CIRCULAR AREA DEVELOPMENT

Guidelines for Circular Design Strategies in Residential Area Development

Master thesis by
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Circular Area Development

Guidelines for Circular Design Strategies in Residential Area Development

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PREFACE

Before you lies the result of an eight-month research into the topic of circular area development processes, "Circular Area Development - Guidelines for Circular Design Strategies in Residential Area Development". This research is the culmination of my graduation process for the master's in Construction Management and Engineering at the Faculty of Civil Engineering and Geosciences.

Six years ago, I began as a first-year Architecture student at the Faculty of Architecture at TU Delft, with the ambition to develop myself as an architect. Throughout the bachelor's programme, I acquired a broad variety of skills and knowledge in the construction sector, including area development processes. As the bachelor's progressed, I found the processes present in the construction sector more interesting than the act of designing itself. Consequently, I decided to start the master's Construction Management and Engineering, aligning more with this interest. Moreover, as far as I can remember I found sustainability an interesting and important topic, as I believe it is the way forward. Hence, when the time arrived to find a topic for my graduation research, I wanted to delve into something related to sustainability. Combined with my interest in area development processes, this led me towards my research topic: circular area development processes.

After months of research, the findings present interesting insights into the processes of circular area developments and how these processes can be enhanced. The results offer valuable insights for clearer practical implementation, which ideally can serve as guidance for practitioners. The past eight months were an intense, but enlightening process, which figuratively speaking (and sometimes quite literally) took blood, sweat, and tears to achieve. Throughout this process, I could apply knowledge and skills acquired during my six years. However, I also acquired many new skills and gained more knowledge, developing myself even further. Before sharing the findings of this research, I want to express my gratitude to everyone who supported me along the way.

To start, I would like to express my appreciation to my graduation committee for their assistance and insights throughout the process. Special thanks to my first supervisor, Dominika Teigiserová, for your enthusiasm and support during this research. Thanks to your guidance towards promising directions, the process became manageable for me. Karel van den Berghe, I would like to thank you for the insights you provided and your knowledge on circular area development. Daan Schraven, I would like to thank you for your critical feedback and guidance during the research. Finally, I would like to thank my company supervisor, Birrutte Samekto, for your enthusiasm for the research topic and your support at Waalpartners, in aiding me to connect with the right people for conducting my research, which made the process smoother. I highly appreciate the time you all spend to helping me achieve this research.

Moreover, I want to thank Waalpartners for the opportunity they provided me to conduct this research. Also, a thank you to all colleagues at Waalpartners who ensured I had an enjoyable graduation period. Additionally, I wish to express my gratitude to all interview participants for their contribution to this research by sharing their experiences and knowledge, aiding me in completing my studies.

To my friends and family; thank you for being there for me during tough times and celebrating with me during the good times. I wish to thank my friends for your support, for studying together, but also for the distractions and laughter you provided. Finally, many thanks to my parents for your support during this research, and over the past six years. Thank you for creating a situation for me, where I can pursue my dreams.

Enjoy reading.

Karlijn van Velzen
November, 2023

EXECUTIVE SUMMARY

Globally, efforts are made to transition towards a circular economy, as it offers solutions to many societal challenges, such as climate change, biodiversity losses, and resource security (PBL, 2023). Consequently, the construction sector has to integrate circular economy principles. Further, academics agree that comprehensive implementation of circularity strategies can lead to great benefits in the ecological, economic, and social spheres (Mijer, 2022; Williams, 2021a). In this regard, urban planning plays a significant role in shaping the built environment, offering an opportunity to integrally implement circular design principles in area development (Girard & Nocca, 2020; Infomil, 2023).

However, only limited implementation of circular principles in area development projects is seen. Attributed to several factors. First, the ambiguity of circular design themes for the built environment (Heurkens, 2018; Mhatre et al., 2021). Furthermore, limited information about when to define circular design strategies during the design phases. Lastly, literature suggests a lack of coordination in strategy implementation and urban planning (Augiseau, 2020; Säumel et al., 2019; Williams, 2020). Hence, this research aims to address these gaps, focusing on key circular design themes and understanding the necessary changes in for their implementation in the process. To achieve this research objective, the main research question is phrased as follows:

"How can circularity themes and interventions be integrated in the different phases of the planning process of urban area development?"

RESEARCH METHODS

To conduct this research, a qualitative case-based design study has been conducted. Initially, an extensive literature review was conducted to understand the influential characteristics and definitions of both area development and the circular economy. Following the scientific background, a mixed-method approach was adopted to effectively address the thesis objective. This approach encompassed a systematic literature review and a comparative case study have been conducted.

The systematic literature review aimed to establish a comprehensive overview of significant circular design themes for area development, utilizing the Scopus database for sources. In total, 54 articles were reviewed. Additionally, a comparative case study was employed to gain understanding of barriers and accelerators for the implementation of circular design themes and strategies in the process. A cross-case analysis was used to identify similarities and differences between the case barriers and accelerators across cases, filtering out case-specific information. Conducting the comparative involved semi-structured interviews and document analysis. A total of eleven stakeholders, three to four per case with various roles, were interviewed. Furthermore, the results of the systematic literature review were evaluated in the context of the comparative case study.

The outcomes from both the case study and literature review were triangulated to develop phase-wise guidelines for circular area development processes. These guidelines include information about significant circular design strategies and recommended changes in the process to overcome barriers or enhance accelerators. To ensure the validity of the results, the guidelines underwent two validation sessions. Based on the opinions and needs of the target group, changes were applied.

RESULTS

In the systematic literature review, eleven circular design themes, shown in Figure 0.1, along with 42 corresponding sub-themes, were identified as crucial to consider in the process. These themes cover eleven design topics for establishing and implementing circular strategies, ensuring the inclusion of both quantitative and qualitative aspects.

Through the case study analysis, various barriers, accelerators, and lock-in moments in the process were identified. Overcoming barriers, consciously using accelerators, and addressing lock-in moments are essential for incorporating the eleven design themes. Because establishing ambitions regarding the themes is one, but ensuring implementation is second. To aid this, eleven guidelines were developed based on these identified factors. These guidelines are categorized into five 'change management' elements that influence the entire process and six additional guidelines to apply during the standard development process. These guidelines, illustrated in Figure 0.1, are integrated into the traditional area development process, optimizing the incorporation of circular design strategies.

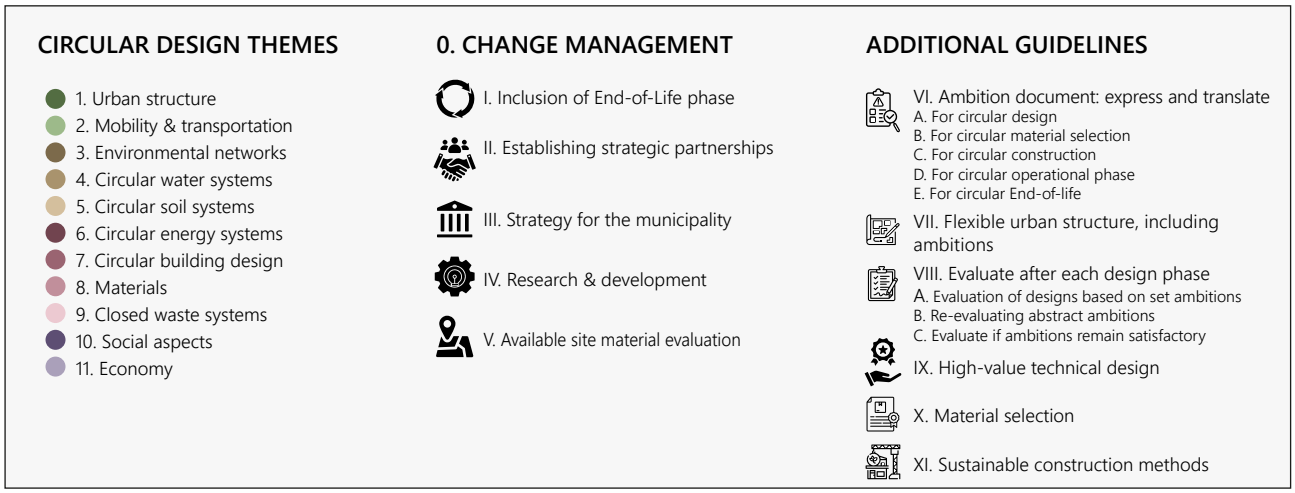


Figure 0.2: Results; circular design themes and guidelines for the process.

CONCLUSION

Figure 0.2 visually represents these guidelines in relation to the process, indicating specific actions or considerations at each stage of the process. Therefore, at any point in the process, the figure and guidelines can be reviewed and used to determine the actions necessary to facilitate circular principles. By emphasising crucial moments and topics, the use of the guidelines maximize opportunities, particularly through actions during the project's initiation phase and change management, setting a conscious foundation for circular area development processes. Ultimately, the guidelines assist development teams in overcoming barriers, utilizing accelerators, and ensuring consistency in decisions made throughout the lengthy development process. The adoption of guidelines in the traditional area development process leads to the most optimal situation for the inclusion of circular design strategies.

DISCUSSION

The developed guidelines offer a comprehensive roadmap for each stage of the development process, providing teams with tools to enhance circular design implementation. They present an extensive overview of all circular design themes, outlining when themes should be elaborated and in which phases they are crucial in achieving circularity. This model is adaptable for use at every process stage. It offers insights into change management, before the process starts, and gives guidance during the actual project phases.

The additional change management elements are identified as temporary actions. These highlight focal points that require attention, which may not yet be commonplace. As a fully circular economy becomes established, these elements are expected to evolve into standard practices or even be incorporated into policy. Until then, these elements deserve attention.

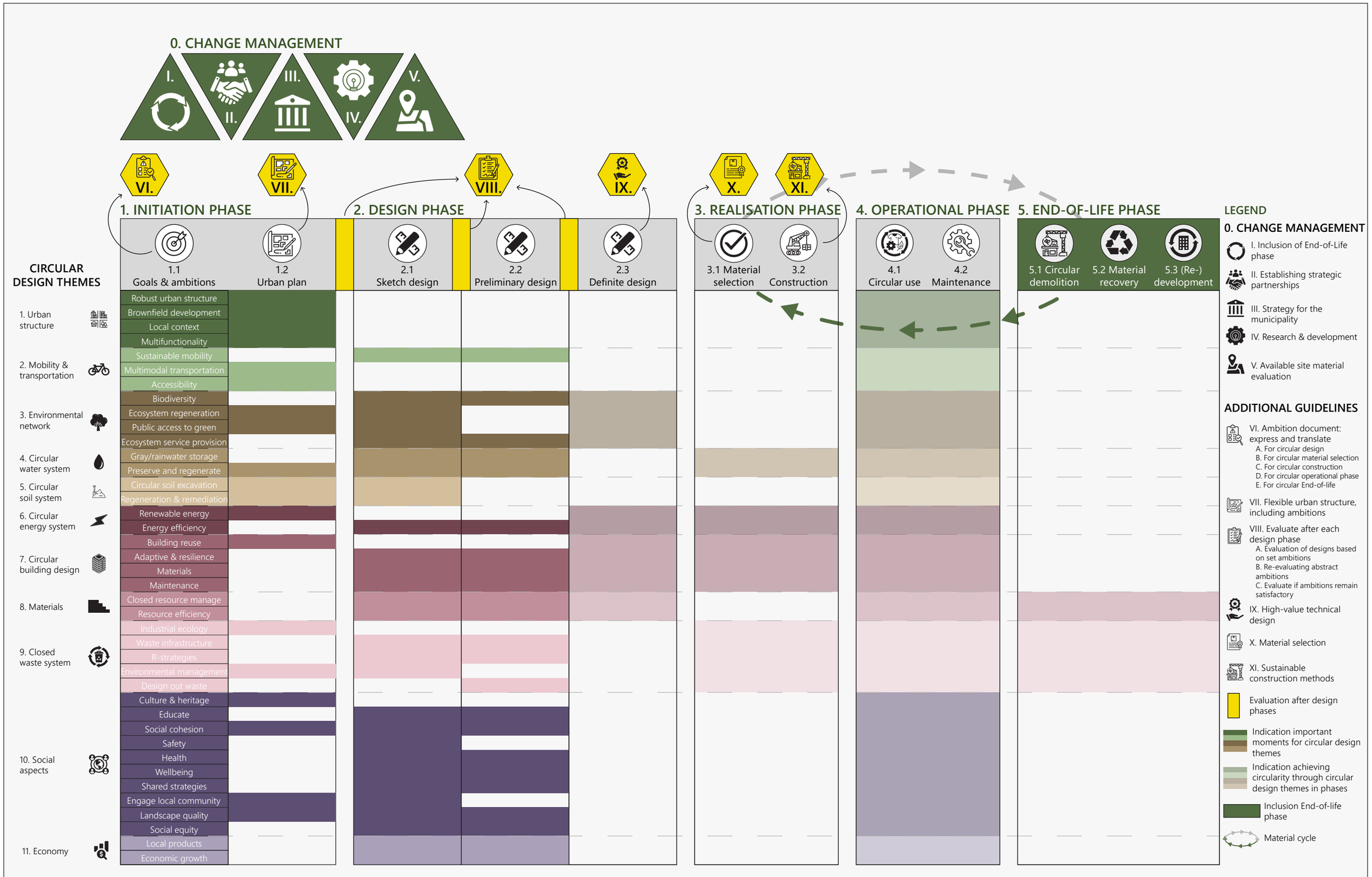
Implementing these guidelines in practice also addresses the tension between clarity and flexibility. They serve as a tool that clarifies ambitions and decisions throughout the process, yet afford stakeholders the flexibility to set their own pace for incorporating themes. Additionally, clarity of descriptive circular design themes is enhanced, while also enhancing flexibility for descriptive circular design themes. Finally, the application of 'evaluation sessions' further amplifies stakeholders flexibility in setting ambitions.

RECOMMENDATIONS

Several recommendations for future research stem from this research. The cases examined in this research offer divers land policies and initiatives, only small-scale developments are considered. There is an underrepresentation of small-scale and active municipal land policy developments. To generalise the results for large-scale developments and municipality initiatives, further research is essential. Increasing the sample size would also increase the validity of the case study research.

With regards to the research results, research into the value and practical application of evaluation sessions seems significant. In particularly, when during the process evaluations can and should be applied. Research regarding evaluation in urban planning was underrepresented in the systematic literature review. Additionally, practitioners mentioned that these are hard to implement, as 'they are working on a moving train'.

In general, a crucial limitation affecting the success of the guidelines and circular design themes, is the market readiness. Notably, substantial technological barriers, such as the absence of warranties on reused materials, impede transitions. Addressing these barriers is crucial for the transition towards a circular economy.



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LIST OF ABBREVIATIONS

CBE	Circular Built Environment
CBS	Centraal Bureau voor de statistiek
CE	Circular Economy
DD	Definite Design
EMF	Ellen MacArthur Foundation
EU	European Union
GHG	Greenhouse gas
NOAA	National Centers for Environmental Information
PBL	Planbureau voor de Leefomgeving
PD	Preliminary Design
R&D	Research and Development
UN	United Nations
SD	Sketch Design
SD	Sustainable development
SDGs	Sustainable development goals
SQ	Sub-question
TU Delft	University of Technology Delft

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CHAPTER

01

INTRODUCTION

1. INTRODUCTION

The impact of climate change is becoming increasingly visible and tangible as the frequency and intensity of extreme weather events, such as droughts, floods and wildfires, are on the rise, accompanied by a steady rise in the average global temperature (Moleman, 2023; NOAA, 2023; NOS Nieuws, 2022). For instance, nine of the top ten hottest years on record have occurred within the past nine years (2014 to 2022).

Simultaneously, the world's population continues to grow fast. From 1950 until 2021 it has grown from about 2.5 to 8 billion, and it is expected to peak at nearly 10.4 billion by 2080 (United Nations, 2022a). Meaning that more resources are needed to meet the demands of the population. As a result of urbanisation, more than half of these people currently reside in urban settlements, including cities, towns and suburbs. Europe has an even higher urbanization rate of 75% (United Nations, 2022b). For the Netherlands, it has been predicted that urbanisation requires the construction of 75 thousand extra houses each year (Circular Economy, 2022).

In this regard, circular economy (CE) principles have been gaining popularity in the past years. Mainly, due to its promising characteristics, as it offers solutions to many societal challenges, such as climate change, biodiversity losses, and resource security (PBL, 2023).

The challenges of both climate change and urbanization are interrelated, given that the expanding global population and urbanisation demand more and more finite resources, thereby imposing a strain on the environment and society. Continuing down this path could potentially trigger abrupt changes in environmental systems, transforming the world into a state that is unsuitable or less favourable for human development (Rockström et al., 2009).

Given the urgent nature of the possible global impacts and the potential of the CE, governments, policymakers and civilians find the topic highly relevant. This becomes evident when examining national, European and international goals and policies; CE principles are embedded in the sustainable development goals (SDGs) of the United Nations (UN), and European and Dutch governmental policies (European Commission, 2020, 2021; Rijksoverheid, 2022; United Nations, 2015).

