, given the rapidly evolving nature of circular economy practices, what is considered a barrier or best practice today may change as new policies are introduced, technologies advance, or societal attitudes shift. This temporal limitation could reduce the long-term relevance of the research.

These limitations suggest that while the findings offer valuable insights into circular asset management, they should be applied with caution. The results may not be entirely generalisable, and future research or practical applications should take these limitations into account. Addressing these limitations informs some of the recommendations outlined in section 7.2.

CONCLUSION

7

7. Conclusion

This research addresses the identified knowledge gap by exploring current practices, barriers, needs and best practices in circular asset management within Dutch municipalities. This analysis provides a foundation for developing a practical decision-support tool to help Dutch municipalities make informed choices for circular asset management, ultimately accelerating the transition from a linear to a circular approach in maintaining and replacing public assets.

This chapter concludes by answering the research question and presenting recommendations. Section 7.1 starts by addressing the subquestions, leading to an answer to the main research question. Section 7.2 offers recommendations for future research as well as for practical implementation.

7.1 Answering the Research Question

In the municipalities of Amsterdam, Haarlem, and Oegstgeest, the current practice of asset management reflects a structured and organised regime, aimed at ensuring public spaces are safe, functional, and attractive, while keeping costs and risks manageable. Although all three municipalities follow a similar organisational structure divided into "policy," "project," and "management" levels, with each level having its own set of responsibilities, their approaches differ slightly based on their size and available resources.

Amsterdam and Haarlem, being a large and a medium-sized municipality, have more complex, multi-department structures and use external cooperation agreements to ensure consistency in projects and to better integrate sustainability and circular principles, such as material reuse. In contrast, Oegstgeest, as a smaller municipality, has a simpler structure with only teams and does not rely on external partnerships. All three municipalities manage their assets using a lifecycle-based approach, with decisions on maintenance and replacement guided by technical standards and financial considerations.

To meet European and national targets of reducing primary abiotic resource use by 50% by 2030 and achieving full circularity by 2050, there needs to be a shift towards circular asset management practices. While all three municipalities aim for this same goal using the four strategies introduced in the NPCE, their approaches and commitment levels vary significantly. Both Amsterdam and Haarlem have developed ambitious action plans specifically focused on the circular economy and the built environment, with goals and initial steps, such as minimising the ECI, implementing the "Duurzaam, tenzij..." guideline, and creating circular hubs. In contrast, Oegstgeest has a more general focus on sustainability with limited ambitions for the circular economy and no concrete action steps yet, indicating that it is at a much earlier stage in this transition.

These varying levels of ambition result in different barriers that hinder the adoption of circular asset management. However, the barriers across the municipalities can be grouped into political, organisational, technological, social, economic, environmental, and legal categories.

Prominent *political* barriers include a lack of clear and unified visions for circularity, insufficient prioritisation of circularity, and the absence of clear indicators to measure the progress of the transition. Additionally, action programs do not specifically focus on circular asset management, and governance models are not aligned with long-term results. Limited collaboration between

municipalities further delays the transition. *Organisational* barriers are the most commonly mentioned, indicating that they have a significant impact. These include the current linear structure of systems, compartmentalisation, poor communication (both internally and externally), unclear role assignments, and a lack of concrete action plans. *Technological* barriers involve the struggle municipalities face in integrating new circular processes into existing public spaces. A key challenge is the lack of knowledge and experience in implementing processes such as material reuse and effective data management. *Economic* barriers are also a major hurdle for all municipalities. The lack of resources (budget, time, and expertise) and the increased costs associated with the transition make it difficult for municipalities to prioritise circular solutions over traditional approaches. Existing financial systems and unclear budget responsibilities add further complications. *Social* barriers stem from a lack of understanding and communication within the organisation, leading to inefficiencies. Unfamiliarity with circular principles reduces employee engagement. This can result in uncertainty, resistance, or insufficient motivation among stakeholders, which is another prominently identified barrier. *Environmental* barriers relate to the constraints of the existing environment. These include challenges in implementing technical circular innovations in existing public spaces and resistance from users and other stakeholders with competing interests. Finally, *legal* barriers arise from existing contractual agreements designed for linear asset management, which limit the flexibility to adopt circular asset management practices.

Although Amsterdam is often seen as a pioneer and considers itself more advanced than other municipalities, it shares many barriers with Haarlem and Oegstgeest. Amsterdam faces barriers particularly related to its organisational structure (entrenched linear systems, compartmentalisation), inadequate communication, and challenges in technological integration and data management. Amsterdam also struggles to engage stakeholders in the circular transition, and the lack of clear frameworks combined with the need for concrete action plans remains a barrier. Despite having more resources than Oegstgeest and Haarlem, budget constraints are still a significant barrier.

Barriers are interconnected and cannot be seen in isolation; they often overlap, influence, or reinforce one another. These relationships highlight the need for an integrated approach to circular asset management. Without addressing the multi-level barriers, scaling up circular asset management will remain difficult. Therefore, various interventions across multiple levels are considered to support niche innovations, reshape existing structures, and influence broader political environments. Municipalities can make significant progress by shifting mindsets, setting clear priorities, defining goals with actionable steps, enhancing communication, supporting asset managers and optimising data management.

Key interventions include introducing circularity as the standard operating norm, prioritising circular decisions over cost considerations, and focusing on "quick wins" to achieve early success. Sharing successes both internally and externally helps to build and maintain momentum. Optimising data management through systematic data collection and monitoring is essential for demonstrating the effectiveness of circular practices, enhancing transparency, and enabling informed decision-making. Additional roles, such as officials responsible for data management and sharing, are needed, as well as appointing circularity ambassadors within each department to embed circular principles across teams. Moreover, agile, collaborative work practices enable effective, integrated approaches. Adjusting supplier agreements and incorporating circular criteria in tenders (supported by financial incentives) also encourage circular practices. Involving asset managers and integrating circularity principles early in project lifecycles and developing a coordinated multi-year plan will further ensure circular asset management. Effective communication is essential; structured dialogues between policymakers, asset

managers and other project stakeholders foster mutual understanding, ensuring that policies are both ambitious and practical. To guide asset managers in practical implementation, step-by-step manuals, in-field training, and support programs are necessary. Lastly, collaboration among municipalities to share knowledge, best practices, and collectively lobby for stronger political support can accelerate the transition towards circular asset management.

These interventions can be adapted by municipalities across the Netherlands to advance circular asset management. Dutch municipalities can be supported in the practical application of these interventions through a specially developed decision-support tool. This Excel-based tool assists municipalities in structured decision-making, helping to prioritise interventions by first assessing their current situation. By identifying the most relevant barriers early on, municipalities can select and apply context-specific interventions to address or mitigate their most pressing barriers to circular asset management. This decision-support tool also shows opportunities for addressing multiple barriers simultaneously for an integrated approach. As a "living document," this tool evolves with new insights and experiences from municipalities, enriching the data and refining interventions over time. It also fosters connections and collaboration among municipalities by facilitating knowledge-sharing and building a collective knowledge base accessible to all.

To answer the research question, *"How can Dutch municipalities change and optimise their way of working in order to enhance circular asset management significantly?"*

Municipalities first need to be aware of and understand the barriers they face in implementing circular asset management practices. This starts with analysing their current situation to identify the specific barriers they encounter. Once identified, these barriers can be addressed through targeted interventions. Municipalities may choose to implement the "easiest" interventions for early successes and/or focus on the most significant barriers for a greater impact. However, one should keep in mind that barriers often correlate and may need a multi-interventional approach (or an assessment to determine whether a single intervention makes sense). In any case, interventions should be prioritised. A practical decision-support tool can guide municipalities in this decision-making process. This tool helps them to prioritise actions and identify areas where multiple barriers can be tackled simultaneously, fostering an integrated approach. An integrated approach is crucial for a successful transition towards circular asset management. This also involves multi-year planning and close collaboration with all stakeholders. Collaboration enables the sharing and combining of knowledge, preventing redundant efforts as all municipalities can learn from each other.

In this way, Dutch municipalities can effectively progress towards circular asset management, advancing it from a niche concept to a new regime.

7.2 Recommendations

The recommendations from this research are organised into two subsections: research recommendations (7.2.1) and stakeholder recommendations (7.2.2). Research recommendations are theoretical suggestions, offering recommendations for future research, while stakeholder recommendations provide suggestions for application in practice.

7.2.1 Research Recommendations

Investigating municipalities of varying sizes

This research initially assumed that the size of a municipality influences its ability to implement circular asset management. Oegstgeest was selected as a small municipality, Haarlem as a medium-sized one, and Amsterdam as a large municipality (with Amsterdam having approximately six times the population of Haarlem, and Haarlem about six times the population of Oegstgeest). Findings confirmed this assumption; the larger the municipality, the better equipped it is to put circular asset management into practice. However, the medium-sized municipality, Haarlem, showed similarities with Amsterdam, while Oegstgeest faced distinct challenges, especially related to limited capacity and expertise within its civil service. It is therefore recommended to further investigate municipalities within the Oegstgeest-Haarlem size range and to determine the critical mass needed for a more seamless adoption of circular policies.

Exploring reluctance toward collaboration
A contradiction emerged from this research: although municipalities express a willingness to collaborate, effective collaboration remains limited. Several possible explanations include differences in transition stages, execution capacity, and a lack of established consultation or collaboration structures. Additionally, less visible factors, such as the fear of losing autonomy, also play a role. Considering the benefits of collaboration, it is recommended to further research the underlying motivations behind municipalities' hesitancy to fully engage in collaborative efforts.

Integrating interconnectedness in frameworks
The PESTEL-O framework, used to categorise barriers in this study, is a useful method for classification. However, a limitation of this framework is that it does not illustrate the interdependencies between categories. This may lead to a fragmented understanding of how barriers interact across categories. This study has made an initial attempt to clarify these interconnections among barriers (section 4.4.3). Recognising these interdependencies is essential, as effective interventions often rely on them. It is therefore recommended to integrate these interconnections into the PESTEL-O framework or consider developing a new model to capture these relationships.

Expanding the range of interventions
This study identified 13 interventions to address barriers in circular asset management, primarily based on best practices and insights from literature and interviews. However, these interventions may not encompass all possible approaches. Alternative or additional strategies could also be effective. Therefore, it is recommended to explore further potential interventions, broadening the range by developing both more detailed, generalised interventions, and specific ones tailored to municipalities of varying sizes (small, medium, large).

Leveraging insights for comparable transitions
By reviewing the literature, this research also examined the transition to a circular economy in other sectors related to the built environment. Many barriers identified in empirical research on circular asset management were similarly relevant in other sectors, such as social housing. It is recommended to consider the new findings from this research in other comparable transitions and sectors, as they may support further advancements.

7.2.2 Stakeholder Recommendations

In addition to the interventions recommended in section 4.5, this section provides practical recommendations. While the interventions in section 4.5 serve as specific and substantive recommendations included in the decision-support tool, they place less emphasis on the processes

necessary for effective implementation. Therefore, this section offers recommendations on implementing the decision-support tool and the interventions, as well as other recommendations for practice, highlighting the primary stakeholders targeted by each recommendation.

Refining interventions
For consultants (Sweco) and, secondarily, municipalities: In this research, the focus has been on identifying interventions. Consequently, some interventions are broadly described or focus more on what should be achieved (e.g., defining indicators) without providing detailed steps on how to implement it. It is recommended to research the most effective methods for implementing specific interventions. This could involve developing step-by-step plans, manuals, and guidelines for each intervention.