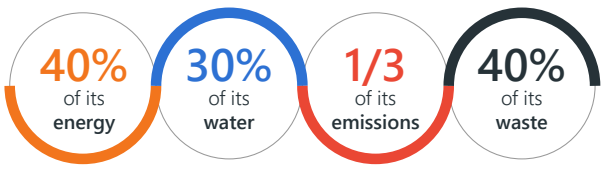


Figure 1.1: Dutch built environment. Source: (Circular Economy, 2022)

1.1. POTENTIAL OF CIRCULAR AREA DEVELOPMENT

The construction sector is one of the key areas that requires a transformation. Globally, the built environment is accountable for immense amounts of resource consumption, emissions and waste production. According to the European Commission (2020), the built environment accounts for around 50% of the extracted materials and is responsible for around 35% of all waste in the EU. Similarly, in the Netherlands, the built environment accounts for 40% of the energy consumption, a third of the emissions and 40% of the waste production, Figure 1.1 (Circular Economy, 2022; PBL, 2023).

These facts highlight the need for sustainable practices, as well as improving the existing built environment in the fight against climate change. Implementing CE is seen as an opportunity, as the concept theoretically eliminates waste (EMF, 2013; Kirchherr et al., 2017). Resources, products and materials are continuously reused at their highest value, minimizing the burden on the environment.

Nonetheless, implementing circularity principles in the built environment can yield more benefits than solely minimizing resources usage. Comprehensive implementation of circularity strategies in area development can lead to great benefits in the ecological, economic and social spheres (Mijer, 2022; Williams, 2021a). Urban planning and, specifically, area development have a significant role in designing, shaping and governing functionalities in the built environment (Girard & Nocca, 2020), as it includes an integrative process that brings different aspects in cohesion (Infomil, 2023). Thus, area developments can integrally implement circular design principles and drive systematic change, and thereby can improve the circular design of areas (Van den Berghe & Vos, 2019; Williams, 2021b).

Therefore, area development provides a tool through which CE principles can be translated and implemented into the built environment, enabling the creation of regenerative and adaptable urban environments. Urbanization can be used as an adaptation strategy; it is an opportunity to address the pressing consequences of climate change through the development of resilient cities (Nhamo et al., 2021).

1.2. KNOWLEDGE GAP

Although the concept of a CE is widely recognised as potentially ground-breaking to mitigate the effects of climate change and create environments that are not only sustainable but also desirable and enable human habitation, only limited progress regarding circular projects in the construction industry is seen in practice (Ghaffar et al., 2020; Ghisellini et al., 2016). The limited progress could partially be explained by three factors regarding comprehensiveness of strategies, the planning phases of area development and the coordination between these. These factors are elaborated in the following paragraphs.

Firstly, information on how to achieve circular design and what aspects to include in area development projects **remains ambiguous** (Heurkens, 2018; Mhatre et al., 2021). There is no broad consensus about the circular built environment (CBE) and the associated circular strategies and aspects (Adams et al., 2017; Bucci Ancapi et al., 2022; Heurkens, 2018; Lieder & Rashid, 2016; Mhatre et al., 2021; Rahla et al., 2021a). Various studies highlight that comprehensive approaches are lacking, however they are essential for circular and sustainable environments (Adams et al., 2017; Bucci Ancapi et al., 2022; Mhatre et al., 2021; Munaro et al., 2020). According to Bosone et al. (2021), comprehensive strategies consist of both tangible (quantitative) and intangible (qualitative) values. They indicate that in practise tangible indicators for CE are dominant, **while intangible values are still often neglected.**

This phenomenon is noticeable in the current research on circular principles, which focuses on looping and recycling actions, or in other words the 'end-of-life' strategies (Adams et al., 2017; Kirchherr et al., 2017). Similarly, in practice circular projects are often promoted through the reuse of building materials; e.g. 95% material reuse in Park070 in Voorburg (BPD, 2023b); 80% of reused materials in the office renovation for Alliander (Dura Vermeer, 2023). While, strategies such as 'rethink', reduce' or strategies regarding social benefits, such as health, are intangible and, therefore, often forgotten (Corvellec et al., 2022; Ghisellini et al., 2016, 2018; Girard & Nocca, 2020; Kirchherr et al., 2017).

Secondly, Munaro (2020) and Smitha & Thomas (2021) suggest that CE strategies should be applied by integrating them into the early phases of the design process, as implementation in the earlier phases of the process influences the amount of circularity in the later phases (Smitha & Thomas, 2021). However, none of these authors specify which decisions are necessary for which phase of the design process.

The 'cost for change' theory affirms the indication that it is more feasible to include changes at the beginning of the process, as these first phases are characterised by high design freedom and low cost for changes (Dewulf, 2013; Gerritse, 2008; Wamelink, 2010), visible in Figure 1.2. Similarly, the 'process theory' indicates that outcomes in the process are strongly influenced by the sequence of events (Van de Ven, 2007). These theories confirm that early adoption of strategies is vital for circular design. However, there is **still lack of knowledge about specific strategies in combination with specific phases** of the process.

Finally, a **lack of coordination** exists between these comprehensive strategies and their implementation in urban planning, although this is important for CE advancement in the built environment (Augiseau, 2020; Säumel et al., 2019; Williams, 2020).

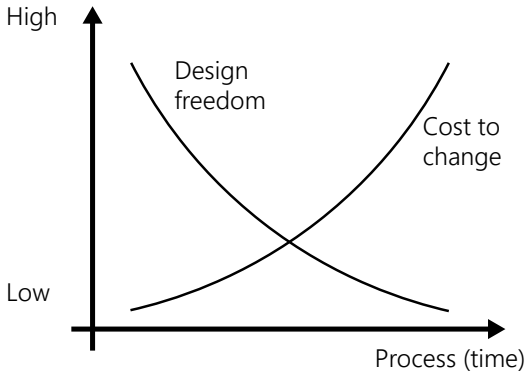


Figure 1.2: Cost for change and design freedom during the process. Source: (Dewulf, 2013; Gerritse, 2008; Wamelink, 2010)

1.2.1. PROBLEM STATEMENT

Thus, to advance implementation, the necessary strategies and their placement in the process of circular area development should be made clearer. Therefore, the problem statement addressed in this thesis is:

In the current literature, there is a lack of knowledge regarding comprehensive circular design themes for circularity measures in area development. Furthermore, there is a lack of understanding about the impact of the sequence of decisions and actions and their placement in planning phases of the process.

This problem statement comprises of three elements. Firstly, it addresses the need for knowledge about circularity strategies and aspects. Strategies are currently fragmented and tend to favour tangible indicators above intangible ones (Bosone et al., 2021; Corvellec et al., 2022; Girard & Nocca, 2020; Kirchherr et al., 2017). Research on this topic clarifies what circular strategies and measures are available.

Additionally, it addresses the temporal aspect in the design process, as studies state that circularity strategies should be implemented early in the process, to optimise results (Munaro et al., 2020; Smitha & Thomas, 2021), but do not elaborate further on this.

Lastly, it combines the first two, as it creates the necessary link between strategies and their placement in the development process (Augiseau, 2020; Säumel et al., 2019; Williams, 2020).

This problem statement suggests the need for a holistic overview of the strategies in combination with the design process; a framework that can be used as a guiding tool, can bring clarity for both science and practice, without constraining on the design flexibility that is necessary for circular solutions. A framework in the form of phase-specific meta-guidelines can improve the connection to practice, making it easier to overcome barriers.

1.3. RESEARCH OBJECTIVE

This thesis attempts to make a relevant contribution to the existing academic literature about implementation of circular strategies in area development. This is accomplished by critically reflecting on the existing body of knowledge and conducting an empirical review on the necessary changes in the process.

Therefore the objective of this research is:

"To gain insight into circular design themes, as well as the required changes during circular area development processes. This will be achieved by developing phase-specific meta-guidelines for the planning process of area development."

With this objective, this research makes the application of circular design strategies in area development more concrete and easier to manage. The guidelines clarify the importance and impact of certain decisions in the planning process, as well as their window of opportunity. These guidelines fit with the dynamic nature of area development projects, while at the same time providing the desired guidance.

1.3.1. RESEARCH QUESTIONS

The research objective of this thesis is studied through the following main research question:

"How can circularity themes and interventions be integrated in the different phases of the planning process of urban area development?"

This research question generates knowledge about the actions and decisions necessary in the planning phases of area development to enable and circular design in neighbourhoods. Based on information gathered through this research question, generalised phase-wise meta-guidelines can be developed. Enabling and enhancing circular design strategies in future area development projects.

NULL-QUESTION

Before conducting the research, a 'null' question was answered, to get grip on the theoretical foundation of this research. The 'null'-question is:

SQ0. What are the key principles of the circular economy in the context of area development?

SUB-QUESTIONS

To answer the main research question addressed in this research, three sub-questions have been established.

The first sub-question elaborates on the different themes that should include circular design strategies to accomplish circular area development designs. Given the limited existing knowledge about these aspects in current literature, this is necessary to facilitate an objective analysis of the case studies and to create the guidelines objectively.

SQ1. What are the essential themes or elements that should be considered when developing a circular area development project?

Sub-question two elaborates on the necessary changes in design processes of area developments to facilitate the application of circular design strategies.

SQ2. What actions are necessary in the different planning phases of area development to facilitate and enhance circular design strategies in the projects?

Finally, the implications of the results obtained from the preceding sub-questions on future area development processes are explained using sub-question three.

SQ3. What are the implications of the identified changes for the planning process of future area development projects?

The coherence of these research questions is illustrated in figure 1.3.

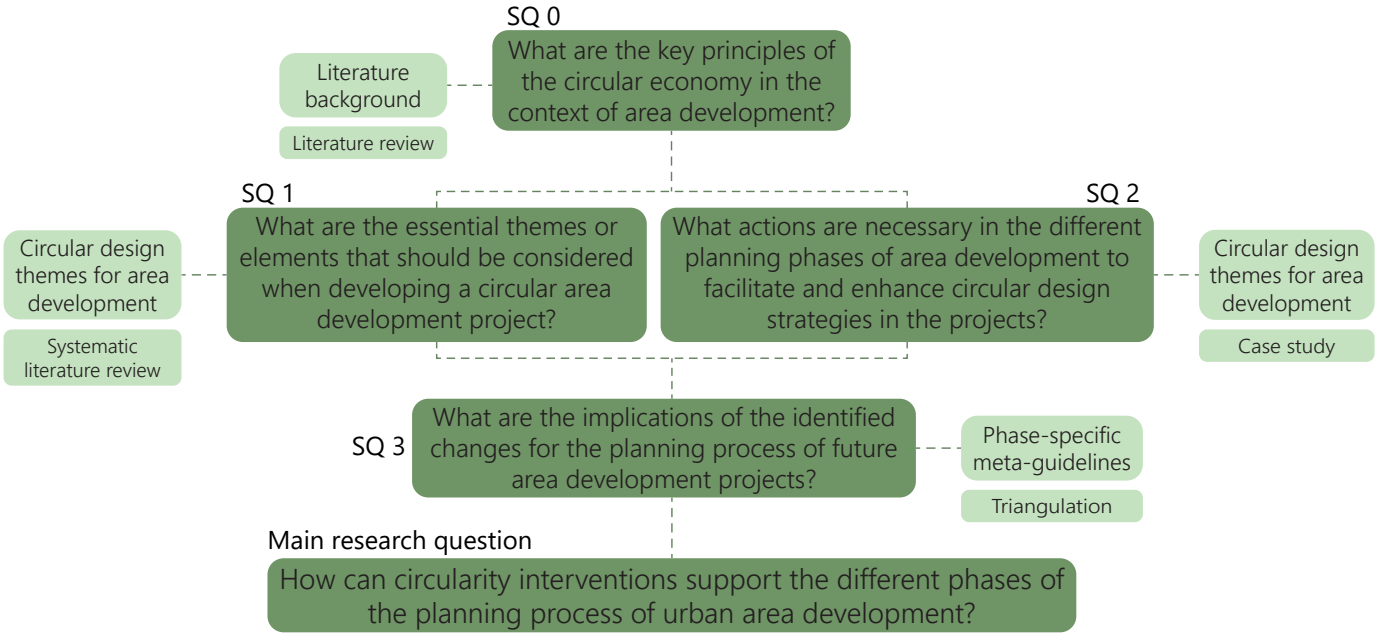


Figure 1.3: Coherence research questions.

1.4. THESIS STRUCTURE

Figure 1.4 illustrates the structure of this thesis. The research is organised into six chapters: (1) introduction, (2) theoretical background, (3) research methodology, (4) research results and analysis, (5) discussion, and (6) conclusion.

Chapter two provides the theoretical background on the key topics researched in this thesis; area development and the circular economy in relation to the built environment.

Chapter three elaborates on the used research methodology, to ensure objectivity in the empirical research. Furthermore, the process regarding objective gathering and analysis of research data is explained.

Chapter four elaborates on the research findings for the sub-questions defined in this chapter. First, themes for circular design strategies in area development projects are explained, this provides the answer to the first sub-question. Subsequently, the case study analysis and required changes to the process are explained. The required changes encompass actions necessary to overcome barriers and enhance accelerators during the process. Thereby these changes facilitate and enhance circular design strategies in area development projects, providing the answer to the second sub-question. Lastly, this chapter provides the implications for future area development projects, providing the answer to the final sub-question.

Chapter five provides a critical discussion of the research findings.

Finally, in chapter six the conclusion for the main research question is provided. Furthermore, the limitations of the research are elaborated and recommendations for future research are provided.

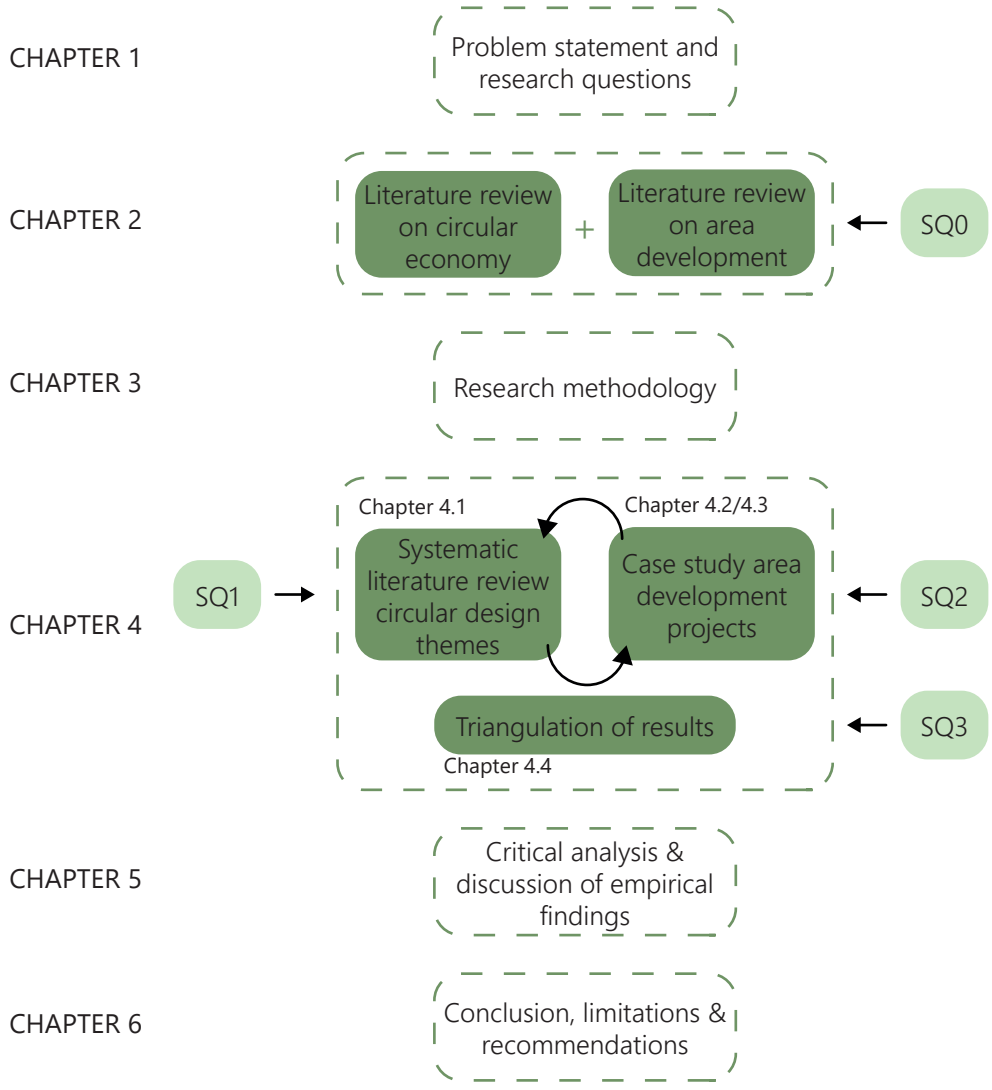
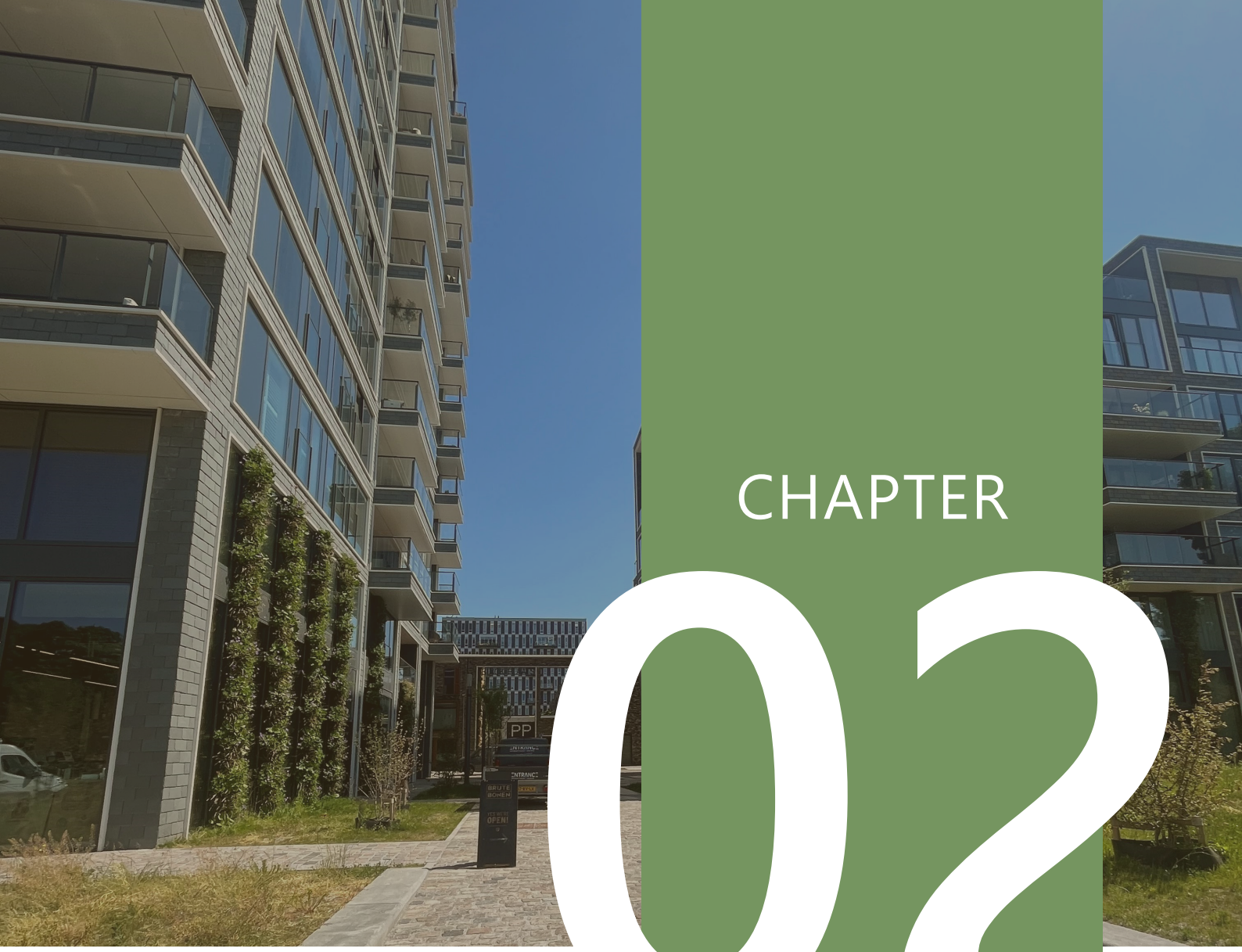


Figure 1.4: Thesis structure and research strategy



CHAPTER

02

THEORETICAL BACKGROUND: CIRCULAR AREA DEVELOPMENT

2. THEORETICAL BACKGROUND: CIRCULAR AREA DEVELOPMENT

This chapter provides the theoretical background of the fundamental topics for this thesis, by answering sub-question zero: "*What are the key principles of the circular economy in the context of area development?*". First, the circular economy (CE) in the context of the built environment is explained in paragraph 2.1. This is followed by paragraph 2.2., in which the characteristics of the area development projects are explained to clarify the context in which this research takes place. This paragraph elaborates on the approaches, scale, phases and relation to sustainable development. Finally, in paragraph 2.3. the theoretical framework for this research is elaborated. Information on several CE models that have been developed over the past years, is provided in Appendix B.

2.1. CIRCULAR ECONOMY IN THE BUILT ENVIRONMENT

There is little consensus about the definition of the circular built environment or the possible circularity strategies. However, there have been several attempts to identify characteristics, benefits and measures related to circularity in the built environment. According to Williams (2021b, 2021a), the current literature contains three different types of measures available for circular development, Figure 2.1;

1. **Looping** actions focus on waste hierarchies and R-strategies, promoting efficient use of resources. Where it is possible processes should be closed to reduce waste. This should be encouraged through provisional systems within areas (e.g. water recycling systems, renewable energy and recyclable infrastructure) (Williams, 2021b).
2. (Ecologically) **regenerative** actions focus on restoring and enhancing urban ecosystems. This often includes green and/or blue infrastructure. According to Williams (2021b) this also includes improving the health of those living in urban environments.
3. **Adaptive** actions – focussing on design that is adaptable to change. Flexible design and collaborative planning are examples. Circular development provides space for transformation and growth, and adaptable infrastructure that evolve when needs change (Williams, 2021b).

According to the research of Williams (2021b, 2021a), circular development is achieved if all three of these strategies are implemented in tandem, while at the same time waste and resource consumption is minimised. Furthermore, the benefits from the resulting synergies are then maximised (Williams, 2021b).

Additionally, Williams (2021b) has identified three benefit categories, associated with implementing these measures in tandem; (1) ecological, (2) economic, and (3) social benefits. These three measures are often mentioned by researchers whom explored the concept of CE in relation to the built environment (Amenta & van Timmeren, 2022; Bîrgovan et al., 2022; Bosone et al., 2021; Cerreta et al., 2020; Säumel et al., 2019; Smitha & Thomas, 2021)

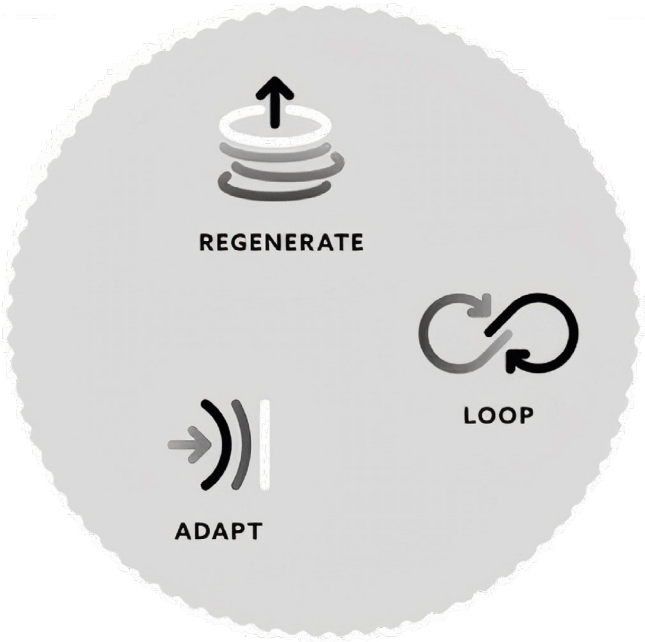


Figure 2.1: Three circular strategies according to Williams, 2020.

2.1.1. CIRCULAR ECONOMY PRINCIPLES IN THE BUILT ENVIRONMENT

All of the CE models, explained in Appendix B, have similar objectives. The grey literature research of the Circle economy (2021) tries to link the different strategies from these models together by creating three overarching categories; (1) 'prioritise regenerative resources', (2) 'stretch the lifetime' and (3) 'use waste as a resource'. This integration of strategies is visible in the first four columns of Table 2.1. In this framework strategies such as the 'narrow and regenerate' categories mentioned by Bocken et al. (2016, 2021) and the 'regenerate and reduce and preserve' categories of EMF are combined by the 'prioritise regenerative resource'. However, this only emphasises the use of regenerative resources, excluding strategies such as reduce, preserve and rethink, which are meant to narrow resource loops.

This does not do justice to the division between regenerative and adaptive strategies made by Williams (2021b, 2021a) as depicted in the fifth column of Table 2.1. In particular, the 'adaptive' category provides additional depth to the R-framework, as this ensures efficient resource use through designs that reduce energy consumption or encourage multifunctional use of space. Therefore, the division of strategies made by Williams (2021b, 2021a) should be leading for research into the circular built environment and implementation in development projects. It was found that these strategies provide a more comprehensive understanding of the different type of tangible available strategies.

Furthermore, many practitioners emphasize the R-framework or looping strategies, and view them as the operationalisation of CE. Similarly, many of the previously discussed frameworks emphasise more on the looping strategies than regenerative or adaptive strategies. However, literature suggests that to achieve sustainable development through circular economies, including adaptive and regenerative strategies is also important.

Regenerative and adaptive actions share significant similarities with the highest R's of the R framework. These strategies focus on changing the way we think about products, environments and sustainable materials, while also reducing the resources that are necessary, rather than solely continuously recirculating the resources that are used.

Circle economy	**R-strategies**		**Ellen MacArthur Foundation**	**Resource strategies**	**Williams**
Prioritise regenerative resources	Smarter product use and manufacture	R0 Refuse R1 Rethink R2 Reduce	Regenerate (biological cycle)	Regenerate	Regenerative
			Reduce and preserve	Narrow	Adaptive
Strech the lifetime	Extend lifespan of product and its parts	R3 Reuse R4 Repair R5 Refurbish R6 Remanufacture R7 repurpose	Maintain and prolong	Slow	Loop
			Reuse and redistribute		
			Refurbish and remanufacture		
Use Waste as a resource	Useful application of materials	R8 Recycle R9 Recover	Recycle	Close	

Table 2.1: Summary circular economy models. Based on: (Bocken et al., 2016, 2021; Circle economy, 2021; EMF, 2015, 2017; Konietzko et al., 2020; Potting et al., 2017; Stahel, 1981; Williams, 2021a).

2.2. AREA DEVELOPMENT

'Gebiedsontwikkeling' is the Dutch concept for a broad combination of activities and procedures paired with developing an area. Franzen, Hobma, De Jonge & Wigmans (2011) translate the concept to 'urban area development', which concerns the (re)development of a specific area within the urban environment on various scales (local, regional, etc.). During the process, several stakeholders are involved, including urban planners, developers, local authorities and residents.

Urban development and (urban) area development sound very similar, however, the two concepts differentiate from each other in the scale it is manifested (Van 't Verlaat & Wigmans, 2011a). Urban development encompasses the spatial changes of various locations within a region, e.g. development of buildings, while area development is about the development process of these broader regions. Thus, area development determines the coherence of urban development and influences how and where urban development needs to be created. This difference in scale is also visible in Figure 2.2.

Area development is a broad and complex concept; therefore, it has no common definition or description. Nonetheless, according to De Zeeuw (2019), most of the definitions given in the literature complement each other. De Zeeuw (2019) himself provides the following definition: "*Area development is the art of connecting functions, disciplines, parties, interests and money flows, with a view to developing or transforming an area*".

Van 't Verlaat (2008) defines area development as: "*Active interventions made by governments and other organisations on the development of urban areas*".

Daamen (2010) defines the concept as: "*A system of concrete material interventions within a geographically defined area*".

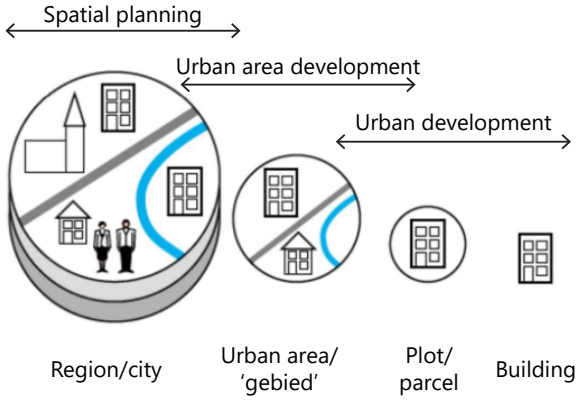


Figure 2.2: Scale urban area development. Source: (Heurkens, 2018)

The definition by Heurkens (2017) combines the previous three: "*Area development is the process of physical adaptation of a specific location to socio-economic and spatial needs, by different parties using different tools and activities to realise an integral-functioning area*" (Heurkens, 2017). This thesis follows this definition, as this is the most complete definition of area development. Ultimately, area development aims to create an integrated spatial composition in which different uses (residential, business, etc.) are located and can coexist in harmony (Van 't Verlaat & Wigmans, 2011a).

2.2.1. APPROACHES

Since the emergence of area development in the Netherlands, social and economic developments have caused a change in its approach. The most important change is the one from the traditional 'integrated' approach to the more modern 'organic' approach.

The traditional approach is project-based and large-scale, during which the result and development plans are clear (Infomil, 2023). The process is characterised by its 'top-down' manner, in which the governmental parties have an operating and risk-bearing role (Heurkens, 2018). Furthermore, this approach offers little room for third-party initiatives and has little flexibility.

The modern organic area development is based on a 'bottom-up' approach in which developments are more gradually phased and more demand-driven (Heurkens, 2017, 2018). The developments are strategic, flexible and able to respond to changing needs (Heurkens, 2018). Management of the process, is more important than project management, as the outcome is unknown (Heurkens, 2018; Infomil, 2023)

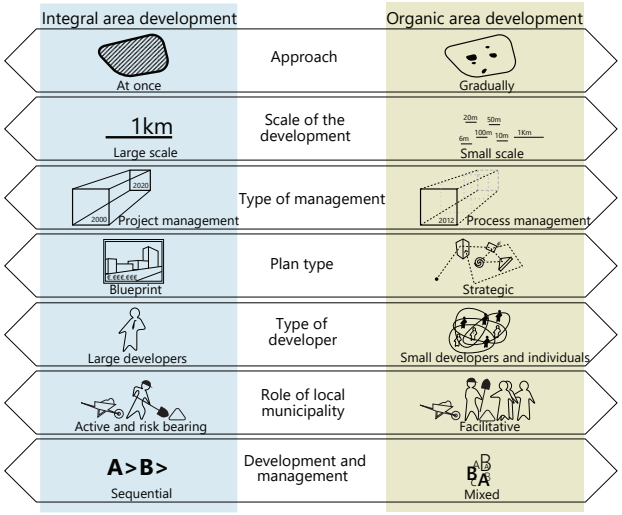


Figure 2.3: Integral vs. organic area development. Source: (Heurkens, 2017, 2018).

Figure 2.3 provides an overview of the differences. Although the two approaches differ in theory, both strategies' characteristics are applied in practice (Heurkens, 2017). Furthermore, there is a wide range of approaches possible between these two forms (Kersten et al., 2019).

2.2.2. SCALE

The built environment can be divided into multiple spatial scales, which helps to understand the components and reduce complexity (van Bueren, 2012). Van Bueren (2018) expands on the various scales identified by Pomponi & Moncaster, identifying five distinct physical scales as shown in Figure 2.4. These are the material, component, building, city and natural environment scales. Although, the built environment can be divided into different levels, these levels always remain interrelated; cities always consist of buildings, and buildings always consist of components, and so on.

However, the characteristics of each level do differ. Van Bueren (2018) indicates that the variety of stakeholders increases as the scale increases, thereby increasing the complexity of the process. She also suggests that the ambiguousness of circularity increases as the scale increases. Meaning that the different levels in the built environment call for different circularity measures.

As shown in Figure 2.4, the urban area scale can be placed between the city (macro-) level and the building (meso-) level. In this context, area development consists of two physical components; both buildings and the public spaces. Thus, it deals with both the plans of buildings, the layout of plots, and the designs of the public space and the related infrastructure (Van 't Verlaat & Wigmans, 2011a).

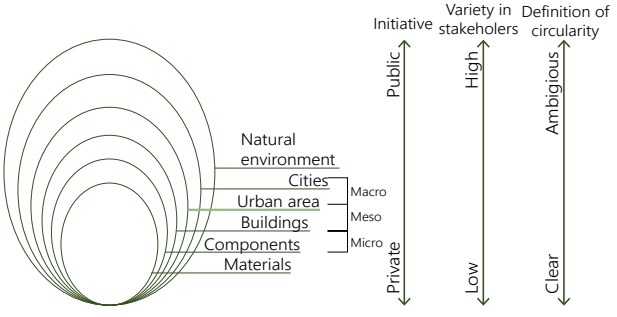


Figure 2.4: Scales in the built environment. Source: based on (Pomponi & Moncaster, 2018; Van Bueren, 2018).