Piloting interventions
For municipalities and, secondarily, consultants: Interventions were developed based on analyses of experiences, ideas, and needs of directly involved stakeholders and experts. Some interventions may be more suitable for certain municipalities than others. It is recommended to pilot these interventions, document the results (feedback and lessons learned), and incorporate findings into the tool. This will refine and optimise the interventions, turning the tool into a dynamic resource that continuously expands its applicability.

Assistance with implementing the decision-support tool
For consultants (Sweco) and, secondarily, municipalities: Given their frequent exposure to practices across different municipalities, consultants serve as valuable, independent sources of knowledge and experience. Leveraging this expertise is recommended by involving consultants in the implementation process to guide users on effectively using the decision-support tool. Consultants could develop a training program that supports municipal employees in using the tool, interpreting the results, and implementing interventions. Additionally, consultants can assist with communication efforts to promote broader adoption, enhancing the tool's overall effectiveness.

Updating the decision-support tool
For municipalities: The decision-support tool is a living document. As the environment evolves and as the number of users and their experience grows, significant new knowledge will emerge. It is recommended to update the tool consistently and systematically, to keep its relevance and accuracy. These updates may include newly identified barriers, best practices, feedback from practical applications, and lessons learned, allowing each municipality to learn from others. An up-to-date tool also ensures knowledge retention, valuable during staff transitions or collaborations between municipalities.

Optimising the decision-support tool
For consultants (Sweco) and, secondarily, municipalities: It is recommended to continuously monitor and evaluate the tool's use and outcomes, translating observations into new or adapted features. This ongoing improvement will help the tool evolve to better meet users' needs.

Establishing common terminology
For municipalities, market parties, and consultants: To foster effective collaboration among stakeholders, establishing shared terminology is recommended. Standardised definitions facilitate clear communication, reducing misunderstandings and delays due to varying interpretations.

Consultants, as "travelling advisors," can help ensure consistent terminology across all parties involved.

Early participation in the transition process
For market parties, municipalities, and consultants: The transition towards circular asset management is complex and requires an integrated approach. Transition efforts span multiple years, and the existing environment can present obstacles. Early involvement of all parties is recommended to incorporate diverse perspectives during the initiation phase. This allows operational parties time to develop protocols and prepare for change with minimal resource impact. Consultants can play a bridging role, acting as facilitators in this transition.

References

Abdulai, S. F., Nani, G., Taiwo, R., Antwi-Afari, P., Zayed, T., & Sojobi, A. O. (2024). Modelling the
relationship between circular economy barriers and drivers for sustainable construction industry.
Building and Environment, 254, 111388. https://doi.org/10.1016/j.buildenv.2024.111388

Ancapi, F. B. (2021). Policy instruments for circular built environment implementation: A systematic literature
review. IOP Conference Series Earth and Environmental Science, 855(1), 012019.
https://doi.org/10.1088/1755-1315/855/1/012019

Bassens, David & De Boeck, Sarah & Kębłowski, Wojciech & Lambert, Deborah & Reinhardt, Hunter. (2020).
Toward a Circular Economy Scan: Measuring Circular Practices among Retailers in the Brussels
Capital Region.

Bureau Integriteit Gemeente Amsterdam. (2023). Jaarverslag 2022.
https://assets.amsterdam.nl/publish/pages/866195/jaarverslag_bureau_integriteit_2022.pdf

Buren, N., Demmers, M., van der Heijden, R., & Witlox, F. (2016). Towards a Circular Economy: The Role of
Dutch Logistics Industries and Governments. Sustainability, 8(7), 647.
https://doi.org/10.3390/su8070647

Carmichael, T., & Hadžikadić, M. (2019). The fundamentals of complex adaptive systems. In Understanding
complex systems (pp. 1–16). https://doi.org/10.1007/978-3-030-20309-2_1

Çetin, S., Gruis, V., & Straub, A. (2021). Towards Circular Social Housing: An Exploration of practices,
barriers, and enablers. Sustainability, 13(4), 2100. https://doi.org/10.3390/su13042100

Circle Economy - Practical, scalable implementation of the circular economy. (n.d.).
http://www.circle-economy.com/

Circle Economy, TNO, & Gemeente Amsterdam. (2021, August 4). Circular Amsterdam: A vision and action
agenda for the city and metropolitan area.
https://www.circle-economy.com/resources/developing-a-roadmap-for-the-first-circular-city-amsterdam

Davari, S., Jaberi, M., Yousfi, A., & Poirier, E. (2023). A traceability framework to enable circularity in the built
environment. Sustainability, 15(10), 8278. https://doi.org/10.3390/su15108278

Davis, J. (2007). What is asset management and where do you start?. Journal AWWA, 99(10), 26-34.
https://doi.org/10.1002/j.1551-8833.2007.tb08042.x

De Los Rios, I. C., & Charnley, F. J. (2016). Skills and capabilities for a sustainable and circular economy: The

   changing role of design. Journal Of Cleaner Production, 160, 109–122.

   https://doi.org/10.1016/j.jclepro.2016.10.130

Duivenvoorden, E., Hartmann, T., Brinkhuijsen, M., & Hesselmans, T. (2021). Managing public space – A blind

   spot of urban planning and design. Cities, 109, 103032. https://doi.org/10.1016/j.cities.2020.103032

Ellen MacArthur Foundation. (2013). *Towards the Circular Economy Vol. 1: An Economic and Business

   Rationale for an Accelerated Transition*.

   https://www.ellenmacarthurfoundation.org/towards-the-circular-economy-vol-1-an-economic-and-busi

   ness-rationale-for-an

European Commission. (2020). European Commission.

   https://environment.ec.europa.eu/topics/circular-economy_en

European Commission. (n.d.). Circular economy action plan. European Commission Environment.

   https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en

European Commission. (2020). Communication from the Commission to the European Parliament, the Council,

   the European Economic and Social Committee and the Committee of the Regions: A new circular

   economy action plan for a cleaner and more competitive Europe.

   https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=COM:2020:98:FIN

Fastenrath, S., & Braun, B. (2018). Lost in Transition? Directions for an Economic Geography of Urban

   Sustainability Transitions. *Sustainability*, 10(7), 2434. https://doi.org/10.3390/su10072434

Fossey, E., Harvey, C., Mcdermott, F., & Davidson, L. (2002). Understanding and Evaluating Qualitative

   Research. Australian &Amp; New Zealand Journal of Psychiatry, 36(6), 717-732.

   https://doi.org/10.1046/j.1440-1614.2002.01100.x

Fratini,C.F., Georg, S. and Jorgensen, M.S. (2019), 'Exploring circular economy imaginaries in European cities:

   A research agenda for the governance of urban sustainability transitions', Journal of Cleaner

   Production, 228, pp. 974–989. https://doi.org/10.1016/j.jclepro.2019.04.193

Friant, M. C., Reid, K., Boesler, P., Vermeulen, W. J., & Salomone, R. (2023). Sustainable circular cities?

   Analysing urban circular economy policies in Amsterdam, Glasgow, and Copenhagen. Local

   Environment, 28(10), 1331–1369. https://doi.org/10.1080/13549839.2023.2206643

Geels, F. W., & Schot, J. (2010). The dynamics of socio-technical transitions: a sociotechnical perspective in grin'. *Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change. Ed. by J. Rotmans and J. Schot. London: Routledge.*

Geels, F. W. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions,* 1(1), 24–40. https://doi.org/10.1016/j.eist.2011.02.002

Geissdoerfer, M., Savaget, P., Bocken, N.M.P., Hultink, E.J., 2017. The circular economy a new sustainability paradigm? J. Clean. Prod. 143, 757–768. http://dx.doi.org/10.1016/j.jclepro.2016.12.048.

Gemeente Amsterdam. (2020). Amsterdam Circulair 2020-2025: Strategie. https://www.amsterdam.nl/bestuur-organisatie/volg-beleid/duurzaamheid/circulaire-economie/

Gemeente Amsterdam. (2024, 13 mei). Bevolking in cijfers | Onderzoek en Statistiek. https://onderzoek.amsterdam.nl/artikel/bevolking-in-cijfers-2024

Gemeente Amsterdam. (2023). *Programma Circulaire Economie: Lessen en Aanbevelingen 2023-2026.* https://www.amsterdam.nl/wonen-leefomgeving/duurzaam-amsterdam/publicaties-duurzaam-groen/amsterdam-circulair-documenten/?PagClsIdt=17394314#PagCls_17394314

Gemeente Haarlem. (2023). Actieprogramma Circulaire Economie 2023 t/m 2025. https://gemeentebestuur-haarlem.notubiz.nl/document/12710290/1/20230317984+2_+Bijlage+1_+Actieprogramma+Circulaire+Economie+2023+t_m+2025

Gemeente Haarlem. (2024). Haarlem in cijfers - Dashboard - Bevolking - Haarlem. https://haarlem.incijfers.nl/mosaic/haarlem-in-cijfers---dashboard/bevolking

Gemeente Haarlem. (2022). Strategisch personeelsbeleid 2022-2027: Betrokken, gedreven en open aan het werk. https://gemeentebestuur.haarlem.nl/bestuurlijke-stukken/20220056077-2-Bijlage-1-Startegisch-personeelsbeleid-1.pdf

Gemeente Oegstgeest, Boomsma, J., & Kamermans, J. (2020). De toekomst is nu: Duurzaam Oegstgeest. In https://www.oegstgeest.nl/bestuur/beleid-en-regelgeving/duurzaamheidsbeleid. https://www.oegstgeest.nl/fileadmin/Oegstgeest_bestanden/Afbeeldingen/Bestuur/Beleid_en_regelgeving/duurzaamheidsbeleid/De_toekomst_is_nu_duurzaam_Oegstgeest.pdf

Grant, M. J., & Booth, A. (2009). A typology of reviews: an analysis of 14 review types and associated methodologies. Health Information &Amp; Libraries Journal, 26(2), 91-108. https://doi.org/10.1111/j.1471-1842.2009.00848.x

Grafström, J., & Aasma, S. (2021). Breaking circular economy barriers. Journal of Cleaner Production, 292, 126002. https://doi.org/10.1016/j.jclepro.2021.126002

Groat, L. N., & Wang, D. (2001). Architectural research methods. http://ci.nii.ac.jp/ncid/BB15770501

Guerra, B. C., & Leite, F. (2021). Circular economy in the construction industry: An overview of United States stakeholders' awareness, major challenges, and enablers. Resources Conservation and Recycling, 170, 105617. https://doi.org/10.1016/j.resconrec.2021.105617

Hammarberg, K., Kirkman, M., & De Lacey, S. (2016). Qualitative research methods: when to use them and how to judge them. Human Reproduction, 31(3), 498–501. https://doi.org/10.1093/humrep/dev334

Hart, J., Adams, K., Giesekam, J., Tingley, D. D., & Pomponi, F. (2019). Barriers and drivers in a circular economy: the case of the built environment. Procedia CIRP, 80, 619–624. https://doi.org/10.1016/j.procir.2018.12.015

Hartwell, R., Macmillan, S., & Overend, M. (2021). Circular economy of façades: Real-world challenges and opportunities. Resources Conservation and Recycling, 175, 105827. https://doi.org/10.1016/j.resconrec.2021.105827

Hennink, M., & Kaiser, B. N. (2021). Sample sizes for saturation in qualitative research: A systematic review of empirical tests. Social Science & Medicine, 292, 114523. https://doi.org/10.1016/j.socscimed.2021.114523

Heurkens, E., & Dąbrowski, M. (2020). Circling the square: Governance of the circular economy transition in the Amsterdam Metropolitan Area. European Spatial Research and Policy, 27(2), 11–31. https://doi.org/10.18778/1231-1952.27.2.02