The theory of shearing layers is of interest in this regard. This theory, introduced by architect Frank Duffy, assumes that different elements in the built environment age at different rates. Brand (1994) expands Duffy's theory to six layers, from least to most rapidly aging; site, structure, skin, services, space plan, stuff. Schmidt and Austin (2016, p. 55) add two more layers to this theory; social and surroundings, Figure 2.5.

The surroundings and site are important to take into account for the public space. The building layers, skin, structure, services, space plan, and stuff, are important for the design of the buildings. And the social layer is an overarching topic, that is important to consider during the complete design; for whom are you designing?

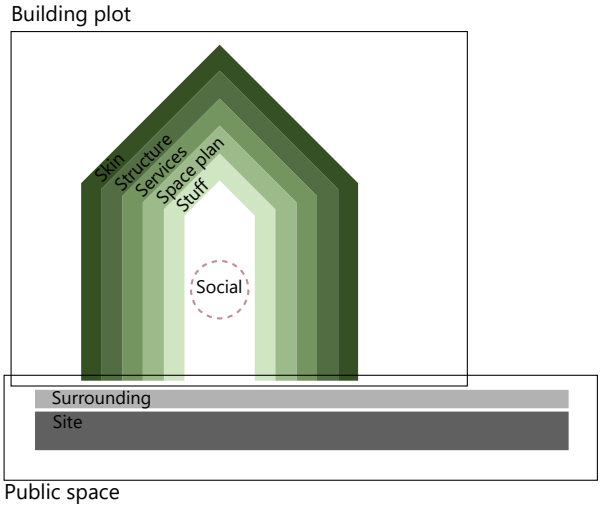


Figure 2.5: Building plot vs public space. Source: based on (Brand, 1994; Schmidt & Austin, 2016).

2.2.3. PHASES

The literature indicates that the area development process generally consists of four successive phases (Heurkens, 2017; Kersten et al., 2019; Van 't Verlaat & Wigmans, 2011b). Table 2.2 provides an overview of the different labels researchers provide for the different phases.

The phases do not follow a linear or structured process; instead, they involve unstructured processes that may take unexpected turns (De Zeeuw, 2019). Furthermore, they apply to both bigger and smaller area development. Besides this, the phases that are found in the design stage are similar to those found in urban or real estate development (Den Heijer & Van der Voordt, 2017). Common phases are the initiation, feasibility, realisation and operational phase, these are explained in the following paragraphs.

INITIATION PHASE

The initiation of each area development process may vary, as it can stem from market initiatives submitted by professional, non-professional and the public or private parties (Kersten et al., 2019). However, its function stays the same; this phase is intended to investigate if the development is desirable, has a chance of success, and which parties want to/can be involved. A possible conclusion is that there are better alternatives for the area (Infomil, 2023; Kersten et al., 2019). Furthermore, the main aim of this phase is to establish a vision and set ambitions for the area (Heurkens, 2017; Van 't Verlaat & Wigmans, 2011b).

The possible outcome of this phase is an agreement of intent and/or a partnership agreement (Chao-Duivis et al., 2011). The agreement of intent includes the joint objective of the cooperation, the division of tasks, roles and costs, perspectives after the agreement's end, and the cooperation's duration (Kersten et al., 2019). The agreement helps to avoid ambiguities during and after the cooperation.

FEASIBILITY

The feasibility phase is the most important and influential, but also the most complex phase of the process. Due to its complexity, it is divided into three sub-phases, each having its own outcome (Infomil, 2023; Kersten et al., 2019):

- **Definition phase** in which the preconditions for the site are drawn up.
- **Design phase** in which the urban design is prepared.
- **Preparation phase** is when architectural designs are made and permit applications are prepared.

The process of these sub-phases is iterative, as the first plan is never the final plan (Kersten et al., 2019). Simultaneously, calculations and drawings of possible plans are made (Heurkens, 2017). All aspects related to the area are incorporated into a plan that creates the highest functional and spatial quality (Van 't Verlaat & Wigmans, 2011b).

In practice involved parties already start with the preload and site preparation as soon as the concept and definite preliminary design is completed (Waalpartners civil engineering, 2022). During the elaboration of the definite design, dwellings are sold and construction can start right after. This means that earlier in the process the structure and lay out needs to be defined. The only factor that can induce change are the house sales.

REALISATION

Different actors are involved during this phase. These parties have to make agreements about the work that needs to be carried out (Heurkens, 2017). In this phase, parties proceed to the realisation of the designs made in the preceding phases.

OPERATIONAL

During the operational phase, the buildings and areas are in use and require maintenance and operational expenses.

Research	Phase 1	Phase 2	Phase 3	Phase 4
(Franzen et al., 2011)	Initiation	Planning	Realisation	Maintenance
(Heurkens, 2017)	Initiation	Design & Feasibility	Realisation	Operational
(Infomil, 2023)	Initiation	Feasibility	Realisation	Operational
(Kersten et al., 2019)	Initiation	Feasibility	Realisation	Operational
(De Zeeuw, 2019)	Initiative & Exploration	Planning & conditioning	Construction	Property operation

Table 2.2: Urban area development phases in current literature.

FREEDOM DURING THE PROCESS

Kersten et al. (2019) further indicate that the design freedom during the process decreases over the phases, as is illustrated in Figure 2.6. During the initiation phase, the vision and ambitions for the area are set. These shape guidance for the initial designs for the area as a whole. When the spatial plans mature, the set ambitions and vision determine how real estate develops in the area.

Due to the varying decisions, activities and outcomes in the process, the level of flexibility in decision-making is the lowest during the realisation and operational phases. This has consequences for the impact of decisions. At the beginning of the process, decisions about circularity and sustainability have a greater impact, than in later phases, in which there are fewer possibilities.

2.2.4. SUSTAINABLE AREA DEVELOPMENT

According to Van Bueren (2012), the built environment is a crucial setting in which the three components of sustainable development (sustainability, social and economic aspects) interact. This indicates that these components need to be considered during the area development process.

However, there is no consensus about what is considered as and how to achieve sustainable urban development (Heurkens, 2018). Similarly, Puylaert & Werksma (2011) have indicated that sustainability in area development is achieved through sensible actions of all stakeholders, not specific measures.

However, it can be said that sustainable area development involves the creation of social, economic, and ecological value (Heurkens, 2017). Puylaert & Werksma (2011, p. 3) further elaborate this by stating that "*sustainable urban areas develop into places where;*

1. *It is pleasant to stay now and in the future (social);*
2. *Physical area qualities are future-proof interlinked (environment);*
3. *Investments in real estate and public space are value-retaining (economy)*".

Central in this definition lies the future perspectives regarding the area.

Thus, sustainable area development is more than environmental or technological measures. Sustainable, social and economic aspects all need to be integrated to realise sustainable area development.

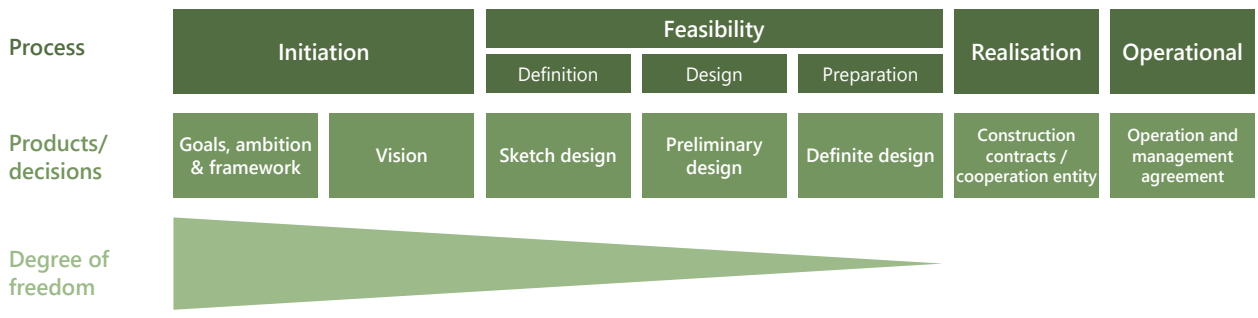


Figure 2.6: Degree of freedom during the area development process. Source: Based on (Kersten et al., 2019).

2.3. CONCLUSION THEORETICAL FRAMEWORK

In relation to area development, literature suggests that there is a connection between sustainable development and the circular economy. As both literature on sustainable area development and circular economy implementation emphasise the need for implementation of all three pillars of sustainable development; social, economy, and sustainability (Geissdoerfer et al., 2017; Kirchherr et al., 2017). In line with this, the three overarching strategies found by Williams (2021a), have the ability to generate benefits on all three dimensions of sustainable development. This provides more benefits than solely implementing strategies that focus on closing resource loops.

Furthermore, the literature background suggests that the activities and characteristics of area development influence how circularity can be implemented in the process. And due to its scale, both real estate and spatial plans have an important role. Furthermore, as the process progresses, the degree of flexibility in decision-making decreases. Therefore, the initiation phase is crucial for shaping the circular vision and ambitions for the area. Decisions made during this phase have a greater impact on circularity and sustainability than those made later on. Circular decisions or changes to the plans have the least impact during the realisation and operational phase.

It is clear that the three types of strategies of should be incorporated as design strategies during the process. However, the themes for implementation are not yet clear in current literature. Insight into these themes and the practical process is necessary, to enhance its implementation.

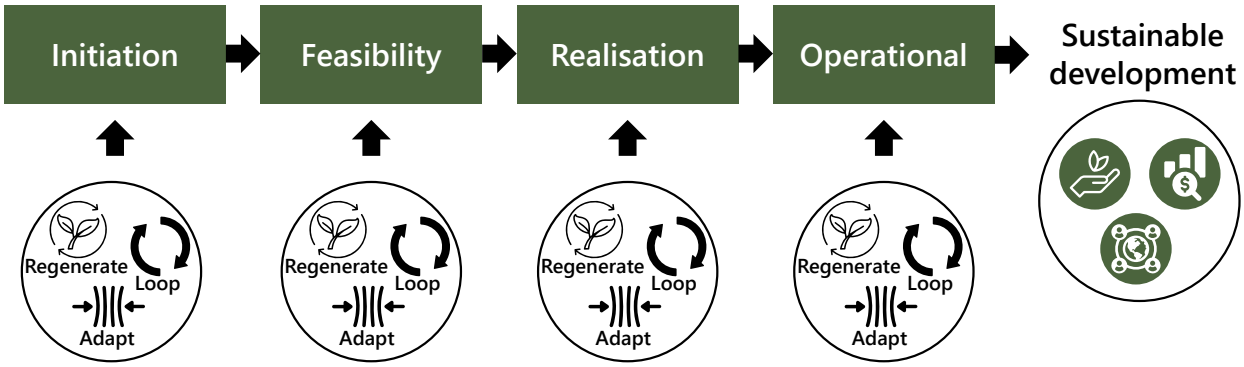


Figure 2.7: Theoretical framework.

CHAPTER

03

RESEARCH METHODOLOGY

3. RESEARCH METHODOLOGY

This chapter elaborates the research methodologies employed to systematically investigate the integration of circular design in urban development processes. The chapter outlines the research approach of this thesis.

For this research, several research methods were uses to answer the main and sub research questions. First in paragraph 3.1., the research type is elaborated. Paragraph 3.2. elaborates on the research design of this thesis, including the various research methods used. A systematic literature review, case studies and interviews were conducted to achieve the research objective stated in the introduction, see Figure 3.1. Following this, paragraph 3.3. transparently discusses the data collection methods and the related choices. Paragraph 3.4. Paragraph 3.4. explains the data analysis process, paragraph 3.5. elaborates on the validation of the research findings, and paragraph 3.6. elaborates on the methodological limitations.

3.1. CASE-BASED DESIGN RESEARCH

Both case study and design research are well-suited to the research objective of this thesis. Consequently, a combination of these two approaches is used, characterising the research as a case-based design study. Therefore, a mixed-methods approach was utilised, combining various qualitative research methods. This approach allows research into the integration of circular design strategies and themes across the different planning phases of the urban area development process.

Mixed-method research are characterised by the use of more than one research method, usually by using both qualitative and quantitative methods (Öhlén, 2011). However, Morse (2010) concludes that it can also be characterised by the use of two or more qualitative research methods that complement each other. Morse (2010) defines mixed-method research as utilizing one core method and one or more supplementary methods.

Morse (2010), furthermore, indicates that utilizing multiple qualitative research methods is justified when there is a distinct difference in data types, levels of analysis or participant perspectives, necessitating segregating research methods to reach a comprehensive result (Morse, 2010). This is the case for the objective in this research. To be able to objectively analyse the process surrounding circular design themes in area development projects, it is imperative to gain a well-rounded understanding of what themes should be included to reach comprehensive circular designs. As this knowledge was not identified in the literature background, a separate qualitative research is necessary to ensure a more nuanced and comprehensive understanding of circular design themes and to provide valuable insights into its application in area development processes.

The research objective benefits from this type of research, as the combination of qualitative research methods provides a thorough understanding of the process. Firstly, the systematic literature review provides in-depth insights and an enhanced understanding of the circular design themes. Furthermore, this knowledge ensures a comprehensive approach for the case study research, as all themes can be analysed in practice. Furthermore, the case studies can be used to identify barriers and enablers during the development processes. Lastly, triangulation of the findings ensures robustness and credibility of the interpretations.

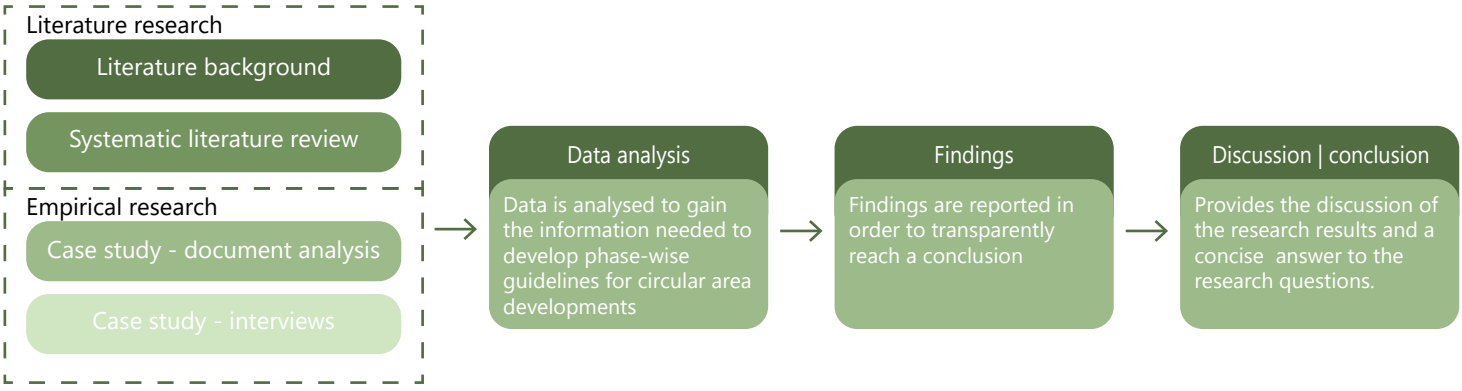


Figure 3.1: Research methods and analysis sequence.

3.2. RESEARCH DESIGN

A systematic literature review and comparative case study were conducted to acquire the knowledge needed to address the sub-questions and, consequently, the main research question outlined in the introduction. This paragraph introduces the research methods utilised, their relation to the sub-questions and acquired knowledge. Figure 3.2 illustrates these relations between the chosen research methods and sub-questions, essentially illustrating the research design.

As can be seen in this figure, a systematic literature review was conducted on the circular design themes related to area development. This literature review was necessary to ensure objectivity during the analysis of case studies. The resulting knowledge on a comprehensive framework of themes that should be included in circular designs could be used during the interviews to discuss the circular process regarding these themes specifically. The initial review has shown that practical and scientific knowledge does not provide a complete view on these themes. During the interviews this was confirmed, as circular designs were often only associated with the reuse of materials.

To provide input for the second sub-question, a comparative case study was conducted, using document analysis and interviews. Results were analysed for barriers, accelerators and the circular design themes identified through the systematic literature review.

The combined knowledge gained through the systematic literature review and comparative case studies provide the knowledge necessary to create the envisioned phase-wise meta-guidelines. Triangulation of acquired knowledge strengthens the credibility of and adds nuance to the research findings (Yin, 2014).

When the sub-questions are answered, it is know what circular design themes should be included in circular area development projects, what actions are necessary during the process to deal with barriers, and how to enhance circular design strategies during the process. Together, this information provides the answer to the main research question.

3.3. DATA COLLECTION

The following paragraphs explain the data collection process for each of the research methods utilised in this thesis, starting with the systematic literature review. Then the comparative case study process is explained, including case selection and interviews. Lastly, the use of triangulation is explained.

3.3.1. SYSTEMATIC LITERATURE REVIEW

To get a grip on the complexity that is related to a circular economy in area development, related themes and strategies are identified through conducting a systematic literature review. Systematic literature reviews are not free from biases, it is an appropriate way to map and review literature (Tranfield et al.,

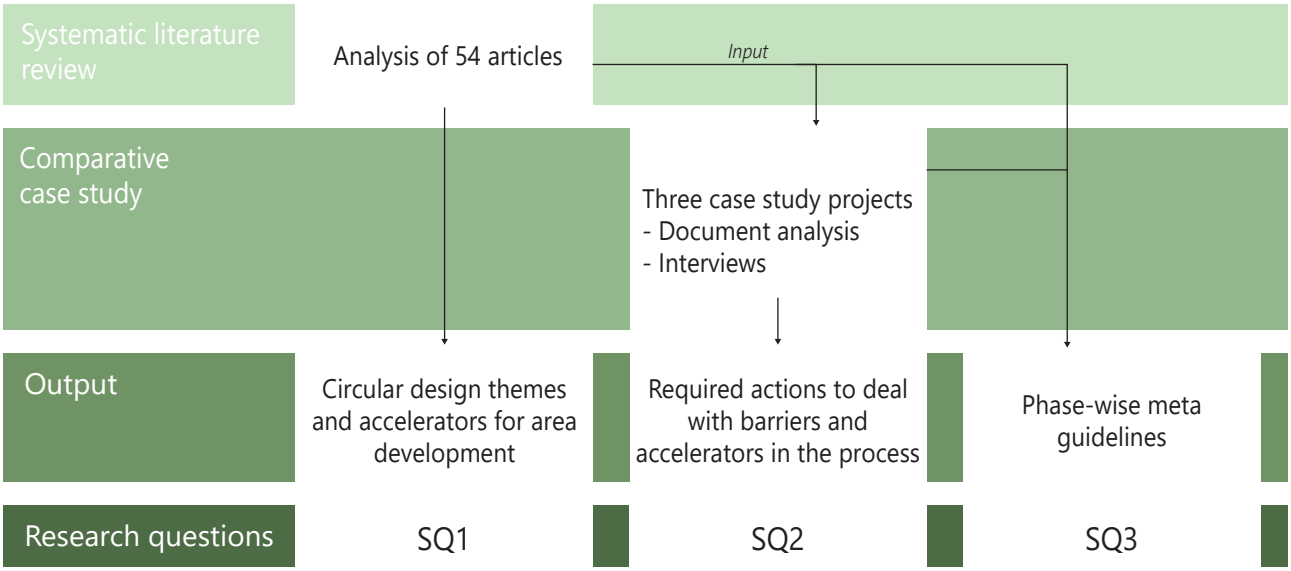


Figure 3.2: Research design.

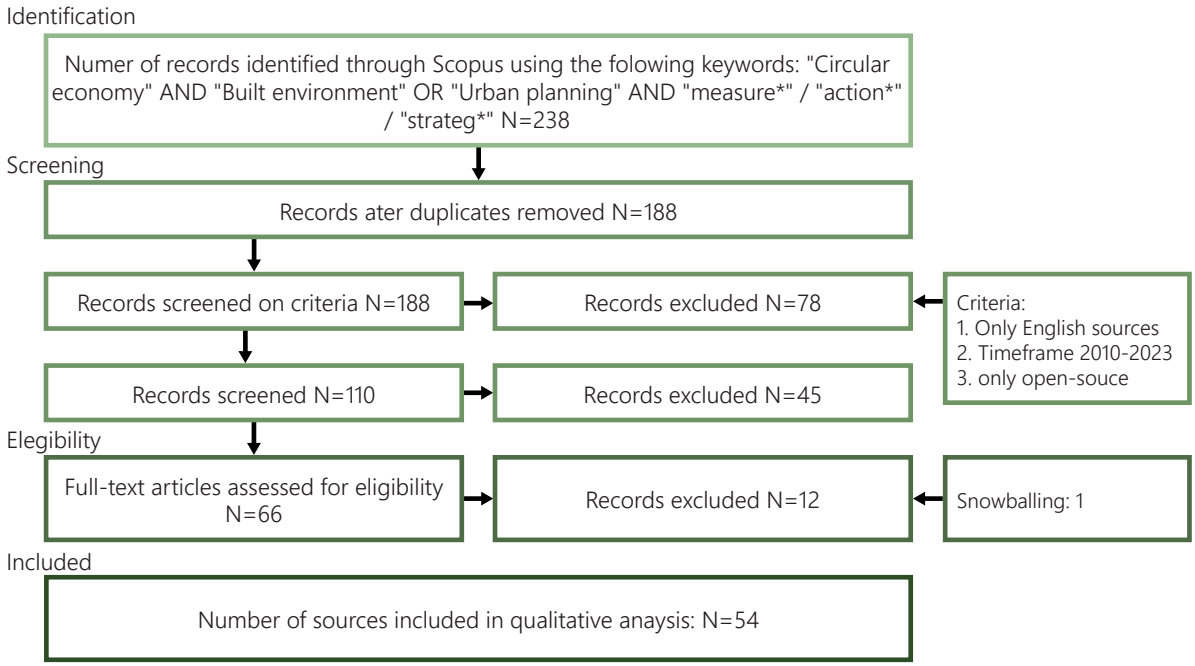


Figure 3.3: Screening process for final selection of included references, based on the PRISMA guidelines

2003). The purpose is to create a theoretical framework that outlines all themes and sub-themes that are significant for circular area development projects. The corresponding sub-research question is as follows: What are the essential themes or elements that should be considered when developing a circular area development project?

The systematic literature review was conducted according to the PRISMA guidelines (Page et al., 2021). This process is visible in Figure 3.3.

Before conducting this research, keywords were carefully chosen and combined. Results yielded from various keyword searches were reviewed in VOSviewer, to find the optimal combination of keywords. Appendix C provides an additional explanation about the keyword selection process.

The following keywords were included as the base of the search in circular area development: ("circular economy") AND ("built environment" OR "urban planning"). Further exclusions were made using the following keywords: ("measure*" OR "action*" OR "strateg*"). To gather relevant articles, the several criteria were included in the selection process, see Figure 3.1. Firstly, only English publications are included in the review. Secondly, the period of 2010-2023 is chosen as this guarantees early development inclusion (Bucci Ancapi et al., 2022). Fourthly, only open-source articles are included. These criteria do possibly exclude relevant articles, books or other publications.

Articles were screened on the field of research, title, and abstract. If the articles seemed relevant, the whole article was analysed. During the process one additional article was found through the snowballing method. Subsequently, in total, 54 articles were included in the results. A noteworthy observation is that the majority of these studies were conducted post-2020. This underscores the increasing significance of the topic. This also suggests that research on this topic is still evolving and will continue to develop in the coming years.

3.3.2. COMPARATIVE CASE STUDY

Once the information in the systematic literature review was acquired, case studies were employed. These case studies are examined in a subsequent part. Case studies can be used to gain insight into the processes that take place in projects (Verschuren & Doorewaard, 2010). A comparative case study method is chosen as evidence yielded from multiple cases are often perceived as more compelling (Blaikie & Priest, 2019; Van de Ven, 2007; Verschuren & Doorewaard, 2010). This provides greater robustness of and confidence in the findings and research. Furthermore, comparative case studies can be used to draw parallels between development processes of different cases (Verschuren & Doorewaard, 2010).

The comparative case study includes three case study projects; two re-development and one new

Case	Type of development	Location	Status	Municipality	Circularity goals	Direct contact
Erasmusveld midden	New development	Sub-urban	Realisation phase	The Hague	Yes	Yes
Binck eiland	Re-development	Sub-urban	Completed	Binckhorst, The Hague	Yes	Yes
Tuinen van Genta	Re-development	Urban	Realisation phase	Breda	Yes	Yes

Table 3.2: Possible case study projects.

development. These cases are analysed through both document analysis and qualitative interviews. Furthermore, site visits were conducted.

The comparative case study is aimed at identifying actions and decisions that enhance the implementation of circular design strategies in area development projects. The acquired findings can expand theoretical knowledge, as it provides insight into the (sequence of) decisions and discussions during circular area development process, for both new and re-development projects. The following sub-question has been established for the comparative case study; "*What actions are necessary in the different planning phases of area development to facilitate and enhance circular design strategies in the projects?*"

3.3.3. CASE STUDY SELECTION

The comparative case study is conducted through three case studies. Possible projects for the case study were identified and are visible in Table 3.2. To create a representable combination of projects some selection criteria have been established, visible in Table 3.1. By including case studies in varying context, a comprehensive analysis of circular strategies in diverse urban contexts can be achieved. This both enhances and validates the applicability of findings.

Eventually, 'Binck Eiland', 'Tuinen van Genta' and 'Erasmusveld midden' were selected for the comparative case study.

The 'Binck Eiland' project considers a redevelopment project, therefore, this case provides insight into the processes related to circular redevelopment projects. The 'Tuinen van Genta' project also revolves around the redevelopment of an old industrial site. This is similar to the 'Binck Eiland project.

The 'Erasmusveld midden' revolves around a new development. The insights acquired in this case study can be compared to the results found the in the two previously stated case study projects. This comparison can provide insights in the similarities and differences between new and redevelopment processes.

3.3.4. INTERVIEWS

Interviews, and in particular semi-structured interviews, are one of the most popular methods for data gathering in qualitative research (Kallio, Pietilä, Johnson & Kangasniemi, 2016). Semi-structured interviews are both flexible, versatile and allow for dialogue to emerge. Furthermore, it is a great measure to capture in-depth information, while also considering individuals' perceptions and beliefs (Hennink et al., 2020). Therefore, semi-structured interviews are conducted.

The purpose of these interviews is to gain knowledge about the development process surrounding circular area development projects. Interviewees were encouraged to share their perspectives about the implemented circularity interventions and the development process. Eventually gaining knowledge about important moments and decisions during the process. The goal was to find information that cannot be found in document analysis.

Aspect	Requirement
Development type	Both new and redevelopment project should be included in the case study.
Location	The development is preferably in a peri-urban or sub-urban location. Either at the outer skirts of a city or in a village.
Project status	The project is at least started or completed.
Municipality	The case studies have to be located in different municipalities to consider differences in approaches.
Circularity goals	Circularity is embedded in the goals of the project.
Direct contact	Contact through Waalpartners BV is possible.

Table 3.1: Project selection criteria.

Case	Type of stakeholders
Binck Eiland	Developer Municipality Landscape architect Civil engineering advisor
Tuinen van Genta	Developer Municipality Landscape architect Civil engineering advisor
Erasmusveld Midden	Developer Civil engineering advisor 1 Civil engineering advisor 2

Table 3.3: Interviewees per case study project.

Before interviews can start, an interview guide should be formulated that can structure the interviews. It consists of predetermined questions regarding topics that should be discussed during the interviews. The questions are formulated in such a way that the interviews are structured in a certain way, while still leaving room for the participant's own perspectives. The corresponding interview protocol can be found in Appendix D.

The interview protocol starts with introducing the topic and goal of the interview. Hereafter, the interview questions are divided into three parts. First, general questions regarding the project and the participants role in it. Second, themed questions about the circularity strategies in the development process were asked. And third, questions about the future of circular area development projects.

The results obtained from the systematic literature review were often, but not in every interview, presented to the interviewee as a guidance. The decision to verbally elaborate the framework was dependent upon the manner in which the conversation progressed. Furthermore, it was only presented at the end of the interview, to ensure full impartiality in their first thoughts about the process.

To ensure reliability of the data, the interviews were audiotaped and transcribed. The transcription was shared with participant to allow them to implement changes or include clarifications. The interviews were conducted in July and the beginning of August of 2023. In total, eleven stakeholders were interviewed, divided over the three case study projects, with three to four stakeholders per project. The type of interviewed stakeholders are visible in Table 3.3. A combination of different stakeholders was important in the research, as the different viewpoints gave different insights into the process, creating a complete picture.

Although the preference was to conduct the interview face-to-face, some interviews were also conducted online. Face-to-face meetings were preferred as, this setting has some additional benefits compared to an online setting. For example, body language was better interpreted and a better personal connection was established, making it easier to ask follow-up and personal questions. Furthermore, internet and connection issues are avoided. Nonetheless, four of the eleven interviews were online.

3.3.5. TRIANGULATION

The retrieved results in the systematic literature review and comparative case studies are combined to answer the third sub-question, which states as follows: "*What are the implications of the identified changes for the planning process of future area development projects?*"

The triangulation of results improves accuracy and completeness of the findings (Yin, 2014). Through this research question the phase-wise meta-guidelines are developed. Thus, the use of different sources, ensures the credibility of these guidelines.

3.4. DATA ANALYSIS

The following paragraph shines light on the data analysis process of each research method. Again, starting with the systematic literature review, followed by the comparative case-study and triangulation process.

3.4.1. SYSTEMATIC LITERATURE REVIEW

The articles found in the systematic literature review were analysed through systematic open-coding in several steps to gain a deeper understanding of the CE themes. The coding process was conducted according to the codes and categories to theory explanation of Saldana (2009), visible in Figure 3.4.

The following steps were taken during the coding process:

1. To start, two broad themes were established based on the results from the theoretical background (chapter 2) (van Bueren, 2018; Van 't Verlaat & Wigmans, 2011). These were 'CE themes and strategies for buildings' and 'CE strategies and themes for Urban planning/area development'. Any strategies, themes or interventions related to other broader or more specific topics were left out, providing clear direction for the coding process and required data.
2. Next, all relevant text, strategies, and themes were meticulously documented in Excel, allowing for comprehensive recording of the sources. In total,

over 500 relevant quotes, strategies, and themes were found in the articles.

3. The next step involved coding this data in CE themes for buildings and urban areas. To make sense of the multiple disciplines that are used in CE theory for area development, the focus was placed on harmonizing the characteristics quality and shared practices of the found themes and strategies. Many theories use different terminologies to describe similar themes or strategies, therefore, the coding started with combining these. In total, 91 codes for buildings and 205 codes for urban areas were identified.
4. With the help of Atlas.ti the codes were further refined into categories. For area development 103 category codes were identified, and for buildings 49 category codes were identified.
5. As the coded data was analysed and combined further, some patterns and similarities were found.

Eventually, four accelerating themes were found, these consisted of 16 code groups or categories, each acting as a accelerator for CE implementation in area development.

Furthermore, eleven circular design themes with 42 code groups or categories for CE implementation were found that are crucial to consider in circular area development projects.

Appendix C contains an example of how data was collected and coded in the found themes.

3.4.2. COMPARATIVE CASE STUDY

For the comparative case study analysis it was chosen to use a hierarchical method. This method consists of two phases. In the first phase, each case is separately examined (Verschuren & Doorewaard, 2010). In the second phase, the information gathered in the first phase is used as input for the comparative analysis. In this stage similarities and differences are identified and explained.

Of each case a separate individual report was created, these reports can be found in Appendix E and F. Appendix E includes the separate analysis of each case based on their development process and the inclusion of circular design strategies. Appendix E includes the separate analysis of each case based on the barriers, accelerators and design processes. These Appendices are separated as the dominant source of information differs; E is mainly based on document analysis and the site visits, while E is mainly based on the information acquired through the interviews.

The last paragraphs of both Appendices E and F include cross-case comparisons. The information of these Appendices are utilised in findings.

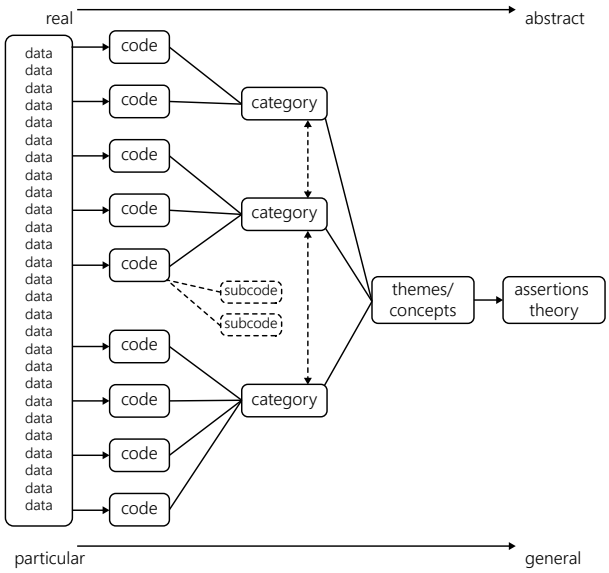


Figure 3.4: A streamlined codes-to-theory model for qualitative inquiry. (Saldana, 2009)

3.4.3. SEMI-STRUCTURED INTERVIEWS

The qualitative data gathered through interviews is also analysed through the use of the coding theory of Saldana (2009), Figure 3.4. The retrieved interview transcripts were analysed and coded using Atlas.ti. Throughout the analysis process a structured and systematic approach was applied to ensure consistency. The same interview protocol was used to ensure a similar structure. However, deviations from the topics were to some extent allowed, to ensure participants' perspectives were included in the interviews.