Hossain, M. U., Ng, S. T., Antwi-Afari, P., & Amor, B. (2020a). Circular economy and the construction industry: Existing trends, challenges and prospective framework for sustainable construction. Renewable and Sustainable Energy Reviews, 130, 109948. https://doi.org/10.1016/j.rser.2020.109948

Hillier, B. (2012). The city as a socio-technical system: a spatial reformulation in the light of the levels problem and the parallel problem. In Communications in computer and information science (pp. 24–48). https://doi.org/10.1007/978-3-642-29758-8_3

Jolicoeur, P. W., & Barrett, J. R. (2004). Coming of age: Strategic asset management in the municipal sector. Journal of Facilities Management, 3(1), 41–52. https://doi.org/10.1108/14725960510808383

Kemp, R., and J. Rotmans (2004), Managing the transition to a sustainable mobility, forthcoming, in B. Elzen, F. Geels and K. Green (eds.) *System Innovation and the Transition to Sustainability: Theory, Evidence and Policy,* Cheltenham: Edgar Elgar

Kemp, R. (1994). Technology and the transition to environmental sustainability. *Futures*, 26(10), 1023–1046. https://doi.org/10.1016/0016-3287(94)90071-x

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. Resources, Conservation and Recycling, 127, 221-232. https://doi.org/10.1016/j.resconrec.2017.09.005

Kunisch, S., Menz, M., Bartunek, J. M., Cardinal, L. B., & Denyer, D. (2018). Feature Topic at Organizational Research Methods: How to Conduct Rigorous and Impactful Literature Reviews? Organizational Research Methods, 21(3), 519-523. https://doi-org.tudelft.idm.oclc.org/10.1177/1094428118770750

Ladyman, J., Lambert, J., & Wiesner, K. (2012). What is a complex system?. *European Journal for Philosophy of Science*, *3*(1), 33-67. https://doi.org/10.1007/s13194-012-0056-8

Linnenluecke, M.K., Griffiths, A., 2013. Firms and sustainability: mapping the intellectual origins and structure of the corporate sustainability field. Glob. Environ. Chang. 23, 382–391. http://dx.doi.org/10.1016/j.gloenvcha.2012.07.007.

Lodder, M., Roorda, C., Loorbach, D., Spork, C., & DRIFT. (n.d.). Werkdocument als bijlage bij Staat van Transitie: Patronen van opbouw en afbraak in vijf domeinen. https://drift.eur.nl/wp-content/uploads/2017/09/DRIFT-Werkdocument-Staat-van-Transitie.pdf

Loorbach, D., Frantzeskaki, N., & Avelino, F. (2017). Sustainability Transitions Research: Transforming Science and Practice for Societal Change. *Annual Review of Environment and Resources*, 42(1), 599–626. https://doi.org/10.1146/annurev-environ-102014-021340

Loorbach, D., & Rotmans, J. (2006). Managing transitions for sustainable development. In Kluwer Academic Publishers eBooks (pp. 187–206). https://doi.org/10.1007/1-4020-4418-6_10

Loorbach, D. (2009). Transition Management for Sustainable Development: A Prescriptive, Complexity‑Based Governance Framework. Governance, 23(1), 161-183. https://doi.org/10.1111/j.1468-0491.2009.01471.x

Loorbach, D. (2007). *Transition Management : New mode of governance for Sustainable development.*

    https://repub.eur.nl/pub/10200/proefschrift.pdf

Mahpour, A. (2019). Prioritizing barriers to adopt circular economy in construction and demolition waste

    management. Resources Conservation and Recycling, 134, 216–227.

    https://doi.org/10.1016/j.resconrec.2018.01.026

Managing Public Space. (2024, April 11). Arjan Hijdra: kandidaat voor de buitengewoon hoogleraarspositie

    Managing Public Space - Managing Public Space.

    https://www.managingpublicspace.com/publicaties/arjan-hijdra-kandidaat-voor-de-buitengewoon-hoog

    leraarspositie-managing-public-space/

Maring, L., & Blauw, M. (2018). Asset management to support urban land and subsurface management. The

    Science of the Total Environment, 615, 390–397. https://doi.org/10.1016/j.scitotenv.2017.09.109

Marshall, M. N. (1996). Sampling for qualitative research. Family Practice, 13(6), 522–526.

    https://doi.org/10.1093/fampra/13.6.522

Markard, J., Raven, R., & Truffer, B. (2012). Sustainability transitions: An emerging field of research and its

    prospects. *Research policy*, 41(6), 955-967.

Metabolic. (2021). Handboek Circulaire Gebiedsontwikkeling: Een integrale aanpak.

    https://www.metabolic.nl/wp-content/uploads/2021/12/Metabolic_HandboekCirculaireGebiedsontwikk

    eling.pdf

Ministerie van Infrastructuur en Waterstaat. (2023). Nationaal Programma Circulaire Economie: 2023 - 2030.

Ministerie van Sociale Zaken en Werkgelegenheid. (2019). Uitvoering van Beleid: Gemeente Inwoneraantal

    groot, middelgroot en klein.

    https://www.uitvoeringvanbeleidszw.nl/binaries/uitvoeringvanbeleidszw/documenten/publicaties/subsid

    ies/veranderopgave-inburgering-pilots/tabel-aantal-inwoners-gemeenten-per-1-januari-2019/tabel-aanta

    l-inwoners-gemeenten-per-1-januari-2019-op-alfabetische-volgorde/Aantal+inwoners+gemeenten+per

    +1+januari+2019+gesorteerd+op+naam+gemeente.pdf

Ness, D. A., & Xing, K. (2017). Toward a Resource‑Efficient Built Environment: A Literature Review and

    Conceptual Model. Journal Of Industrial Ecology, 21(3), 572–592. https://doi.org/10.1111/jiec.12586

Obersteg, A., Arlati, A., Acke, A., Berruti, G., Czapiewski, K., Dąbrowski, M., Heurkens, E., Mezei, C.,

    Palestino, M. F., Varjú, V., Wójcik, M., & Knieling, J. (2019). Urban Regions Shifting to circular

Economy: Understanding challenges for new ways of governance. Urban Planning, 4(3), 19–31.

https://doi.org/10.17645/up.v4i3.2158

Olsthoorn, A., & Wieczorek, A. (2006). *Understanding industrial transformation: Views from different disciplines.* http://ci.nii.ac.jp/ncid/BA82277735

Planbureau voor de Leefomgeving. (2023). Integrale Circulaire Economie Rapportage 2023.

https://www.pbl.nl/sites/default/files/downloads/pbl-2023-icer-2023-4882.pdf

Pomponi, F., & Moncaster, A. (2017). Circular economy for the built environment: A research framework.

Journal of Cleaner Production, 143, 710–718. https://doi.org/10.1016/j.jclepro.2016.12.055

Priya, A. (2020). Case study Methodology of Qualitative Research: Key attributes and navigating the

conundrums in its application. Sociological Bulletin/Sociological Bulletin, 70(1), 94–110.

https://doi.org/10.1177/0038022920970318

Rahla, K. M., Mateus, R., & Bragança, L. (2021). Implementing Circular Economy Strategies in

Buildings—From Theory to Practice. Applied System Innovation, 4(2), 26.

https://doi.org/10.3390/asi4020026

Ropohl, G. (1999). Philosophy of Socio-Technical Systems. Techné: Research in Philosophy and Technology,

4(3), 186–194. https://doi.org/10.5840/techne19994311

Rotmans, J., Kemp, R. and Van Asselt, M. (2001), 'More evolution than revolution. Transition management

in public policy', Foresight, 3 (1), pp. 15–31. https://doi.org/10.1108/14636680110803003

Rotmans, J. (2005). *Maatschappelijke innovatie: tussen droom en werkelijkheid staat complexiteit.* Drift.

https://repub.eur.nl/pub/7293/EIA-2005-026-ORG%20ROTMANS%20NL.pdf

Rotmans, J. (2021). Omarm de chaos. Singel Uitgeverijen.

Rotmans, J., Kemp, R., Van Asselt, M., Geels, F., Verbong, G., & Molendijk, K. (2000). Transities &

transitiemanagement: De casus van een emissiearme energievoorziening. *International Center for Integrative Studies (ICIS)*.

https://research.tue.nl/nl/publications/transities-amp-transitiemanagement-de-casus-van-een-emissiear

me-e

Said, M., & Tempels, B. (2023). Challenges in managing public space: insights from public space management

practice. Journal of Environmental Planning and Management, 1-20.

https://doi.org/10.1080/09640568.2023.2263635

Schöpfel, J., 2010. Towards a Prague Definition of Grey Literature. Presented at the Twelfth International

  Conference on Grey Literature: Transparency in Grey Literature. Grey Tech Approaches to High Tech

  Issues. Prague, 6–7 December 2010, Prague, Czech Republic. pp. 11–26.

Shooshtarian, S., Maqsood, T., Caldera, S., & Ryley, T. (2021). Transformation towards a circular economy in

  the Australian construction and demolition waste management system. Sustainable Production and

  Consumption, 30, 89–106. https://doi.org/10.1016/j.spc.2021.11.032

Sillitto, H., Martin, J., McKinney, D., Griego, R., Dori, D., Krob, D., ... & Jackson, S. (2019). Systems

  engineering and system definitions. Proceedings of the INCOSE, Biarritz, France, 11-13.

Snyder, C. W., Mastrandrea, M. D., & Schneider, S. H. (2011). The complex dynamics of the climate system. In

  Elsevier eBooks (pp. 467–505). https://doi.org/10.1016/b978-0-444-52076-0.50017-1

Stahel, W.R., Clift, R. (2015). Stocks and Flows in the Performance Economy. In: Clift, R., Druckman, A. (eds)

  Taking Stock of Industrial Ecology. Springer, Cham.

  https://doi-org.tudelft.idm.oclc.org/10.1007/978-3-319-20571-7_7

Systems Innovation. (2015, September 11). SocioTechnical systems [Video]. YouTube.

  https://www.youtube.com/watch?v=0q5CreeOZ1g

Systems Innovation. (2017, May 6). What is a Complex System? [Video]. YouTube.

  https://www.youtube.com/watch?v=vp8v2Udd_PM

Taiwo, R., Shaban, I. A., & Zayed, T. (2023). Development of sustainable water infrastructure: A proper

  understanding of water pipe failure. Journal Of Cleaner Production, 398, 136653.

  https://doi.org/10.1016/j.jclepro.2023.136653

Tansey, O. (2007). Process Tracing and Elite Interviewing: A Case for Non-probability Sampling. PS: Political

  Science &Amp; Politics, 40(4), 765-772. https://doi.org/10.1017/s1049096507071211

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a Methodology for Developing Evidence‑Informed

  Management Knowledge by Means of Systematic Review. British Journal of Management, 14(3),

  207-222. https://doi.org/10.1111/1467-8551.00375

Turnbull, L., Hütt, M. T., Ioannides, A. A., Kininmonth, S., Pöppl, R., Tockner, K., Bracken, L., Keesstra, S.,

  Liu, L., Masselink, R., & Parsons, A. J. (2018). Connectivity and complex systems: learning from a

  multi-disciplinary perspective. Applied Network Science, 3(1).

  https://doi.org/10.1007/s41109-018-0067-2

United Nations Environment Programme, & International Resource Panel (2024). Global Resources Outlook

    2024 - Bend the trend: Pathways to a Liveable Planet as Resource Use Spikes.

    https://wedocs.unep.org/20.500.11822/44901.

Urquhart, T. (2000). Strategic municipal asset management. Worley International, Ltd., 1.

    http://documents.worldbank.org/curated/en/444051468779698444/Strategic-municipal-asset-managem

    ent

Victar, H. C., Perera, B., Palihakkara, A. D., & Dewagod, K. G. (2023). Roles and competencies of quantity

    surveyors in achieving a circular built environment: an investigation according to 3R principles. Smart

    And Sustainable Built Environment. https://doi.org/10.1108/sasbe-10-2022-0231

Wojewnik-Filipkowska A., Rymarzak M. (2013), Decision-making in corporate and municipal

asset management (literature review), International Journal of Real Estate Studies (INTRESTS), vol. 17.

Yin, R. (2014). Case study research and applications: Design and methods (6th ed.). SAGE Publications.

Yin, R. K. (1994). Case study research: Design and methods (2nd ed.). Newbury Park, CA: Sage Publications.

Zaman, A., Ruiz, A. M. C., Shooshtarian, S., Ryley, T., Caldera, S., & Maqsood, T. (2023). Development of the

    Circular Economy Design Guidelines for the Australian Built Environment sector. Sustainability, 15(3),

    2500. https://doi.org/10.3390/su15032500

Appendices

Appendix A: Complex Systems & Socio-Technical Systems

Complex Systems

A system can be defined as "*a set of elements and the relations between them*". Through these relations, elements can collaborate as an entirety to achieve a common purpose (Sillitto et al., 2019). The interaction of elements within a system leads to the emergence of a new level of organisation. Systems can vary from simple to complex. A complex system exhibits emergent behaviour that is intrinsically hard to predict by analysing the individual elements in isolation. A city is seen as a complex system due to the intricate interplay among its numerous elements and their interactions. An emergent behaviour within this complex system could be the transition to a circular economy.

A complex system has multidimensional properties. Numerosity, connectivity, interdependence & nonlinearity, and autonomy & adaptivity are primary parameters that make a system complex (Systems Innovation, 2017). *Figure 3* provides an overview of these parameters.
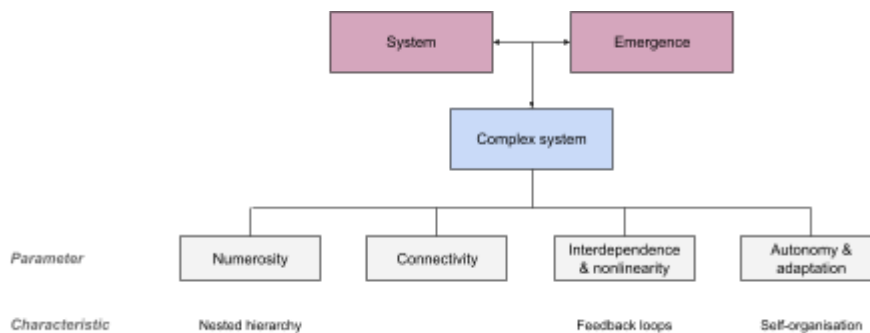
Figure 3: Overview of parameters of a complex system (own figure)

Numerosity refers to the large number of elements and the hierarchical structure of the system. In this structure, elements are nested within subsystems, which are part of larger systems. Each subsystem regulates and organises itself while still being attached to the context of its sub- and subber-systems (Ladyman et al., 2012). In a complex system, the elements are highly interconnected. Connectivity refers to the composition of a system, defining how things flow within the network rather than the properties of the individual elements (Turnbull et al., 2018). The interdependence of elements within a system creates nonlinearity. In a nonlinear relation, small changes in one part of the system can lead to disproportionate effects in other parts of the system. Therefore, a complex system can shift to whole new regimes in short periods. Feedback loops can both stimulate and discourage phase transitions. With feedback loops the output of a system influences its own behaviour (Snyder et al., 2011). Complex systems often show the capacity to adapt to changes, owing to the autonomy of their elements. This adaptation enables self-organisation. Without centralised coordination, elements can cooperate, leading to the emergence of organisational patterns from bottom up. With autonomy and adaptation, often comes the capacity for a variety of different responses, leading to a heterogeneous system with high levels of diversity (Carmichael & Hadžikadić, 2019).

Cities consist of a large number of interconnected elements, ranging from individual buildings and roads to people and organisations. These elements are organised hierarchically into subsystems: buildings form neighbourhoods, neighbourhoods form districts, and districts form the entire city. Each

element of a city functions with some autonomy, allowing for adaptivity. It can independently react to changes and challenges, leading to emergent, self-organised behaviours without centralised control. The hierarchical structure ensures that while there is a degree of self-regulation at each level, the overall city structure remains interconnected and functional. Each level has its own set of rules and interactions but is influenced by the levels above and below it. Due to the strong interdependence among various elements within cities, cities are particularly sensitive to cascading effects that expand the initial impact: changes in one part of the (organisation of the) city can affect other parts due to nonlinear dynamics. The transition to a circular economy can create positive, far-reaching impacts, however, it is important to be aware of and mitigate potential downsides.

Socio-technical systems

Complex systems exist in various domains such as biology, ecology, economics, physics, sociology, and technology. Socio-technical systems are complex organisational structures that involve both social and technical elements interacting within a larger system. These systems are characterised by the integration of people, processes, and technology to accomplish a specific purpose (Systems Innovation, 2015). Understanding this complex system requires a holistic perspective that recognises the structure's interconnected elements. The efficiency of this system depends on how well these elements are designed to fit the demands of each other and the environment and how well they are integrated and managed (Ropohl, 1999).

Cities are complex systems consisting of (at least) the physical subsystem and the human subsystem. The physical subsystem encompasses buildings connected by streets, roads, and infrastructure and the human subsystem involves movement, interaction, and various activities. As socio-technical systems refer to the interaction between human behaviour and society's complex infrastructures, cities can be considered complex socio-technical systems (Hillier, 2012).

Appendix B: The Breakdown of Transition Dynamics

The X-curve framework of Loorbach et al (2017) visualises the transition dynamics involving processes of decline, breakdown, and phase-out, alongside the process of build-up as conceptualised in the multi-phase concept (*Figure 7*). It demonstrates the interactions among these processes and focuses on the distinct roles that regime and niche can play within them. This conceptual framework offers guidance for understanding and developing governance in sustainability transitions (Olsthoorn & Wieczorek, 2006).

A transition starts with the optimization of the current regime, where there is still little urgency to change the system. During this phase, change agents experiment with alternatives. The destabilisation phase is triggered by incidents, factors, or events challenging the stability of the existing regime. Internal or external pressures, such as technological advancements, market shifts, social movements, or environmental changes, can prompt the need for change. This disorder leads to uncertainties and competing interests, resulting in chaos. However, this chaos also creates opportunities for creativity, innovation, or new pathways (acceleration phase). Transformative regime elements evolve into a new regime. Subsequently, the existing system truly begins to break down in the breakdown phase, involving partial or complete failure of existing systems, structures, or processes. Significant restructuring or transformation becomes necessary. The phase-out phase is characterised by the fading out of the old regime, shifting away from obsolete technologies, practices, or institutions towards alternative solutions better aligned with evolving needs, priorities, or values (Olsthoorn & Wieczorek, 2006).

Appendix C: Brief Description of Case Studies

Oegstgeest has developed a sustainability program, "De toekomst is nu; duurzaam Oegstgeest" (2020), which aims to keep available resources in the cycle for as long as possible and to reuse residual streams in the highest possible quality. However, specific targets have not yet been included in this program.

Haarlem has set a more ambitious target to become a circular city by 2040. They have implemented a specific "Circular Economy Action Program" (2023) to accelerate and enlarge the scope of circular practices within the city. This program includes five priority areas: food, textiles, consumer goods, construction, and municipal operations. Additionally, Haarlem has developed a "Sustainability Management Plan", which outlines nine concrete KPIs. The plan also highlights Haarlem's commitment to embedding circular principles in the procurement policies for its construction projects, with the aim that by 2025, half of all groundwork, road and hydraulic engineering (GWW) projects will be tendered using circular principles (Gemeente Haarlem, 2023).

Amsterdam is recognized as a progressive and liberal city, actively experimenting with innovative approaches to urban development, sustainability, technology adoption, and social policies, making it a pioneer for other cities (Gemeente Amsterdam, 2020). Selecting Amsterdam as a pioneering case study is both relevant and well-justified due to its leading position in transitioning towards a circular economy. The city is introducing and scaling up the circular economy throughout the Netherlands and beyond, making it a top policy priority (Heurkens & Dąbrowski, 2020). Moreover, Amsterdam is well-positioned to achieve this goal, supported by its numerous entrepreneurial and innovative businesses, citizens, startups, organisations, and knowledge institutions (Circle Economy et al., 2021).

Appendix D: Table as the Basis for the Research Approach Framework

Subquestion	Project Phase	Method	Results
a. How are assets currently managed by the municipalities of Amsterdam, Haarlem and Oegstgeest?	• Desk research • Empirical research	• Literature study: grey literature, online sources • Semi-structured in depth interviews with the three municipalities	• Clear vision on the approach to asset management across the three municipalities • Clarity on whether (and if so, how) the current approach incorporates circularity • Validation of desk research findings • Gap analysis of lacking information leading to further desk research and/or additional interviews (feedback loop) • Oversight of the main stakeholders involved in asset management • Oversight of relevant interviewees • Foundation for interview questionnaire
b. What are the circular ambitions of the municipalities of Amsterdam, Haarlem and Oegstgeest for circular asset management?	• Desk research • Empirical research	• Literature study: grey literature, online sources • Semi-structured in depth interviews with the three municipalities	• Clear vision/oversight of the ambitions for circular asset management across the three municipalities • Clear vision on the contribution of the different tools and procedures used by the three municipalities to the defined ambitions • Validation of desk research findings • Gap analysis of lacking information leading to further desk research and/or additional interviews (feedback loop) • Foundation for interview questionnaire

c. What barriers are hindering circular asset management within the municipality Haarlem and Oegstgeest, and has Amsterdam also faced these barriers?	• Desk research • Empirical research	• Literature study: academic journals (Scopus), grey literature, online sources • Semi-structured in depth interviews with the three municipalities	• Clear vision of the general barriers for circular asset management (literature) • Inventorisation (long list) of the barriers within the three municipalities. • Categorised longlist of barriers according to PESTEL-O • Shortlist (categorised) of generic barriers • A table containing this shortlist
d. What interventions are considered to tackle these barriers in circular asset management?	• Desk research • Empirical research	• Literature study: academic journals (Scopus), grey literature, online sources • Semi-structured in depth interviews with the three municipalities	• Table of barriers matched with approaches of the municipality of Amsterdam (each barrier will be reviewed, and existing good practices of the municipality of Amsterdam will be attached) This list will serve as the basis for the last phase • Possible approaches, wishes or ideas from Haarlem and Oegstgeest
e. How can Dutch municipalities be supported in applying interventions to advance to circular asset management?	• Tool development		• A coherent framework of the most common barriers, matched with recommendations and the belonging solution, tools and procedures scaled for use in Dutch municipalities

Appendix E: Interview Guide

I. Interview Guide in Dutch

Interviews Gemeente Oegstgeest, Haarlem en Amsterdam
<u>Doel</u>

Dit interview heeft als doel inzicht te krijgen in het huidige assetbeheer bij de gemeente en de rol van de beheerder daarin. In de context van circulair beheer is het belangrijk om te begrijpen hoe de gemeente hier tegenover staat, of er ambities zijn en wat deze ambities inhouden. Daarnaast wordt onderzocht hoe de organisatie werkt om deze ambities te realiseren. Verder worden de uitdagingen, barrières en mogelijke ondersteuningsbehoeften van de gemeente met betrekking tot circulair beheer van de openbare ruimte in kaart gebracht. Hiervoor is het essentieel om de voortgang met betrekking tot hun doelen en ambities te begrijpen. Tot slot streven we ernaar nieuwe contacten te werven voor verdere interviews.