Since, the data acquired through the interviews included separate perspectives of three separate cases, it was decided to first analyse each case separately. Identified themes and participant responses were analysed, compared and examined, enabling identification of similarities, patterns or differences. Several overarching themes could be identified as barriers, accelerators and topics related to the design process. During the period the interviews were conducted, certain themes could immediately be identified, as almost each participant mentioned them. Therefore, these topics were analysed first, hereafter, each interview was analysed for additional barriers, accelerators or process development topics. This process ensured that no topics were left out.

To ensure transparent and thorough analysis each interview participants' transcript was separately analysed and included in the analysis. This resulted in tables that show what each stakeholder experienced and perceived. As mentioned previously, the interview-

dominant analysis per case study project is provided in Appendix F. The found topics were, if possible, cross -referenced with available documentations, to ensure the credibility of the findings.

Through the interviews patterns, barriers and accelerators in the process of circular area development projects could be identified. Based on this information necessary actions during the development process could be identified, resulting in a list of changes and partial redesign of the area development process. These actions encompass moments and actions that enable easier overcoming of barriers, accelerate circular design implementation or highlight an important moment in the process.

3.4.4. TRIANGULATION

The combination of the results found through the systematic literature review and comparative cases study is the last step in this research methodology.

The required actions identified through the comparative case study and the themes found through the systematic literature review are combined to create a phase-wise meta-guideline that enables stakeholders to implement more circular practices in the development process of area development projects.

3.5. VALIDATION

It is important for viable guideline development to evaluate research findings with experts in the field. These validation sessions ensure that realistic interventions are created, that meet the need of the involved stakeholders.

Therefore, during the research process two validation sessions were held, with experts from different disciplines, to confirm the findings and validate the developed guidelines. Furthermore, the goal was to assess two key aspects related to the nature of this study (case-based design research): first, the extent to which the observations from the case studies inform the developed guidelines, and second, the practical executability of the developed guidelines from the perspective of the directly involved experts in the field. Subsequently, the guidelines can be further developed and implemented during area development processes to enhance circular design implementation in practice.

The conceptual guidelines explained and developed in chapter four were discussed. Participants received the guidelines accompanied by an explanation in advance. The sessions were recorded and analysed, results are explained in chapter 4.5.

Session	Type of stakeholders
6 October 2023	Municipality (in-depth interview)
26 October 2023	Five Civil engineering advisor (focus group)

Table 3.4: Validation sessions

Two sessions were held in order to guarantee diversity in the involved stakeholders, table 3.4. The first session was held with a policy maker positioned at the municipality of Leiden. This municipality was involved as it is different from the case study characteristics. Furthermore, this municipality is known for their advanced methods regarding circular practices.

The second session was organised internally in the civil engineering firm cooperating in this research. This session was accompanied by five civil engineering project managers. In total six stakeholders were involved in the validation sessions. Of these stakeholders, three were previously interviewed on the process of specific case study projects. However, they were not involved during the development of the guidelines, ensuring independence.

3.6. LIMITATIONS

The utilised research methods do include limitations that are important to be aware of for this research. These are highlighted in this paragraph.

Firstly, the systematic literature review use observational and retrospective research designs, therefore, they are subjective to systematic and random error (Owens, 2021). Owens (2021) further explains that risk of bias, e.g. selection biases and selective outcome reporting can occur. Especially, because the systematic literature review is conducted by one person.

Secondly, the comparative case study analysis is characterised by self-report methods (Morgan et al., 2017). These rely on information participants and their willingness to talk about certain topics. Furthermore, their recollection and perception of the situation could also be (unconsciously) influenced by the interviewer.

Furthermore, case study research is harder to generalise. The more cases are used, the easier it is to draw general conclusions (Verschuren & Doorewaard, 2010; Yin, 2014).

CHAPTER

04

RESULTS & ANALYSIS: DYNAMIC PHASE-WISE GUIDELINES FOR CIRCULAR AREA DEVELPMENT

4. RESULTS AND ANALYSIS: DYNAMIC PHASE-WISE GUIDELINES FOR CIRCULAR AREA DEVELOPMENT

In this chapter, the results of the systematic literature review, case studies, and interviews are presented. These research efforts were been conducted to gain insight into and understand the application of circular design measures in the design phases of area development.

Paragraph 4.1. provides the answer to the first sub-question: "*What are essential themes or elements that should be considered when developing a circular area development project?*" This paragraph offers comprehensive insight into all the themes and elements for which circular design strategies can be considered to establish a circular designed residential neighbourhood. Paragraph 4.2. provides insight into the case study project analysis. Results from the systematic literature review are tested in the case study, furthermore, barriers and enablers in the process are identified. Paragraph 4.3. provides the answer to the second sub-question: "*What actions in the planning phases of area development are necessary to facilitate and enhance circular design strategies in the projects?*" Through the major insights of the case studies, required changes to the process are identified. A thorough elaboration of the changes is provided in paragraph 4.2.1. Furthermore, paragraph 4.4. provides the answer to the third sub-question: "*What are the implications of the identified changes for the planning process of future area development projects?*" Here findings from both the systematic literature review and case studies are combined to develop guidelines for circular area development. Lastly, in paragraph 4.5., information is provided on the validation sessions held to enhance the reliability of the results.

4.1. SYSTEMATIC LITERATURE REVIEW RESULTS: CIRCULAR DESIGN THEMES FOR AREA DEVELOPMENT

As described in the research methodology chapter, an in-depth alignment and synthesis of academic literature on circular design themes for area development was performed. Appendix B offers an explanation about the process and coding analysis. Additionally, the Appendix includes a coding example regarding the analysis process of the first three scientific articles. The analysis and corresponding coding were instrumental in deriving the results presented in this chapter.

In total, eleven themes for circular design strategies for area development projects were found through the systematic literature review. Additionally, accelerator concepts were identified through the review, and these are explained in paragraph 4.1.2. The circular design themes are represented in the first column of Table 4.1. The identified themes are; 1. Urban structure, 2. Mobility & transportation, 3. Environmental networks, 4. Circular water systems, 5. Circular soil systems, 6. Circular energy systems, 7. Circular building design, 8. Materials, 9. Closed waste systems, 10. Social aspects, and 11. Economy.

As visible in the table, the majority of research has been conducted on circular building strategies. The strategies found in the literature review can be divided into four main themes for circular buildings: building reuse, adaptive and resilience strategies, materials, and maintenance. Adaptive and resilience strategies are typically focused on new developments, while building reuse strategies are primarily applicable to redevelopment projects (Nußholz et al., 2023).

Multiple articles emphasise the fact that current theoretical literature overfocuses on certain concepts, such as circular design, energy, material reuse, technical quality of buildings, and tangible values (Belaud et al., 2019; Çetin et al., 2021; Foster, 2020; Giorgi et al., 2019; Nußholz et al., 2023; Rahla et al., 2021a; Smitha & Thomas, 2021). Intangible values, such as health and social values, and mobility are rarely analysed with the same thoroughness (Bosone et al., 2021; Gravagnuolo et al., 2019; Haselsteiner et al., 2021). A similar observation was made in this systematic literature review, as mobility and transportation, soil, and the economy are the least researched themes. Foster (2020) and Petit-Boix & Leipold (2018) are the only researchers who have highlighted the importance of sustainable mobility and transportation options. While this aspect is important to include in area developments, as these determine future transportation options. Furthermore, multimodal transportation options are very necessary for the promotion and enhancement of unmotorised transportation.

Themes such as energy, environmental networks, and circular water systems are highlighted thoroughly by the reviewed articles. This can be explained by their importance for sustainability themes, such as renewable energy and climate adaptation, which have received a lot of attention in previous years. This is also noticeable in the years the researches have been conducted, e.g., 2014, 2018, 2019. It is also noticeable that the social

theme has only received attention in the past couple of years from scientific researchers (2020-2023). This might be explained by the keyword selection, aiming at research conducted in the Western hemisphere.

Furthermore, some of the sources shed light on circular strategies in combination with the project life-cycle in the built environment. These sources do not specifically differ between the different design phases. However, they do correlate themes with the general life-cycle phases, indicating what circular strategies to aim for to facilitate circularity in the different phases. The most used phases are 'design', 'material selection', 'construct,' 'operate', and 'end-of-life' (Belaud et al., 2019; Çetin et al., 2021; Foster, 2020; Giorgi et al., 2019; Nußholz et al., 2023; Rahla et al., 2021a; Smitha & Thomas, 2021). Eberhardt et al (2022) identified a difference between 'preventive strategies', aimed at the design, and 'management strategies', which are aimed at achieving circularity in construction, operational, and end-of-life phases of the project.

The specific strategies and themes related to each phase are further elaborated in paragraph 4.2.1., in the elaboration of the stage they are aimed at (e.g., High-value design, material selection, or Operational phase).

Table 4.1: Circularity themes for area development, results from systematic literature review. (The first column represents the circular design themes found, the second column contains the sub-categories related to each theme. The third column provides an explanation for each sub-category. In these explanations, text formatted in italic represent related codes.)

Themes	Categories (code groups)	Explanation & related codes	Sources
1. Urban structure	Robust urban structure (evolvability & versatility)	Robust urban structures are needed with the current challenges of urbanisation and climate change, strategies such as *adaptive, resilient structures* and *densification* are important to meet the needs. Urban structures need to be able to evolve to and satisfy changing needs.	(Amenta & van Timmeren, 2022; Augiseau & Kim, 2021; Baffour Awuah & Booth, 2014; Bîrgovan et al., 2022; Cellucci, 2021; Karhu & Linkola, 2019; Petit-Boix & Leipold, 2018; Sala Benites et al., 2022; Santos et al., 2021; Williams, 2020)
	Brownfield development	The redevelopment of brownfields is in line with the CE principle of reuse. Furthermore, it helps with densification and creates liveable environments.	(Amenta & van Timmeren, 2022; Cerreta et al., 2020; Foster, 2020; Gravagnuolo et al., 2019)
	Local context	The local context has a key role in developments, the understanding of it is vital for good end results.	(Amenta & van Timmeren, 2022; Sala Benites et al., 2022; Santos et al., 2021)
	Multifunctionality (land use optimization)	Multifunctionality in urban structures ensures efficient use of land or land optimisation. It allows space to be used in different ways and for different functions. '*Shared use´* is a great example of a multifunctionality strategy.	(Baffour Awuah & Booth, 2014; Bîrgovan et al., 2022; Cellucci, 2021; Karhu & Linkola, 2019; Morel & Dorpalen, 2023; Petit-Boix & Leipold, 2018; Sala Benites et al., 2022; Santos et al., 2021)
2. Mobility & transportation	Sustainable mobility and transportation	Providing and improving low carbon mobility options helps to decarbonise society. For example *shared mobility, non-motorised transport* and *public transport*.	(Foster, 2020; Petit-Boix & Leipold, 2018)
	Multimodal transportation infrastructure	Infrastructures that allow for multiple or diverse modes of transports. E.g. walking, cycling (*non-motorised transport*), promoting low carbon options.	(Baffour Awuah & Booth, 2014; Petit-Boix & Leipold, 2018; Sala Benites et al., 2022)
	Accessibility	The accessibility of an area is important for economic growth and success of an area. Among others *pedestrian connections* and *public transport* are important factors.	(Cellucci, 2021; Dell'ovo et al., 2021)

Themes	Categories (code groups)	Explanation & related codes	Sources
3. Environmental networks	Biodiversity	Green spaces should promote, and conserve biodiversity in circular area development.	(Baffour Awuah & Booth, 2014; Bîrgovan et al., 2022; Bosone et al., 2021; Cellucci, 2021; Çetin et al., 2021; D'Amico et al., 2021; Foster, 2020; Ikiz Kaya et al., 2021; Nhamo et al., 2021; Sala Benites et al., 2022)
3. Environmental networks	Ecosystem regeneration and remediation	Public space strategies should be aimed at ecological preservation and regeneration, through for example *nature-based solutions*.	(Baffour Awuah & Booth, 2014; Bîrgovan et al., 2022; Bosone et al., 2021; Bucci Ancapi et al., 2022; Çetin et al., 2021; Foster, 2020; Girard & Nocca, 2020; Haselsteiner et al., 2021; Ikiz Kaya et al., 2021; Kyrö, 2020; Nhamo et al., 2021; Sala Benites et al., 2022; Santos et al., 2021; Säumel et al., 2019; Williams, 2020; Zaman et al., 2023)
	Public access to green space	Public space should be available for everyone.	(Amenta & van Timmeren, 2022; Foster, 2020)
	Ecosystem service provision	Ecosystems service provision includes al material products that are obtained from eco systems. This includes food, water, regulation of climates. Therefore the promotion of ecosystem service provision is completely in line with the biological cycle of CE. Among others *urban farming (food production), recreation appreciation, noise reduction, air purification, heat island effect reductions, fresh water* and *air quality* are part of this concept.	(Bîrgovan et al., 2022; Bosone et al., 2021, 2021; Bucci Ancapi et al., 2022; Cellucci, 2021; Cerreta et al., 2020; Çetin et al., 2021; D'Amico et al., 2021; Dell'ovo et al., 2021; Foster, 2020; Gómez-Baggethun et al., 2013; Gravagnuolo et al., 2019; Nhamo et al., 2021; Petit-Boix & Leipold, 2018; Sala Benites et al., 2022; Säumel et al., 2019; Williams, 2020; Zucaro et al., 2022)
4. Circular water systems	Gray/rainwater collection and storage	Water retention and collection for reuse.	(Baffour Awuah & Booth, 2014; Cellucci, 2021; Çetin et al., 2021; D'Amico et al., 2021; Foster, 2020; Haselsteiner et al., 2021; Nhamo et al., 2021; Petit-Boix & Leipold, 2018; Rahla et al., 2021a; Säumel et al., 2019; Williams, 2020)
	Preserve and regenerate fresh water	Preserve and regenerate fresh water quality.	(Baffour Awuah & Booth, 2014; Belaud et al., 2019; Bîrgovan et al., 2022; Bosone et al., 2021; Cellucci, 2021; Çetin et al., 2021; Gravagnuolo et al., 2019; Haselsteiner et al., 2021; Talamo et al., 2019; Zucaro et al., 2022)
5. Circular soil systems	Circular soil excavation	Avoid the use of natural and fertile soil	(Belaud et al., 2019; Bosone et al., 2021)
	Soil regeneration and remediation	Polluted soil remediation	(Bosone et al., 2021; Foster, 2020)
6. Circular energy systems	Renewable energy	Include renewable energy sources, such as solar or wind energy and reduce dependence on fossil fuels.	(Baffour Awuah & Booth, 2014; Bîrgovan et al., 2022; Cellucci, 2021; Çetin et al., 2021; Foster, 2020; Gravagnuolo et al., 2019; Hamida et al., 2022; Khan et al., 2023; Marrone & Montella, 2021; Nhamo et al., 2021; Petit-Boix & Leipold, 2018; Rahla et al., 2021a; Sala Benites et al., 2022; Säumel et al., 2019; Smitha & Thomas, 2021; Zaman et al., 2023; Zucaro et al., 2022)