Subvragen die aansluiten op de interviews:
a. How are assets currently managed by the municipalities of Amsterdam, Haarlem and Oegstgeest?
b. What are the circular ambitions of the municipalities of Amsterdam, Haarlem and Oegstgeest for circular asset management?
c. What barriers are hindering circular asset management within the municipality Haarlem and Oegstgeest, and has Amsterdam also faced these barriers?
d. What interventions are considered to tackle these barriers in circular asset management?

Interview
<u>Algemene Informatie</u>
Naam van de gemeente:

Naam van de respondent:
Functie:
Contactgegevens:

Introductie
   1.   *Bedanken dat dit interview plaats kan vinden*
Allereerst wil ik u hartelijk bedanken dat dit interview mogelijk is. Het is ontzettend waardevol voor mijn afstudeeronderzoek dat ik deze kans krijg om met uw gemeente te spreken.

   2.   *Uitleg onderzoek en reden voor dit interview*
Ik ben momenteel bezig met mijn afstudeeronderzoek over het circulair beheer van assets binnen Nederlandse gemeenten. De reden dat ik uw gemeente wil interviewen, is omdat uw gemeente ambities heeft op het gebied van circulaire economie en duurzaamheid. Door dit interview hoop ik een uitgebreid beeld te krijgen van de huidige praktijken, ambities, uitdagingen en mogelijke ondersteuningsbehoeften van de gemeente met betrekking tot het circulair beheer van de openbare ruimte.

Het uiteindelijke doel van mijn onderzoek is om gemeenten te helpen hun circulaire ambities te vertalen naar concrete maatregelen, met een speciale focus op circulair grondstoffengebruik.

Om een wetenschappelijk verantwoorde vergelijking tussen de verschillende gemeenten te kunnen maken, heb ik een uniforme vragenlijst opgesteld. Hierdoor kan het zijn dat er vragen tussen zitten die ook (deels) in uw actieplan worden toegelicht. Bij dergelijke vragen zal ik eventueel wat sneller doorgaan, maar ik wil ze toch stellen als validatie.

   3.   *Consent form*
Ik heb u eerder via e-mail een toestemmingsformulier gestuurd voor dit interview. Ik weet niet of u deze al heeft doorgelezen. Hier is nog een uitgeprinte versie. Kunt u deze voor het begin van het interview ondertekenen als u hiermee akkoord gaat? Het is een formaliteit vanuit de universiteit en mijn onderzoek.

   4.   *Vraag interview opnemen*
Mag ik het interview opnemen? Dit helpt me om het gesprek later nauwkeurig te kunnen analyseren. Uiteraard worden de opnames vertrouwelijk behandeld en uitsluitend gebruikt voor mijn onderzoek.

Vragen
Inleiding
   1.   Kunt u uw positie binnen de gemeente beschrijven en uw expertise en rol in het beheren van publieke assets toelichten?

Huidige praktijken en beheer
   2.   Hoe wordt het beheer van assets (verharding, kunstwerken, riolering en straatmeubilair) momenteel georganiseerd binnen uw gemeente? Wat is jullie organisatiestructuur? Wat is beslisboom en wat zijn daarin de criteria waarop die beslissingen gemaakt worden?
   3.   Wat beschouwt u als de grootste uitdagingen bij het beheren van de openbare ruimte? Zijn deze uitdagingen anders wanneer het beheer circulair wordt aangepakt?
   4.   In hoeverre zijn circulaire principes momenteel geïntegreerd in het beheer van assets?

5. (Kunt u voorbeelden geven van bestaande projecten of initiatieven binnen uw gemeente die gericht zijn op circulair beheer?)

Ambities en doelen

6. Heeft uw gemeente ambities en/of concrete doelen gesteld met betrekking tot de circulaire economie en het circulaire beheer van de openbare ruimte? Zo ja, kunt u deze kort beschrijven?
7. Zijn deze doelen breed bekend in zowel directe als indirecte kringen? Zijn er extra partijen bij betrokken in vergelijking met traditioneel beheer?
8. Zijn er concrete plannen of maatregelen om deze doelen te realiseren? Wat zijn de prioriteiten en waarom?

Voortgang/meetbaarheid

9. Hoe monitort uw gemeente de voortgang van circulaire initiatieven en projecten?
10. Zijn er meetbare indicatoren of KPI's vastgesteld om de voortgang te evalueren? Zo ja, welke?
11. Hoe wordt de voortgang gerapporteerd en gedeeld binnen de gemeente en met externe stakeholders?
12. Hoe verloopt het proces richting jullie circulaire ambities binnen het beheer tot nu toe?

Uitdagingen en barrières

13. Wat beschouwt u als de grootste uitdagingen bij het implementeren van circulaire principes in het beheer van publieke assets? Kunt u voorbeelden noemen?
14. Hoe gaat de gemeente momenteel om met deze barrières? Zijn er al stappen ondernomen om deze aan te pakken?

Versnelling

15. Hoe zou de gemeente geholpen kunnen worden om circulair beheer effectief te implementeren, en wie moet hiertoe het initiatief nemen?
16. Zijn er specifieke beleidsmaatregelen of initiatieven (vanuit uw gemeente) die succesvol zijn gebleken in het bevorderen van circulair beheer?
17. Hoe kan de samenwerking met andere gemeenten, organisaties of de overheid bijdragen aan het behalen van uw circulaire doelen?

Afronding
18. Heeft u nog andere opmerkingen of suggesties met betrekking tot circulair beheer binnen uw gemeente?
19. Kent u andere personen of afdelingen (binnen uw gemeente) die waardevolle input kunnen leveren voor dit onderzoek? Zo ja, kunt u mij met hen in contact brengen?

Bedankt voor het meewerken en voor uw antwoorden. U heeft mij enorm geholpen en een belangrijke bijdrage geleverd aan mijn onderzoek. Mag ik later eventueel nog een keer terugkomen of terugbellen als ik nog iets ben vergeten te vragen?

II. Interview Guide translated in English

Interviews with Municipalities of Oegstgeest, Haarlem, and Amsterdam

Aim of the interview

The purpose of this interview is to gain insight into current asset management practices within the municipality and the role of the asset manager in these practices. In the context of circular asset management, it is important to understand the municipality's position, its ambitions, and what these ambitions entail. Additionally, the interview aims to explore how the organization works towards achieving these ambitions. Furthermore, it seeks to identify the challenges, barriers, and potential support needs of the municipality regarding the circular management of public spaces. Understanding the progress made towards their goals and ambitions is therefore essential. Lastly, the interview aims to recruit new contacts for further interviews.

Subvragen die aansluiten op de interviews:
   a. How are assets currently managed by the municipalities of Amsterdam, Haarlem and Oegstgeest?
   b. What are the circular ambitions of the municipalities of Amsterdam, Haarlem and Oegstgeest for circular asset management?
   c. What barriers are hindering circular asset management within the municipality Haarlem and Oegstgeest, and has Amsterdam also faced these barriers?
   d. What interventions are considered to tackle these barriers in circular asset management?

Interview
General Information
Name of the municipality:
Name of the respondent:
Function:
Contact details:

Introduction
   1. *Thank the interviewee for their time*
First of all, I would like to thank you for making this interview possible. It is incredibly valuable for my thesis project to have this opportunity to speak with your municipality.

   2. *Explaining the research and the reason for the interview*
I am currently working on my graduation project on the circular management of assets within Dutch municipalities. The reason for interviewing your municipality is because it has ambitions in the field of circular economy and sustainability. Through this interview, I hope to gain a comprehensive picture of the current practices, ambitions, challenges, and potential support needs of the municipality concerning the circular management of public spaces.

The ultimate goal of my research is to help municipalities translate their circular ambitions into concrete measures.

In order to make a scientifically sound comparison between the different municipalities, I have drawn up a uniform questionnaire. As a result, there may be questions that are also (partly) explained in your action plan.

3. Consent form

I previously sent you a consent form for this interview via email. I am not sure if you have already read it. Here is a printed version. Could you sign it before we begin if you agree? It is a formality required by the university and my research.

4. Request to record the interview

May I record the interview? This will help me accurately analyse the conversation later. Of course, the recordings will be treated confidentially and used exclusively for my research.

Interview questions

Introduction

1. Can you describe your position within the municipality and elaborate on your expertise and role in managing public assets?

Current Practices and Management

2. How is the management of assets (road infrastructure, civil engineering structures, sewage systems, and street furniture) currently organised within your municipality? What is your organisational structure?
3. What do you consider the biggest challenges in managing public spaces? Are these challenges different when management is approached circularly?
4. To what extent are circular principles currently integrated into the management of assets?
5. (Can you provide examples of existing projects or initiatives within your municipality focused on circular management?)

Ambitions and Goals

6. Does your municipality have ambitions and/or specific goals regarding the circular economy and circular management of public spaces? If so, could you briefly describe them?
7. Are these goals widely known in both direct and indirect circles? Are additional parties involved compared to traditional management?
8. Are there specific plans or measures to achieve these goals? What are the priorities, and why?

Progress/Measurability

9. How does your municipality monitor the progress of circular initiatives and projects?
10. Have measurable indicators or KPIs been established to evaluate progress? If so, which ones?
11. How is progress reported and shared within the municipality and with external stakeholders?
12. How has the process towards your circular ambitions in management been so far?

Challenges and Barriers

13. What do you consider the biggest challenges in implementing circular principles in the management of public assets? Can you provide examples?
14. How is the municipality currently dealing with these barriers? Have any steps already been taken to address them?

Acceleration

15. How could the municipality be supported in effectively implementing circular asset management, and who should take the initiative for this?
16. Are there specific policies or initiatives (from your municipality) that have proven successful in promoting circular management?
17. How can collaboration with other municipalities, organisations, or the government contribute to achieving your circular goals?

Wrap-up

18. Do you have any other comments or suggestions regarding circular asset management within your municipality?
19. Do you know other people or departments (within your municipality) who could provide valuable input for this research? If so, could you put me in contact with them?

Closing

Thank you for your cooperation and your answers. You have helped me enormously and made an important contribution to my research. Is it possible to return or call later if I have forgotten to ask something?

Appendix F: Connection Between Interview Questions and Research

Interview Question	(Most relevant) related theory	Connection to sub-question	Insight into
Introduction			
1. Can you describe your position within the municipality and elaborate on your expertise and role in managing public assets?	• Complex systems • Public asset management	How are assets currently managed by the municipalities of Oegstgeest, Haarlem, and Amsterdam?	• Background Information of the Interviewer • Responsibilities and dependence on others • Hierarchy/organisation within the municipality • Influence on the decision-making process
Current Practices and Management			
2. How is the management of assets (road infrastructure, civil engineering structures, sewage systems, and street furniture)	• Complex systems • Socio-technical systems • Public asset management	How are assets currently managed by the municipalities of Oegstgeest, Haarlem, and Amsterdam?	• Organization/current Structure • Involved parties/roles (responsibilities) • Process

	currently organised within your municipality? What is your organisational structure?			● Decision-making process (formal and informal)
3.	What do you consider the biggest challenges in managing public spaces? Are these challenges different when management is approached circularly?	● Complex Systems ● Socio-Technical Systems ● Public Asset Management ● Circular Economy	How are assets currently managed by the municipalities of Oegstgeest, Haarlem, and Amsterdam? What barriers are hindering circular asset management within the municipality Haarlem and Oegstgeest, and has Amsterdam also faced these barriers?	● Barriers ● Additional barriers in circular management
4.	To what extent are circular principles currently integrated into the management of assets?	● Public Asset Management ● Circular Economy ● R-Ladder	How are assets currently managed by the municipalities of Oegstgeest, Haarlem, and Amsterdam? What are the ambitions of the municipalities of Amsterdam, Haarlem and Oegstgeest for circular asset management?	● Current status of circularity ● Degree of translation of ambitions into measures
5.	(Can you provide examples of existing projects or initiatives within your municipality focused on circular management?)	● Public Asset Management ● R-Ladder ● Transition Management	What are the ambitions of the municipalities of Amsterdam, Haarlem and Oegstgeest for circular asset management?	● Concrete view of measures
Ambitions and Goals				
6.	Does your municipality have ambitions and/or specific goals regarding the circular economy and circular management of public spaces? If so, could you briefly describe them?	● Public Asset Management ● Sustainability Transitions ● Circular Economy ● R-Ladder ● Transition Theory ● Transition Management	What are the ambitions of the municipalities of Amsterdam, Haarlem and Oegstgeest for circular asset management?	● Goals and ambitions ● The concreteness of the goals/specific actions
7.	Are these goals widely known in both direct and indirect circles? Are additional parties involved compared to traditional management?	● Complex Systems ● Socio-Technical Systems ● Transition Theory	What are the ambitions of the municipalities of Amsterdam, Haarlem and Oegstgeest for circular asset management?	● Familiarity with the Goals ● Awareness ● Communication
8.	Are there specific plans or measures to achieve these goals? What are the priorities, and why?	● Public Asset Management ● Sustainability Transitions ● Transition Theory ● Transition Management	What are the ambitions of the municipalities of Amsterdam, Haarlem and Oegstgeest for circular asset management?	● Focus ● Afwegingen ● Specific actions ● Concrete results
Progress/Monitoring				

9. How does your municipality monitor the progress of circular initiatives and projects?	• Transition Management	What barriers are hindering circular asset management within the municipality Haarlem and Oegstgeest, and has Amsterdam also faced these barriers? What interventions are considered to tackle these barriers in circular asset management?	• Communication of goals and results • Communication of progress issues • Systems and processes
10. Have measurable indicators or KPIs been established to evaluate progress? If so, which ones?	• Sustainability Transitions • Circular Economy • R-Ladder • Transition Management	What barriers are hindering circular asset management within the municipality Haarlem and Oegstgeest, and has Amsterdam also faced these barriers? What interventions are considered to tackle these barriers in circular asset management?	• Standard • Definition of success • Instruments for measuring progress
11. How is progress reported and shared within the municipality and with external stakeholders?	• Complex Systems • Socio-Technical Systems • Transition Management	What barriers are hindering circular asset management within the municipality Haarlem and Oegstgeest, and has Amsterdam also faced these barriers? What interventions are considered to tackle these barriers in circular asset management?	• Communication • Transparency
12. How has the process towards your circular ambitions in management been so far?	• Sustainability Transitions • Transition Theory • Transition Management	What barriers are hindering circular asset management within the municipality Haarlem and Oegstgeest, and has Amsterdam also faced these barriers? What interventions are considered to tackle these barriers in circular asset management?	• Evaluation • Experience and lessons learned • Functioning of the mechanism (discussing issues, awareness, urgency, support, risks, budget, etc.) • Timelines for realisation
Challenges and Barriers			
13. What do you consider the biggest challenges in implementing circular principles in the management of public assets? Can you provide examples?	• Public Asset Management • Sustainability Transitions • Transition Management	What barriers are hindering circular asset management within the municipality Haarlem and Oegstgeest, and has Amsterdam also faced these barriers?	• Specific barriers • Concrete examples
14. How is the municipality currently dealing with these barriers? Have any steps already been taken to address them?	• Complex Systems • Socio-Technical Systems • Public Asset Management • Transition Management	What barriers are hindering circular asset management within the municipality Haarlem and Oegstgeest, and has Amsterdam also faced these barriers? What interventions are considered to tackle these barriers in circular asset management?	• Progress • Knowledge for approach • Measures • Strategies
Acceleration			
15. How could the municipality be supported in effectively implementing circular asset	• Complex Systems • Socio-Technical Systems	What barriers are hindering circular asset management within the municipality Haarlem and	• Barriers • Necessary help • Missing elements

management, and who should take the initiative for this?	• Public Asset Management • Sustainability Transitions • Transition Theory • Transition Management	Oegstgeest, and has Amsterdam also faced these barriers?	• Required roles from inside and outside the municipality
16. Are there specific policies or initiatives (from your municipality) that have proven successful in promoting circular management?	• Sustainability Transitions • Circular Economy • R-Ladder • Transition Theory • Transition Management	What interventions are considered to tackle these barriers in circular asset management?	• Good practices
17. How can collaboration with other municipalities, organisations, or the government contribute to achieving your circular goals?	• Complex Systems • Socio-Technical Systems • Sustainability Transitions • Circular Economy • Transition Theory	What interventions are considered to tackle these barriers in circular asset management?	• Possibilities for Cooperation • Advantages of cooperation • External parties
Wrap-up			
18. Do you have any other comments or suggestions regarding circular asset management within your municipality?	-	-	• Additional Information
19. Do you know other people or departments (within your municipality) who could provide valuable input for this research? If so, could you put me in contact with them?	-	-	• Expand network

Appendix G: Overview of Interviewees

Function interviewee	Organisation
Process Manager Sustainability - Department Project and Contract Management	Municipality of Haarlem
Policy Advisor Circular Economy	Municipality of Haarlem
Senior Policy Officer Sustainability - Department of Economy, Culture, Sustainability, and Housing	Municipality of Haarlem
Task-Oriented Asset Manager - Department of Management and Public Space Policy	Municipality of Haarlem
Director Future-Proof Assets	Municipality of Amsterdam
Advisor Future-Proof Assets - Urban Management Assets Road Infrastructure	Municipality of Amsterdam
Policy Maker Circular Built Environment	Municipality of Amsterdam

Area Manager - Area & Management	Municipality of Amsterdam
Policy Advisor Sustainability	Municipality of Oegstgeest
Asset manager	Municipality of Oegstgeest
Sustainability Manager	Sweco
Senior Advisor Development and Management of Public Space	Rijkswaterstaat
Advisor & Operational Manager Sustainability	Managing Public Space (MPS) & DON Bureau
Board Member & Senior Program Manager for Public Space, Infrastructure, Traffic and Transport, Mobility, and Procurement and Contracting	Managing Public Space (MPS) & CROW
Consortium Manager Future-proof Living Environment	AMS Institute

Appendix H: Informed Consent Form

Instemmingsformulier interview

Titel van het onderzoek: "*Advancing Dutch Municipalities Towards Circular Asset Management*"
Naam van de onderzoeker: Elise Rutten

Beschrijving van het onderzoek
U wordt gevraagd om deel te nemen aan een onderzoek. Dit is een onderzoek over het circulair beheer van assets binnen Nederlandse gemeenten.

U wordt gevraagd deel te nemen vanwege uw kennis van het beheer van publieke assets binnen uw gemeente en de circulaire ambities en praktijken hiervoor.

U wordt gevraagd om deel te nemen aan een interview. Dit zal ongeveer 1 uur in beslag nemen. Lees dit formulier goed door en stel eventuele vragen voordat u het ondertekent.

Risico's en voordelen van deelname aan het onderzoek
Dit onderzoek brengt weinig risico's voor u met zich mee. U kunt op elk moment stoppen met deelnemen en de vragen niet meer beantwoorden. Er zijn geen directe voordelen voor u bij deelname aan het onderzoek. Uw inbreng zal een belangrijke bijdrage leveren aan dit onderzoeksproject door uw kennis over circulair asset management en de uitdagingen op dit gebied te delen.

Vertrouwelijkheid
- De informatie die uit dit onderzoek voortkomt, kan worden gebruikt in dit onderzoek en worden gepubliceerd in een wetenschappelijk artikel, maar u zult niet persoonlijk worden geïdentificeerd zonder uw toestemming.
- Het interview zal opgenomen worden. Dit helpt om het gesprek later nauwkeurig te kunnen analyseren. Uiteraard worden de opnames vertrouwelijk behandeld en uitsluitend gebruikt voor dit onderzoek.

Vrijwillige aard van het onderzoek
Ik wil u hartelijk danken voor uw deelname aan dit onderzoek. Uw beslissing om deel te nemen is volledig vrijwillig. U kunt ervoor kiezen om geen enkel deel van het interview te beantwoorden of op elk moment te stoppen met deelname zonder enige gevolgen voor u.

_____ Ja, ik wil graag deelnemen aan het onderzoek.

_____ Nee, ik wil niet deelnemen aan het onderzoek.

	JA	NEE
1. Ik heb de informatie over het onderzoek begrepen en ik heb de mogelijkheid gehad om vragen te stellen over het onderzoek en mijn vragen zijn naar tevredenheid beantwoord.	☐	☐
2. Ik doe vrijwillig mee aan dit onderzoek, en ik begrijp dat ik kan weigeren vragen te beantwoorden en mij op elk moment kan terugtrekken uit de studie, zonder een reden op te hoeven geven.	☐	☐
3. Mij is verteld dat er audio-/video-opnames gemaakt kunnen worden tijdens mijn deelname, maar dat deze opnames niet voor publicatie in welk formaat dan ook zijn. Ik ben geïnformeerd dat ik kan vragen dat de opname op elk moment wordt stopgezet. Ik ga ermee akkoord om audio/video-taped te worden onder de hierboven vermelde voorwaarden.	☐	☐
4. Ik geef toestemming om mijn antwoorden, ideeën of andere bijdrages te quoten in resulterende producten.	☐	☐
5. Ik geef toestemming om mijn naam te gebruiken voor quotes in resulterende producten.	☐	☐

HANDTEKENINGEN

_____   _____   _____
Naam deelnemer   Handtekening   Datum

Ik, **de onderzoeker**, verklaar dat ik de informatie en het instemmingsformulier correct aan de potentiële deelnemer heb voorgedragen en, naar het beste van mijn vermogen, heb verzekerd dat de deelnemer begrijpt waar hij/zij vrijwillig mee instemt.