Themes	Categories (code groups)	Explanation & related codes	Sources
6. Circular energy systems	Energy efficiency	Achieve energy efficiency through reducing energy consumption and emissions of buildings, mobility, etc.	(Belaud et al., 2019; Bîrgovan et al., 2022; Bosone et al., 2021; D'Amico et al., 2021; Foster, 2020; Giorgi et al., 2019; Gravagnuolo et al., 2019; Ikiz Kaya et al., 2021; Petit-Boix & Leipold, 2018; Talamo et al., 2019; Zucaro et al., 2022)
7. Circular building design	Building reuse	The adaptive reuse of abandoned buildings is a sustainable strategy that is fully in line with the values of a CE. It is characterised by the reduction of land consumption, preservation of ecosystem services and the maximization of the used materials. It is defined as adjusting, reusing or upgrading a building to suit new conditions. Furthermore, it is a manner in which *cultural heritage* and *local identities* can be preserved and enhanced.	(Baffour Awuah & Booth, 2014; Bosone et al., 2021; Cellucci, 2021; Çetin et al., 2021; Dabaieh et al., 2022; Dell'ovo et al., 2021; Eberhardt et al., 2022; Foster, 2020; Gravagnuolo et al., 2019; Hamida et al., 2022; Ikiz Kaya et al., 2021; Morel & Dorpalen, 2023; Nußholz et al., 2023; Rahla et al., 2021a; Zaman et al., 2023)
	Adaptive and resilience strategies	In the current literature several design strategies are indicated that enhance the circularity potential of buildings. For example; *Design for adaptability and flexibility* which enhances the operational functionalities; *High design standards* which ensure operational efficiency; *Design for longevity and durability* which prolong its operational lifetime; *Design for deconstruction and disassembly* which enhance its circular potential; *Standardization and modularity; Multi-use of space; Passive design; Lightweight structure; Design for short use*.	(Askar et al., 2021; Azcarate-Aguerre et al., 2022; Cellucci, 2021; Çetin et al., 2021, 2022; Dabaieh et al., 2022; Eberhardt et al., 2022; Foster, 2020; Gallego-Schmid et al., 2020; Gillott et al., 2023; Giorgi et al., 2019, 2020; Gravagnuolo et al., 2019; Hamida et al., 2022; Ikiz Kaya et al., 2021; Kyrö, 2020, 2020; Lynch, 2022; Marrone & Montella, 2021; Music, 2019; Nußholz et al., 2023; Petit-Boix & Leipold, 2018; Rahla et al., 2019, 2021a, 2021b; Smitha & Thomas, 2021; Williams, 2020; Zaman et al., 2023)
	Materials	The circularity of buildings depends highly on the materials that are used, as materials and construction account for 15% of total building emissions. Therefore, material strategies are at the core of CE. Examples are; *Material passport¸ Durable materials, R-strategies, Regenerative & resilient materials, Bio-based materials, Embodied carbon, Life cycle thinking, Local source, Resource flows*. Each of these strategies ensures sustainability in its own way; either long durability, harmless or non-toxic materials, reusable materials, etc.	(Augiseau & Kim, 2021; Azcarate-Aguerre et al., 2022; Baffour Awuah & Booth, 2014; Belaud et al., 2019; Cellucci, 2021; Çetin et al., 2021, 2022; Dabaieh et al., 2022; D'Amico et al., 2021; Eberhardt et al., 2022; Foster, 2020; Gallego-Schmid et al., 2020; Ghaffar et al., 2020; Gillott et al., 2023; Giorgi et al., 2019, 2020; Gravagnuolo et al., 2019; Hamida et al., 2022; Hartwell et al., 2021; Haselsteiner et al., 2021; Ikiz Kaya et al., 2021; Karhu & Linkola, 2019; Khan et al., 2023; Kyrö, 2020; Lynch, 2022; Marrone & Montella, 2021; Music, 2019; Nhamo et al., 2021; Nußholz et al., 2023; Petit-Boix & Leipold, 2018; Rahla et al., 2019, 2021b, 2021a; Sala Benites et al., 2022; Santos et al., 2021; Smitha & Thomas, 2021; Zaman et al., 2023; Zucaro et al., 2022)
	Maintenance	Maintenance strategies play an essential role in the construction material flows. Implementing maintenance extents the functional lifetime of building and building components. Strategies such as *designing for easy maintenance* and *product-service systems* enhance circularity in buildings.	(Augiseau & Kim, 2021; Azcarate-Aguerre et al., 2022; Belaud et al., 2019; Çetin et al., 2021, 2022; Foster, 2020; Giorgi et al., 2020; Hamida et al., 2022; Kyrö, 2020; Nußholz et al., 2023; Rahla et al., 2021b)

Themes	Categories (code groups)	Explanation & related codes	Sources
8. Materials	Closed resource management	Create closed resource cycles through *replacing end-of-life with reusing of resources, separation of biological and technical material flows* and *material recovery*.	(Bîrgovan et al., 2022; Bucci Ancapi et al., 2022; Çetin et al., 2021; Cohen & Gil, 2021; Ghaffar et al., 2020; Gravagnuolo et al., 2019; Nußholz et al., 2023; Petit-Boix & Leipold, 2018; Sala Benites et al., 2022; Säumel et al., 2019; Smitha & Thomas, 2021)
	Resource efficiency	Create resource efficient systems	(Baffour Awuah & Booth, 2014; Sala Benites et al., 2022)
	Reduce environmental impact	Reduce environmental impact through e.g. *accounting for pollution costs; costs of exhaustion, water pollution, CO2 emissions, toxicity*.	(Bîrgovan et al., 2022; D'Amico et al., 2021; Dell'ovo et al., 2021; Foster, 2020; Sala Benites et al., 2022; Smitha & Thomas, 2021; Talamo et al., 2019)
9. Closed waste systems	Industrial ecology	The promotion of exchange of excess resources, aiming for zero waste. Achieved through *industrial symbiosis*.	(Baffour Awuah & Booth, 2014; Belaud et al., 2019; Bosone et al., 2021; Çetin et al., 2021; Cohen & Gil, 2021, 2021; Eberhardt et al., 2022; Music, 2019; Petit-Boix & Leipold, 2018; Williams, 2020)
	Waste infrastructure	Rethinking of the traditional waste treatment facilities. E.g. *separate waste*.	(Amenta & van Timmeren, 2022; D'Amico et al., 2021; Foster, 2020; Rahla et al., 2021a; Talamo et al., 2019)
	R-strategies	Frameworks such as the 9R-framework; *Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, Recover*.	(Belaud et al., 2019; Bosone et al., 2021; Foster, 2020; Ghaffar et al., 2020; Ikiz Kaya et al., 2021; Lynch, 2022; Nußholz et al., 2023; Petit-Boix & Leipold, 2018; Rahla et al., 2021a; Säumel et al., 2019; Williams, 2020)
	Environmental management system	Systematic approaches to organise, manage and reduce environmental impacts of waste. E.g. *pre-construction and demolition audits or waste taxes*.	(Bîrgovan et al., 2022; Ghaffar et al., 2020; Giorgi et al., 2020; Nußholz et al., 2023)
	Design out waste	Efficient use of construction materials to reduce the amount of materials used in the process.	(Augiseau & Kim, 2021; Bucci Ancapi et al., 2022; Cohen & Gil, 2021; D'Amico et al., 2021; Gravagnuolo et al., 2019; Haselsteiner et al., 2021; Marrone & Montella, 2021; Rahla et al., 2019, 2021a; Sala Benites et al., 2022; Santos et al., 2021; Smitha & Thomas, 2021; Zaman et al., 2023; Zucaro et al., 2022)
10. Social aspects	Culture & heritage	Include local identity and context in design.	(Bîrgovan et al., 2022; Bosone et al., 2021; Haselsteiner et al., 2021; Ikiz Kaya et al., 2021; Morel & Dorpalen, 2023; Sala Benites et al., 2022)
	Educate	Provide educative aspects in design to *stimulate sustainable lifestyles* and *create user awareness about sustainable, circular and environmental aspects*. Or *provide construction team with training on CE strategies and construction techniques*.	(Belaud et al., 2019; Bîrgovan et al., 2022; Bucci Ancapi et al., 2022; D'Amico et al., 2021; Foster, 2020; Haselsteiner et al., 2021; Marrone & Montella, 2021, 2021; Rahla et al., 2021a; Sala Benites et al., 2022; Santos et al., 2021; Smitha & Thomas, 2021)
	Social cohesion	Increasing trust and consider the needs of future residents, can enhance positive environments and wellbeing	(Bîrgovan et al., 2022; Bosone et al., 2021; Morel & Dorpalen, 2023; Nhamo et al., 2021; Sala Benites et al., 2022)
	Safety	Increase safety of public space	(Bosone et al., 2021; Cellucci, 2021; D'Amico et al., 2021; Talamo et al., 2019)

Themes	Categories (code groups)	Explanation & related codes	Sources
10. Social aspects	Health	Contribute to the health of residents through e.g. healthy materials, enhancing air quality, healthy food, mental health improvement.	(Bîrgovan et al., 2022; Bosone et al., 2021; Cellucci, 2021; Cerreta et al., 2020; D'Amico et al., 2021; Foster, 2020; Haselsteiner et al., 2021; Nhamo et al., 2021; Sala Benites et al., 2022)
	Wellbeing	Strategies that enhance perceived wellbeing of residents. (E.g. access to green space, health, quality of life)	(Bîrgovan et al., 2022; Bosone et al., 2021; Cerreta et al., 2020; Foster, 2020; Haselsteiner et al., 2021; Morel & Dorpalen, 2023; Nhamo et al., 2021; Sala Benites et al., 2022)
	Shared strategies	Include shared strategies to promote e.g. *sustainable consumption* and *bottom-up approaches*.	(Amenta & van Timmeren, 2022; Askar et al., 2021; Belaud et al., 2019; Foster, 2020; Karhu & Linkola, 2019; Kyrö, 2020; Petit-Boix & Leipold, 2018; Zaman et al., 2023; Zucaro et al., 2022)
	Engage community	Promote inclusiveness through engaging of local community	(Bosone et al., 2021; Dell'ovo et al., 2021; Gravagnuolo et al., 2019; Haselsteiner et al., 2021; Sala Benites et al., 2022; Santos et al., 2021)
	Landscape quality and atmosphere (liveability)	Create *high-quality* and *clean* public spaces and living environments. E.g. including *recreational features*.	(Bîrgovan et al., 2022; Bosone et al., 2021; Çetin et al., 2021; D'Amico et al., 2021; Dell'ovo et al., 2021; Foster, 2020; Morel & Dorpalen, 2023; Sala Benites et al., 2022; Säumel et al., 2019)
	Social equity	Promote equality, community participation, fairness inclusiveness and support of vulnerable people in the area.	(Amenta & van Timmeren, 2022; Baffour Awuah & Booth, 2014; Haselsteiner et al., 2021; Nhamo et al., 2021; Sala Benites et al., 2022)
11. Economy	Local products, food and materials	Use local products and materials and locally produce foods. e.g. decarbonisation is achieved through the *optimisation of transport distances*.	(Bîrgovan et al., 2022; Gravagnuolo et al., 2019; Nußholz et al., 2023; Petit-Boix & Leipold, 2018; Sala Benites et al., 2022)
	Economic growth	Create an attractive environment that generates *economic growth, positive spillovers, employment opportunities* and *long-term investment return*, through *attracting sustainable* and *circular businesses*.	(Bîrgovan et al., 2022; Bosone et al., 2021; Dell'ovo et al., 2021; Ikiz Kaya et al., 2021; Nhamo et al., 2021; Sala Benites et al., 2022; Smitha & Thomas, 2021)

4.1.1. ACCELERATOR THEMES FOR CIRCULAR AREA DEVELOPMENT

In addition to the circular design themes for CE in area development, several overarching themes were found that encompass strategies and actions to accelerate and enhance circularity in area development projects. These accelerators are represented in the first column of Table 4.2, following a similar format to Table 4.1. The identified accelerators are; 1. Process, 2. Governance, 3. Technology, and 4. Decision-support tools. These topics are less related to physical alterations or design strategies but encompass strategies related to project processes. Including these topics during the process can enhance the inclusion of circular design strategies.

Circular processes and governance highlight the need for collaboration, strategic partnerships, circular governance (e.g., transparency, innovation, inclusiveness), and circular business models. A topic that is less highlighted in the literature is evaluation in the process. Nonetheless, this is a necessary exercise, as it contributes to a better planning process (Oliveira & Pinho, 2010).

Furthermore, the use of technology to streamline the process and enhance its sustainability has received increasing attention in recent years. New technologies provide new opportunities, making this a dynamic topic. As technology is evolving rapidly and continually enabling more sustainable processes and implementation, also for the circular economy.

Lastly, decision-support tools are available on almost all themes; social, environmental, economic, materials, energy, and buildings or areas. However, tangible indicators are dominant, as it is harder to measure social values (Rahla et al., 2019). It is highly likely that these tools will evolve in the coming years, as practical implementation and knowledge continue to grow.

Table 4.2: Accelerators for circularity in area development (The first column represents the accelerator themes found, the second column contains the sub-categories related to each theme. The third column provides an explanation for each sub-category. In these explanations, text formatted in italic represent related codes.)

Accelerators	Categories (code groups)	Explanation & related codes	Sources
1. Process	Evaluate	Evaluation of benefits, costs and strategies is important to safeguard values and benefits from strategies during the planning process. Furthermore, updates with 'as-built' information creates more efficient processes in future developments.	(Girard & Nocca, 2020; Morel & Dorpalen, 2023; Rahla et al., 2021a)
	Circular business models	Business models that transfer ownership from consumers to producers can help in resolving issues between stakeholders, while promoting circular principles. The implementation of circular business models can improve the amount of materials reused, remanufactured etc.	(Bosone et al., 2021; Çetin et al., 2021; Giorgi et al., 2020; Sala Benites et al., 2022)
	Sustainable construction techniques	Sustainable construction techniques such as electric equipment or energy and water efficient equipment.	(Foster, 2020; Nußholz et al., 2023; Rahla et al., 2021a)
	Strategic partnerships	Strategic partnerships are useful to enhance and implement circularity and circular business models. Topics that are included in this are e.g. common goals, collaboration, the right people, participation in decision-making, cross-departmental thinking, and knowledge and value networks.	(Amenta & van Timmeren, 2022; Belaud et al., 2019; Bosone et al., 2021; Cerreta et al., 2020; Çetin et al., 2021; D'Amico et al., 2021; Giorgi et al., 2020; Hamida et al., 2022; Karhu & Linkola, 2019; Rahla et al., 2021a; Säumel et al., 2019; Zucaro et al., 2022)

Accelerators	Categories (code groups)	Explanation & related codes	Sources
2. Governance	Circular governance	Circular governance models can enhance circularity in the process. Related concepts are participation, inclusiveness, transparency, accountability and collaboration. Furthermore, circular governance allows for innovation. This can be achieved through e.g. green procurement.	(Belaud et al., 2019; Bîrgovan et al., 2022; Bucci Ancapi et al., 2022; D'Amico et al., 2021; Morel & Dorpalen, 2023; Petit-Boix & Leipold, 2018; Sala Benites et al., 2022; Santos et al., 2021; Talamo et al., 2019; Zaman et al., 2023)
	Policy instruments	Policy instruments are an effective way to promote circularity strategies in practice. Furthermore, it ensures implementation.	(Bucci Ancapi et al., 2022; Dell'ovo et al., 2021; Morel & Dorpalen, 2023)
3. Decision-support tools	Social analysis	Health impact analysis Social impact assessment Post-occupancy evaluation	(Girard & Nocca, 2020; Rahla et al., 2019)
	Environmental analysis	Environmental impact analysis	(Girard & Nocca, 2020)
	Economic analysis	Cost-benefit analysis	(Girard & Nocca, 2020)
	Material analysis	Material flow analysis (MFA) Carbon footprint analysis Life-cycle analysis (LCA) Carbon footprint analysis Embodied water	(Foster, 2020; Gillott et al., 2023; Giorgi et al., 2019; Gravagnuolo et al., 2019; Haselsteiner et al., 2021; Rahla et al., 2021a; Sala Benites et al., 2022; Smitha & Thomas, 2021)
	Energy	Energy assessment	(Gravagnuolo et al., 2019)
	Building/area certifications	Green building certifications (e.g. BREEAM)	(Foster, 2020; Gravagnuolo et al., 2019)
4. Technology	Virtualise	Virtualising technologies can improve efficiency during the planning process and phases later on. Technologies that help virtualise are e.g. Artificial intelligence (AI), Building information modelling (BIM), Mobile platforms , Digital twins, Geographical information modelling (GIS), Material passports/ databanks, scanning technologies, cloud computing, and augmented reality (AR)	(Çetin et al., 2021, 2022; D'Amico et al., 2021; Giorgi et al., 2020; Kyrö, 2020; Rahla et al., 2019, 2021a; Williams, 2020; Zaman et al., 2023)
	Smart technologies	Technologies related to smart technologies can help improve operational efficiency of areas. These are technologies such as smart buildings, real-time monitoring (sensors) and the smart-grid.	(Baffour Awuah & Booth, 2014; Belaud et al., 2019; Bîrgovan et al., 2022; D'Amico et al., 2021; Giorgi et al., 2019; Lynch, 2022; Rahla et al., 2021a; Talamo et al., 2019; Zucaro et al., 2022)
	ICT infrastructure	ICT infrastructures create more efficient communication environments eventually creating more efficient processes. Related technologies are big data analysis, telecommunication, and Internet of Things (IoT)	(Belaud et al., 2019; Bîrgovan et al., 2022; Çetin et al., 2021, 2022; D'Amico et al., 2021; Petit-Boix & Leipold, 2018; Rahla et al., 2019; Sala Benites et al., 2022; Talamo et al., 2019)
	Robotics	Robot technology has the ability to make processes and materials more efficient, e.g. 3D printed materials.	(Çetin et al., 2021; Ghaffar et al., 2020; Khan et al., 2023; Lynch, 2022)

4.2. CASE STUDY ANALYSIS: CIRCULAR DESIGN THEMES, BARRIERS, AND ACCELERATORS

When the systematic literature review was completed, the case studies were conducted. Parallel to the completion of the systematic literature review, interviews regarding the process of the three case study projects were held. Furthermore, when the systematic literature review was finalised, the case study projects were reviewed based on the findings of the systematic literature review. The identified themes for circular design strategies were used as a tool to thoroughly analyse the case studies, aiming to identify the implemented circular design strategies.

Both of these elements of the case study research are elaborated on in the next paragraphs. First, findings regarding the case study projects in relation to the circular design themes are explained. Furthermore, the identified barriers and accelerators in circular area development processes are elaborated.

The three case study projects are Binck Eiland, Tuinen van Genta, and Erasmusveld midden. Each of these projects has different characteristics, e.g., both Binck Eiland and Tuinen van Genta can be characterised as 'redevelopment' or 'brownfield developments'. An extensive analysis of the case studies in relation to the circular design themes is provided in Appendix E, and an extensive analysis of the case study interviews is provided in Appendix F.