Elise Rutten

_____   _____   _____
Naam onderzoeker   Handtekening   Datum

Appendix I: Table of Interplay Between Barriers

BARR	P1	P2	P3	P4	P5	P6	ENV1	ENV2	S1	S2	S3	S4	S5	T1	T2	T3	T4	ECO1	ECO2	ECO3	ECO4	L1	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11
P1	0	2	1	2	0	2	0	1	0	1	0	2	0	0	1	0	0	0	1	0	0	0	1	0	0	2	2	0	0	0	0	1	0
P2	2	0	2	1	0	1	0	0	0	0	1	2	1	2	0	1	0	0	2	2	0	1	0	1	0	2	2	0	0	0	0	2	0
P3	1	2	0	1	2	0	0	0	1	0	0	2	0	1	1	2	1	0	0	0	2	0	1	0	2	0	2	0	2	1	0	0	2
P4	2	1	1	0	1	1	0	0	0	0	1	0	2	0	1	1	2	0	1	0	0	2	0	2	0	0	2	0	0	0	0	0	2
P5	0	0	2	1	0	0	0	0	1	0	1	1	0	0	1	0	0	0	1	0	0	0	1	0	0	2	0	0	0	1	0	0	2
P6	2	0	0	1	0	0	0	0	1	0	1	0	2	1	0	2	2	0	2	2	0	0	0	0	0	0	2	1	2	0	0	1	0
ENV1	0	1	0	0	0	0	0	2	0	0	1	0	1	0	0	2	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	1
ENV2	1	0	1	0	0	0	2	0	0	0	1	0	1	0	2	0	1	1	1	1	0	1	0	2	0	0	0	0	1	0	0	0	1
S1	0	1	0	0	1	0	0	0	0	1	1	0	0	2	1	0	1	2	2	0	0	2	1	1	0	0	0	1	0	0	0	0	0
S2	1	0	0	0	0	0	0	0	1	0	1	1	0	2	0	0	1	0	2	1	0	0	0	2	1	1	1	0	2	1	0	0	0
S3	1	1	0	1	1	1	1	1	1	1	0	2	1	2	0	1	1	2	1	1	1	0	0	2	0	0	0	2	2	0	0	1	0
S4	0	2	0	0	0	0	0	0	2	2	0	0	0	2	2	1	2	1	0	0	0	0	2	1	0	0	1	2	1	0	0	0	0
S5	2	1	1	0	2	0	1	0	2	1	2	0	0	1	2	1	0	2	1	1	0	1	0	2	0	0	1	1	1	2	2	0	1
T1	0	2	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	2	0	0	0	2	0	0	0	2	0	0	2	0	0	2	0
T2	1	1	0	2	1	1	0	0	1	1	0	0	0	0	0	2	2	0	0	2	1	1	2	2	2	2	0	0	1	0
T3	0	0	2	1	1	0	0	0	2	1	0	0	1	0	0	0	2	2	2	2	1	0	0	0	0	1	0	0	0	1	0	0	2
T4	0	0	1	2	0	2	0	1	1	1	2	2	0	2	2	2	0	2	2	0	0	1	1	1	1	2	1	1	0	0	0	1
ECO1	0	2	0	1	2	2	0	0	0	2	2	1	0	2	2	2	2	0	2	2	1	0	2	2	0	2	1	1	0	1	2	2
ECO2	1	2	1	0	1	0	0	1	2	2	1	1	1	2	0	0	2	0	2	2	1	2	1	2	1	2	0	0	0	0	1	2
ECO3	0	2	0	0	1	0	0	1	1	0	0	0	0	1	0	2	2	0	0	1	2	2	0	0	1	0	2	2	0	0
ECO4	0	1	0	0	0	2	0	0	0	2	0	0	0	1	1	2	0	2	2	1	0	1	0	0	0	0	0
L1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	2	0	0	0	0	0	0	0
O1	1	1	2	1	2	0	0	0	0	1	2	2	1	2	2	1	2	2	0	2	0	2	0	0	0	0	2	0	2
O2	0	0	0	1	0	0	2	1	1	2	1	2	1	0	0	2	0	1	2	2	0	1	2	2	2	0	0	2
O3	0	0	0	0	0	0	2	0	1	1	0	2	1	0	1	0	2	0	2	0	2	1	0	2	2	0	0
O4	2	2	2	2	0	0	0	0	1	2	0	1	2	2	2	0	2	1	1	0	1	0	0	1	0	0
O5	2	0	0	2	1	2	0	1	1	2	0	2	0	1	2	2	2	2	2	1	2	0	0	0	0	0
O6	0	0	0	0	1	0	0	1	0	1	2	0	1	2	0	1	1	0	1	0	2	2	0	0	0
O7	0	0	0	0	2	0	0	2	0	1	0	2	1	1	1	0	0	0	1	0	2	1	0	0
O8	0	0	0	0	0	0	1	0	0	0	0	0	2	2	2	1	0	0	1	2	1	0	0
O9	0	0	0	0	0	2	0	1	0	0	0	0	0	0	2	2	2	1	0	0	2	0	0
O10	1	2	0	0	1	0	0	0	0	1	2	0	1	0	0	2	1	0	0	0	0	0	0
O11	0	2	2	0	2	0	1	1	0	0	0	0	0	0	2	1	1	2	0	0	0	2	0

Appendix J: Statements from the Excel Questionnaire

Likert Scale:

- Strongly disagree = 5 = red
- Disagree = 4 = orange
- Neutral = 3 = yellow
- Agree = 2 = light green
- Strongly agree = 1 = green

Statements:

P1

- "The municipality has a clear vision regarding what circularity entails." (green - red: 1, 2, 3, 4, 5)
- "It is clear which themes are being addressed to achieve a circular economy within this municipality." (green - red: 1, 2, 3, 4, 5)

P2

- "The municipal circular goals and their priorities are clearly defined." (green - red: 1, 2, 3, 4, 5)

P3

- "There is an action program that concretises the municipality's circular goals." (green - red: 1, 2, 3, 4, 5)
- "The municipality has circular goals specifically aimed at managing public spaces." (green - red: 1, 2, 3, 4, 5)

P4

- "There are clear guidelines and indicators defined to measure the progress of circular goals." (green - red: 1, 2, 3, 4, 5)

P5

- "The municipality has a long-term vision that extends beyond the usual four-year political cycle." (green - red: 1, 2, 3, 4, 5)

P6

- "There is effective collaboration with other municipalities and stakeholders in achieving circular goals." (green - red: 1, 2, 3, 4, 5)

ENV1

- "The interests of residents and other stakeholders are taken into account in the decision-making process regarding circular goals in public spaces." (green - red: 1, 2, 3, 4, 5)

- "Residents and other stakeholders hinder the implementation of circular measures in existing public spaces." (green - red: 5, 4, 3, 2, 1)
- "There is a lack of space in existing public areas, which complicates the realisation of circular measures." (green - red: 5, 4, 3, 2, 1)

ENV2

- "Users of public spaces understand why reused materials are chosen." (green - red: 1, 2, 3, 4, 5)

S1

- "There is sufficient internal communication between different departments and functions within the municipality." (green - red: 1, 2, 3, 4, 5)
- "Conflicting interests between departments hinder the realisation of circular goals." (green - red: 5, 4, 3, 2, 1)

S2

- "Employees are motivated to contribute to circular goals." (green - red: 1, 2, 3, 4, 5)
- "There is sufficient willingness among employees to adopt new circular working methods." (green - red: 1, 2, 3, 4, 5)

S3

- "There are sufficient resources and capacity available to support and follow up on circular initiatives over the long term." (green - red: 1, 2, 3, 4, 5)
- "The municipality is well guided in the use of tools and methodologies for circular goals." (green - red: 1, 2, 3, 4, 5)

S4

- "Employees within the municipality are sufficiently familiar with the concept of circularity." (green - red: 1, 2, 3, 4, 5)
- "There are sufficient training opportunities for municipal employees to learn more about circular processes." (green - red: 1, 2, 3, 4, 5)
- "The benefits of circular goals are clearly communicated to employees within the municipality." (green - red: 1, 2, 3, 4, 5)

S5

- "Municipal employees are hesitant to implement major changes or make decisions due to fear of negative reactions." (green - red: 1, 2, 3, 4, 5)

T1

- "It is clear how to develop policies that align with national goals." (green - red: 1, 2, 3, 4, 5)
- "It is clear how to move from policy to practical implementation." (green - red: 1, 2, 3, 4, 5)
- "It is clear how circular processes should be operationalized." (green - red: 1, 2, 3, 4, 5)

- "There is sufficient knowledge and experience within the municipality to realise circular goals." (green - red: 1, 2, 3, 4, 5)

T2

- "Data on circular goals are consistently collected, stored, and analysed." (green - red: 1, 2, 3, 4, 5)
- "Clear agreements are in place on how data from (circular) projects are measured and shared." (green - red: 1, 2, 3, 4, 5)
- "The municipality has a clear data management system to record the results of circular efforts." (green - red: 1, 2, 3, 4, 5)
- "It is clear where the municipality stands regarding the set circular goals and which measures have the most impact." (green - red: 1, 2, 3, 4, 5)

T3

- "Circular processes can be easily integrated into the current public space." (green - red: 1, 2, 3, 4, 5)
- "The infrastructure is well adapted to facilitate the reuse of materials." (green - red: 1, 2, 3, 4, 5)
- "Circular applications are considered in the design of public spaces." (green - red: 1, 2, 3, 4, 5)

T4

- "There is sufficient technical knowledge about the application of reused materials in public spaces." (green - red: 1, 2, 3, 4, 5)
- "There are clear guidelines and standards for the application of reused materials in public spaces." (green - red: 1, 2, 3, 4, 5)

ECO1

- "The municipality has sufficient financial resources to realise circular projects." (green - red: 1, 2, 3, 4, 5)
- "There is sufficient time and expertise available within the organisation to support the circular transition." (green - red: 1, 2, 3, 4, 5)

ECO2

- "The municipality is willing to implement circular measures in projects, even if it involves higher costs." (green - red: 1, 2, 3, 4, 5)

ECO3

- "The budget allocation for circular goals is clearly defined and communicated within the organisation." (green - red: 1, 2, 3, 4, 5)

ECO4

- "The municipality has sufficient expertise to critically assess suppliers' proposals on circular aspects." (green - red: 1, 2, 3, 4, 5)
- "The suppliers the municipality works with are flexible in offering circular alternatives." (green - red: 1, 2, 3, 4, 5)
- "The municipality can effectively negotiate with suppliers to implement circular solutions." (green - red: 1, 2, 3, 4, 5)

L1

- "Existing contracts hinder the implementation of circular measures in public spaces." (green - red: 5, 4, 3, 2, 1)
- "The municipality can easily adapt ongoing contracts to accommodate circular goals." (green - red: 1, 2, 3, 4, 5)

O1

- "The (financial) systems within the municipality are designed to support circular goals." (green - red: 1, 2, 3, 4, 5)
- "Decisions within the organisation are primarily made based on financial and economic considerations." (green - red: 5, 4, 3, 2, 1)
- "The financial models used by the organisation consider the benefits of circular applications." (green - red: 1, 2, 3, 4, 5)

O2

- "Roles and responsibilities for (circular) projects are clearly defined within the municipality." (green - red: 1, 2, 3, 4, 5)
- "The municipality has sufficient expertise to realise circular goals." (green - red: 1, 2, 3, 4, 5)
- "Circular tasks are assigned to the right employees within the organisation." (green - red: 1, 2, 3, 4, 5)
- "The inflow of new employees with knowledge of circularity is sufficient to ensure the continuity of the transition." (green - red: 1, 2, 3, 4, 5)

O3

- "There is good communication between departments, and information and knowledge are actively shared." (green - red: 1, 2, 3, 4, 5)
- "Departments within the municipality work effectively together to achieve circular goals." (green - red: 1, 2, 3, 4, 5)
- "An integrated approach is adopted when realising circular goals." (green - red: 1, 2, 3, 4, 5)

O4

- "Concrete actions have been formulated to realise the circular goals." (green - red: 1, 2, 3, 4, 5)

O5

- "The municipality's circular goals are clearly communicated." (green - red: 1, 2, 3, 4, 5)

- "The results of circular projects are actively shared with internal and external stakeholders." (green - red: 1, 2, 3, 4, 5)
- "Best practices are shared with other municipalities." (green - red: 1, 2, 3, 4, 5)

O6

- "All relevant staff within the municipality know where and how to find relevant information about (circular) projects." (green - red: 1, 2, 3, 4, 5)
- "It is clear with whom information and knowledge should be shared, and this communication is tailored to the target audience that needs to be reached." (green - red: 1, 2, 3, 4, 5)

O7

- "Knowledge exchange about circular projects within the municipality is efficient and structured." (green - red: 1, 2, 3, 4, 5)
- "Knowledge and experience related to circular projects are well retained within the organisation." (green - red: 1, 2, 3, 4, 5)
- "The municipality has a central place where knowledge and experiences (regarding circular projects) are shared and stored." (green - red: 1, 2, 3, 4, 5)

O8

- "The physical layout of the organisation hinders collaboration on circular goals." (green - red: 5, 4, 3, 2, 1)
- "The role allocation within the organisation is clear and promotes integrated work on circular projects." (green - red: 1, 2, 3, 4, 5)

O9

- "Responsibilities within (circular) projects are clearly divided and well-defined." (green - red: 1, 2, 3, 4, 5)
- "The decision-making process is complicated by many small responsibilities assigned to various officials." (green - red: 5, 4, 3, 2, 1)
- "There is an equal level of influence among departments within the organisation." (green - red: 1, 2, 3, 4, 5)

O10

- "The municipality has a good understanding of the impact of the circular transition on the organisation." (green - red: 1, 2, 3, 4, 5)

O11

- "The municipality is able to integrate circular goals with the regular management of public spaces." (green - red: 1, 2, 3, 4, 5)

Appendix K: Chord Diagrams of Individual Barriers

Political

Environmental

Social

Technological

119
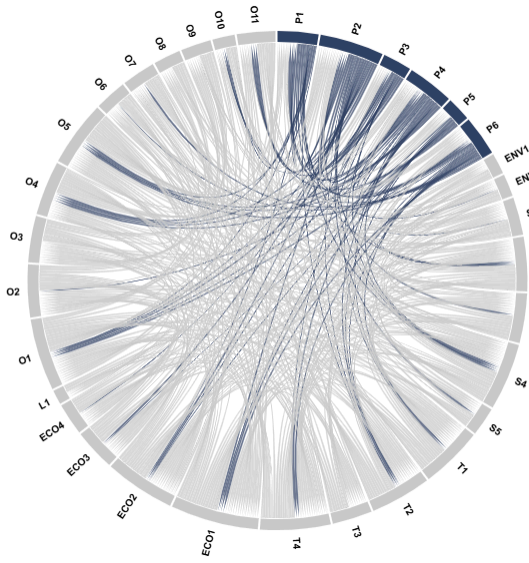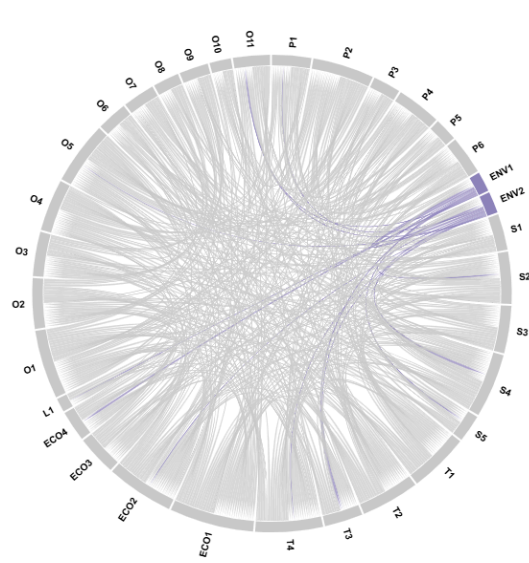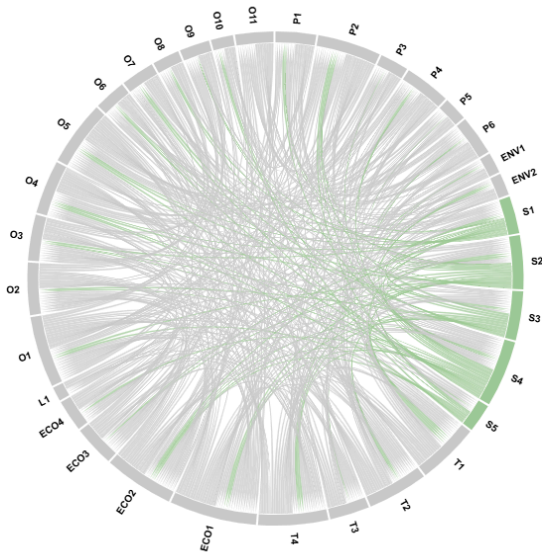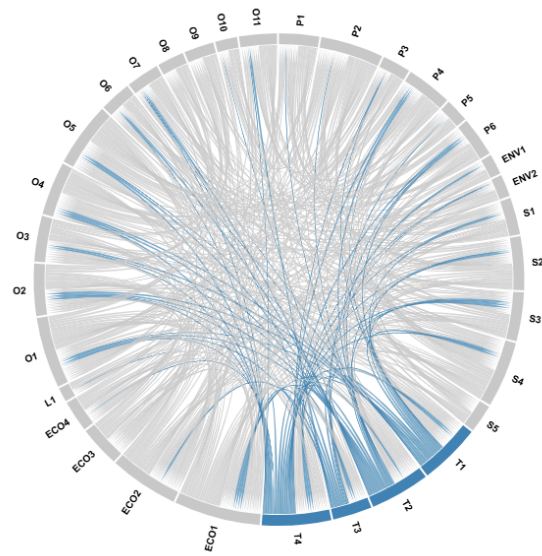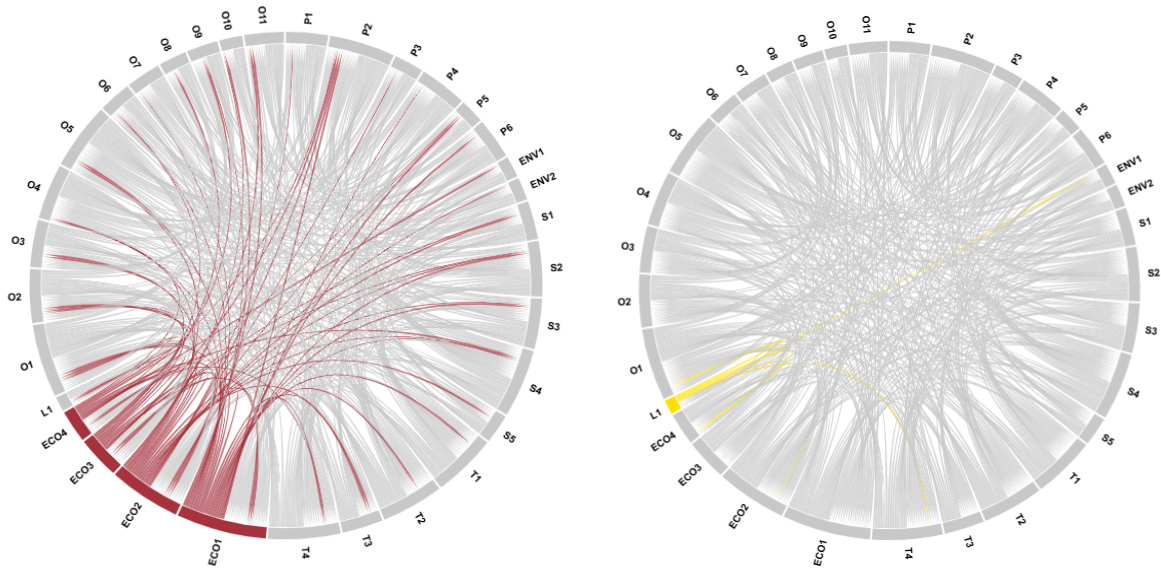
Economic

Legal
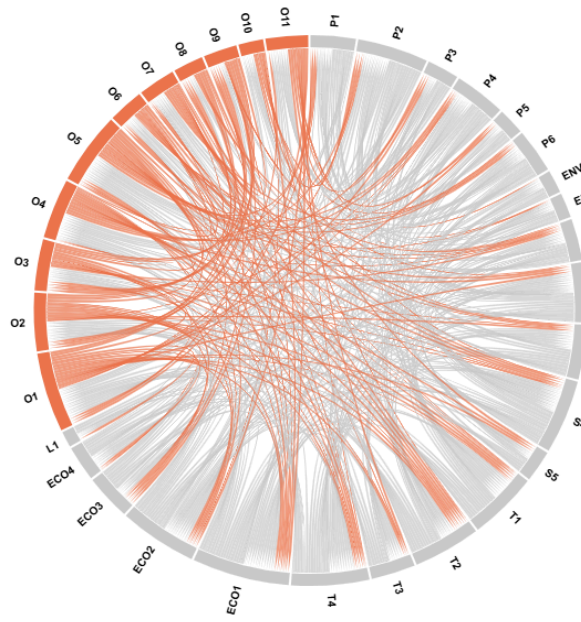
Organisational

Appendix L: Step-by-Step Guide from the Decision-Support Tool

Appendix M: Excel Questionnaire from the Decision-Support Tool

QUESTION	Strongly disagree	Disagree	Neutral	A
1. The municipality has a clear vision regarding what circularity entails.				
2. It is clear which themes are being addressed to achieve a circular economy within this municipality.				
3. The municipal circular goals and their priorities are clearly defined.				
4. There is an action program that concretises the municipality's circular goals.				
5. The municipality has circular goals specifically aimed at managing public spaces.				
6. There are clear guidelines and indicators defined to measure the progress of circular goals.				
7. The municipality has a long-term vision that extends beyond the usual four-year political cycle.				
8. There is effective collaboration with other municipalities and stakeholders in achieving circular goals.				
9. The interests of residents and other stakeholders are taken into account in the decision-making process regarding circular goals in public spaces.				
10. Residents and other stakeholders hinder the implementation of circular measures in existing public spaces.				
11. There is a lack of space in existing public areas, which complicates the realisation of circular measures.				
12. Users of public spaces understand why reused materials are chosen.				
13. There is sufficient internal communication between different departments and functions within the municipality.				
14. Conflicting interests between departments hinder the realisation of circular goals.				
15. Employees are motivated to contribute to circular goals.				
16. There is sufficient willingness among employees to adopt new circular working methods.				
17. There are sufficient resources and capacity available to support and follow up on circular initiatives over the long term.				
18. The municipality is well guided in the use of tools and methodologies for circular goals.				
19. Employees within the municipality are sufficiently familiar with the concept of circularity.				
20. There are sufficient training opportunities for municipal employees to learn more about circular processes.				
21. The benefits of circular goals are clearly communicated to employees within the municipality.				
22. Municipal employees are hesitant to implement major changes or make decisions due to fear of negative reactions.				
23. It is clear how to develop policies that align with national goals.				
24. It is clear how to move from policy to practical implementation.				
25. It is clear how circular processes should be operationalised.				
26. There is sufficient knowledge and experience within the municipality to realise circular goals.				
27. Data on circular goals are consistently collected, stored, and analysed.				
28. Clear agreements are in place on how data from (circular) projects are measured and shared.				
29. The municipality has a clear data management system to record the results of circular efforts.				
30. It is clear where the municipality stands regarding the set circular goals and which measures have the most impact.				
31. Circular processes can be easily integrated into the current public space.				
32. The infrastructure is well adapted to facilitate the reuse of materials.				
33. Circular applications are considered in the design of public spaces.				

Appendix N: Theoretical Reflection of CE

The concept of the Circular Economy (CE) presents a transformative solution to the prevailing linear economic model by addressing its inherent social, economic, and environmental issues. By aiming to decouple economic growth from resource depletion and environmental degradation, the CE emphasises preserving the value of products and materials throughout their lifecycle. The assumption in theory that the take-make-dispose model is fundamentally opposed to the circular model is confirmed from various perspectives in this research. Transitioning to a circular model requires many aspects of business operations to be adjusted. For instance, the logistics of replacement in the traditional model are based on fixed replacement cycles, with logistics aligned accordingly. In contrast, the circular model necessitates an assessment of the condition of public assets, after which logistics have to be arranged based on the outcome. Such a fundamental change in logistics and operations can initially hinder cost efficiency, but with central guidelines and policy support prioritising circularity, the entire system can be aligned to work effectively under this new paradigm.