4.2.1. CIRCULAR DESIGN THEMES IN THE CASE STUDY PROJECTS

Using the findings of the systematic literature review, a complete overview of the cases was created, elaborating on the relationship between each of the design themes and the projects' characteristics. The following paragraphs elaborate on this analysis for both the circular design and accelerator themes.

CIRCULAR DESIGN THEMES IN CASE STUDY PROJECTS

Overall, all case study projects include quite a few of the previously identified circular design themes, Table 4.3. Through the analysis, it was immediately apparent that not every theme is equally represented in each of the designs. This indicates that either themes were 'forgotten' in the process or left out due to the projects' characteristics. Furthermore, some themes were more emphasised than others in each of the development projects.

For example, in Binck Eiland, many reuse strategies were implemented, as it is situated at a location where companies were previously located. Furthermore, due to the project's characteristics, there were constraints for energy efficiency and energy sources for the reused buildings. The Binck building also shows the limiting factor of reusing buildings regarding energy efficiency. Due to the building characteristics, insulation is lower than desired. Furthermore, sustainable energy sources were not feasible to implement; therefore, the building still has a gas connection. Moreover, the Binck Eiland development is the only development that includes economic themes in the design. This can be explained by its location, as it is an inner-city residential area development. While the other developments are more located outside of the city centre, and, therefore, economic themes are less relevant. Another emphasised theme for this development was the circular water system; creative solutions were necessary to get approval from the municipality. Furthermore, it is located at a site with an industrial history, which the municipality of The Hague intends to visualize in designs for the area.

The Tuinen van Genta project shares similar characteristics with the Binck Eiland projects but has a different history, influencing the emphasis on design themes. In this project, the emphasis lies in the social themes, owing to the history of failed plan-making, resulting in critical neighbours. Furthermore, in this project, construction methods were highly influenced by the included contractor, resulting in less sustainable and circular construction methods. Moreover, due to the industrial past of the site, the project was highly influenced by the contaminated soil, resulting emphasis on the soil theme. Lastly, interviewees indicated that policies had greatly influenced this project, for both the energy and water themes. Sustainable energy sources were likely implemented as the policy that banned gas sources was already expected. Furthermore, the municipality indicated that this project only complied with the water retention standards of that time, which are now considered outdated.

In contrast to the first two projects, Erasmusveld midden can be described as an inner-city greenfield development, which provides more design freedom and, therefore, also more space for green facilities. Therefore, more emphasis was placed on the environmental design theme compared to the other cases.

In general, circular waste design themes were excluded by all projects. Included waste infrastructures often remain very traditional, with limited emphasis on promoting a circular economy in the projects. Erasmusveld and the Tuinen van Genta do include a compost pile for biodegradable waste, intended for reuse in communal gardens. Furthermore, general recycling facilities are implemented in the plan.

Table 4.3: Circular design themes in case study project summarizes. ✓/✗ indicate the inclusion or exclusion of the circular design theme, if both are filled in it means certain parts are implemented but not for the whole project. Furthermore, ? means it is unsure if the theme is implemented.

Themes	Categories (code groups)	Binck eiland	Tuinen van Genta	Erasmusveld midden
1. Urban structure	Robust urban structure (densification, evolvability & versatility)	✗	✗	✓
	Brownfield development	✓	✓	✗
	Local context	✗	✓	n/a
	Multi-functionality (land use optimization)	✓	✗	✓
2. Mobility & transportation	Sustainable mobility and transportation	✓	✗	✓
	Multi-modal transportation infrastructure	✓	✓	✓
	Accessibility	✗	✓	✗
3. Environmental networks	Biodiversity	✓	✓	✓
	Ecosystem regeneration and remediation	✓/✗	✓	✓
	Public access to green space	✓	✓	✓
	Ecosystem service provision	✓	✓	✓
4. Circular water systems	Gray/rainwater collection and storage	✓	✓	✓
	Preserve and regenerate fresh water	✗	✓	✓
5. Circular soil systems	Circular soil excavation	✗	✗	✓/✗
	Soil regeneration and remediation	✗	✓/✗	✓
6. Circular energy systems	Renewable energy	✓	✓	✓
	Energy efficiency	✓	✓	✓
7. Circular building design	Building reuse	✓	✓	-
	Adaptive and resilience strategies	✓	✓	✓
	Materials	✓/✗	✗	✓
	Maintenance	✗	✗	✗
8. Materials	Closed resource management	✓	✓	✗
	Resource efficiency	✗	✗	✗
	Reduce environmental impact	✗	✗	✓
9. Closed waste systems	Industrial ecology	✗	✗	✓
	Waste infrastructure	✓	?	✓
	R-strategies	?	✓/✗	✓/✗
	Environmental management system	✗	✗	✗
	Design out waste	✗	✗	✗
10. Social aspects	Culture & heritage (local context/identity)	✓/✗	✓	n/a
	Educate	✓	✗	✗
	Social cohesion	✓	✓	✓
	Safety	✗	✗	✗
	Health	✗	✗	✓
	Well-being	✗	✗	✓
	Shared strategies	✓	✓	✓
	Engage community	✗	✓	✗
	Landscape quality and atmosphere (liveability)	✓	✓	✓
	Social equity	✗	✗	✓
11. Economy	Local products, food and materials	✓	✗	✗
	Economic growth	✗	✗	✗

Similarly, waste strategies regarding the end-of-life of the projects were not included in the case study projects, possibly due to the long lifespan of area development projects. In addition to this, the material theme seems to be underemphasized in the designs of all cases.

Similarly, several social themes are also underexposed in the plans. The inclusion of outdoor public spaces is often implemented, but that can be explained by its general value in a good plan, not its connection to sustainability or a circular economy. Furthermore, it can be observed in Table 4.3. that the excluded categories often possess intangible characteristics, making them harder to translate into design strategies.

Furthermore, circular soil excavation is a challenging theme to address in redevelopments. Redevelopment sites are often polluted due to historic activities, especially when the site has an industrial background. Interviewee 8 suggests that the topic might have deserved more attention in the early phases of the process when design options are clearer. "*If you knew that, then perhaps you could have played along a bit or maybe.. There are also options for contaminated soils, or at least up to industrial classes, then you can maybe still look at disposal options*" (Interviewee 8, personal communication, 26 July 2023).

Furthermore, none of the cases emphasise and none of the interviewees mentioned the implementation of maintenance strategies for building designs.

The last theme that is underemphasised in the projects is the economic aspect. Only Binck Eiland included space for retail facilities. However, it remains a question whether implementing retail facilities is necessary for primarily residential areas. The difference in project characteristics might be the reason for the exclusion of this theme for the other development projects.

Overall, almost all themes are implemented in the plans. However, the focus on different themes and strategies is determined by the project characteristics.

ACCELERATOR THEMES IN THE CASE STUDY PROJECTS

Similarly to the circular design themes, the four accelerators were identified and analysed in the case studies, but not all of these were present in every case.

In general, many interview participants in all case study projects emphasised the importance of strategic partnerships and the development team they worked with. For example, Interviewee 11 stated, "*because sometimes you have a team that works a bit in isolation. Well, I don't think that's the case with us. The team was just really good, so yeah, that works*" (personal communication, 2 August 2023). This emphasis arises mainly due to the high dependence on other stakeholders in the development processes. Another interviewee explained, "*But with the new construction, it's much more challenging. We had less influence on that. We asked the other developers in advance (they did those sub-projects) to consider that in their choices. I wasn't there to make all those considerations*" (Interviewee 2, personal communication, 10 July 2023). This is visible in the 'Tuinen van Genta' case, as the constructor had a negative influence on the inclusion of sustainable or circular construction techniques. Interviewee 1 highlighted that the constructor preferred to work with traditional prefabricated systems.

The 'Tuinen van Genta' case has shown the importance of circular policies. Interviewee 8 indicates that policies might be the reason the development was not connected to gas sources: "*the plan was only submitted to the zoning plan after 2020, and all plans after 2020 were no longer allowed to be connected to gas*" (personal communication, 26 July 2023). Furthermore, Interviewee 5 indicated that the water retention only complied with the standard at that moment.

The use of decision-support tools is discussed in many projects; however, their implementation is limited. While this could provide an incentive for stakeholders to implement circular design strategies and themes. Interviewee 1 indicates that the use of BREEAM certificates did help a lot during another project he worked on (personal communication, 7 July 2023).

Lastly, it is worth noting that the projects did not explicitly include any technological accelerators. This could suggest a disconnection between the findings in academic literature and practical application. This might be attributed to the relatively recent attention the technological theme has received in scientific literature.

4.2.2. BARRIERS AND ENABLERS IN THE CASE STUDY PROJECTS

Through the analysis of the case-related interviews, several barriers and accelerators for circular-designed area development projects were identified. These barriers hinder the effective implementation of circular design strategies, while consciously including accelerators can facilitate and enhance circularity. Appendix F contains a full comprehensive analysis of the case study interviews.

This paragraph offers a cross-case analysis, comparing separate analyses to extract valuable insights regarding patterns and similarities in barriers, accelerators and lock-in moments in the development process. This comparison provides the information

needed to draw conclusions about necessary changes to the area development process, facilitating and enhancing circular design strategies.

BARRIERS

Several similar or identical barriers for circular designs could be identified in the different cases. These barriers are related to the municipality, the lengthy duration of processes, communication, people, and technical aspects. The following paragraphs provide an explanation of these barriers and why they are perceived as such.

MUNICIPALITY

The maintenance departments of the municipalities can be seen as one of the most influential barriers in the processes. In all cases, almost all interviewees (10 out of 11 interviewees) mentioned discussions with the municipality as a limiting factor during the process. Even the municipal project leaders of both 'Binck Eiland' and 'Tuinen van Genta' pointed out the conservative stance of the municipal maintenance department towards interventions that deviate from the standard (Interviewee 5, personal communication, 17 July 2023; Interviewee 9, personal communication, 28 July 2023).

Interviewees point out several reasons that can explain the conservative or hesitant attitude. Some believe it could have something to do with lack of knowledge and experience with the interventions, because circular design strategies often deviate from the standard they apply (Interviewee 2, personal communication, 10 July 2023). Therefore, the costs and practical implications are unknown. They lack experience with these interventions and, therefore, are reluctant to bear the risks when maintaining public space.

The interviewees identify a noticeable difference between big and small municipalities, as evident in the case study. Smaller municipalities seem to be more open and willing to implement innovative circular design strategies that differ from the standard (Interviewee 8, personal communication, 26 July 2023; Interviewee 10, personal communication, 31 July 2023). "*The larger the municipality, the more difficult it becomes, especially if the municipality is not very ambitious*" (Interviewee 7, personal communication, 26 July 2023). This difference is also evident in the 'Tuinen van Genta' project compared to the other cases, as this barrier was perceived as less dominant in this case.

As an explanation, the interviewees refer to a more integral or coherent decision-making process, having more time available, and a better communication flow within smaller municipalities. Interviewee 8 emphasized the benefits of the municipal project leader in this case: "*Although within this project, I do think that the project leader was superb. She ensures that there are connections within the different departments. She dared to fight for certain things to achieve the project's interests, instead of adhering strictly to the demands of the maintainers*" (personal communication, 26 July 2023).

Furthermore, activities such as visiting reference projects with municipal managers to address concerns are very valuable for innovative projects. In municipalities such as Breda (Tuinen van Genta), this is possible. However, the interviewees indicate that these activities are nearly impossible for municipalities such as The Hague.

Lastly, several interviewees indicate that the maintenance departments join the process quite late. Hence, they lack understanding of the reasoning behind innovative choices (Interviewee 3, personal communication, 12 July 2023; Interviewee 6, personal communication, 19 July 2023; Interviewee 11, personal communication, 2 August 2023). This results in a lack of a sense of responsibility for the project.

PROCESS DURATION

Another barrier pointed out by several interviewees concerns the duration of the development process. Depending on the scale, area development projects often take a considerable amount of time, typically around 10 to sometimes 20 years (Interviewee 3, personal communication, 12 July 2023). This duration implies that during the initiation phase, you are establishing goals and ambitions for a world a decade into the future. This is already quite challenging for standard measures, let alone for circular design strategies. The circular economy is a very dynamic concept, extensively studied over the last decade, indicating rapid development. Ambitions, goals, and the urban structure should be flexible so that they can be adapted to the current standard and societal needs.

Furthermore, due to the long duration of the process, a change in the development team may occur. Companies or individuals might be included later in the process, or team members might change for various reasons. When this occurs, knowledge regarding the process and the choices made might disappear with them. In both 'Erasmusveld midden' and 'Tuinen van Genta', changes within the construction teams posed challenges during the process. Erasmusveld should have been one of the most sustainable neighbourhoods in NL; however, Interviewee 3 indicated that after many years, this ambition was somewhat forgotten (personal communication, 12 July 2023). Furthermore, Interviewee 4 indicated that due to changes within the development team during the definite design phase,

it was challenging to keep track of the developments (personal communication, 17 July 2023).

COMMUNICATION

Transparent and open communication is key in processes where intensive collaboration takes place. Several interviewees in each case indicated moments when clear communication had been lacking. Interviewee 4 mentioned that during the initiation of projects, everyone collaboratively works on an integral design (personal communication, 17 July 2023). However, as time progresses, stakeholders tend to focus on developing their discipline independently, and regular communication within the team is no longer automatic.

Furthermore, the municipality involved in the 'Tuinen van Genta' project indicated that some discussions were held to late and lacked transparency, suggesting that certain themes were somewhat overlooked in t he process.

Lastly, both landscape designers involved in the 'Binck Eiland' and 'Tuinen van Genta' projects indicated that during the elaboration of the definite design, they did not have a clear view of the development and which measures were included in the realisation phase (Interviewee 4, personal communication, 17 July 2023; Interviewee 11, personal communication, 2 August 2023).

PEOPLE

Throughout development processes, there is a significant dependence on other stakeholders and their willingness to integrate circular design strategies, highly influencing the outcome. Meaning that other stakeholders can negatively affect circular design implementation. In each case, this barrier is noticed by the interviewees. . In 'Binck Eiland', this was evident through the designs for the three sub-developments on the site, all developed by different developers (Interviewee 2, personal communication, 10 July 2023).

In the case of 'Tuinen van Genta', this became apparent in the building techniques that were preferred by the constructor: "*That wasn't possible because our builder wanted to use a prefab concrete construction system*" (Interviewee 1, personal communication, 7 July 2023). Lastly, for 'Erasmusveld midden', it was evident in the dominance of the architecture: "*Often, the architect is still leading, so then we have to follow. We have to solve it*" (Interviewee 10, personal communication, 31 July 2023).

Furthermore, in each case, some interviewees pointed out that it takes a lot of time and effort to convince municipalities or other stakeholder of the value of implementing circular design strategies. Interviewee 2 indicates that the transition toward circular-designed areas requires breaking traditions in both the construction industry and that of residents, and that takes time (personal communication, 10 July 2023).

TECHNICAL BARRIERS

In all three case study developments, interviewees identified technical barriers regarding project characteristics that were limiting for the designs. The redevelopment sites both encountered challenges related to soil contamination, acting as a limiting factor for circular water or soil systems.

Another technical barrier was mentioned by Interviewee 3, who indicated that reusing materials is still uncommon in the construction of buildings because there is no warranty provided on reused materials (personal communication, 12 July 2023). Therefore, developers are unable to provide warranties on residential buildings.

ACCELERATORS

Interviewees in each case also identified similar or identical accelerators for circular design interventions during the process. These accelerators relate to ambitions, strategic partnerships, and decision-support tools.

SET AMBITIONS FOR CIRCULARITY THEMES

In each case study, interviewees highlight the importance of setting ambitions for sustainable and circular design strategies. They indicate that it starts there, and if not defined properly, ambitions are most likely forgotten. The more concrete and precise the ambitions, the better they are integrated: "*The sharper you formulate and establish the goals together in the beginning, the better it is*" (Interviewee 1, personal communication, 7 July 2023). Additionally, Interviewee 6 states: "*basically, it starts with those high ambitions that have been set, and once they are there, the plan continues and might be tweaked a bit*" (personal communication, 19 July 2023).

STRATEGIC PARTNERSHIPS

Strategic partnerships are often considered by the interviewees as something that stimulates the implementation of circular design strategies. Interviewee 1 indicates that "*it is important you can address everyone*", especially when disagreements arise or you believe measures can be incorporated into the design better (personal communication, 7 July 2023).

Strategic partnerships are particularly effective in overcoming the 'people' barrier, as they ensure the involvement of companies and individuals who share the same values, and are willing to create a circular and

sustainable neighbourhood. This is especially visible in the 'Binck Eiland' project. Interviewee 11 indicates that the project team collaborated really well, positively affecting the final design (personal communication, 2 August 2023). Even though ambitions regarding circularity and sustainability weren't set clearly upfront, many circular design strategies were incorporated into the design.

Additionally, Interviewee 3 indicates that establishing a strategic partnership with the municipality is an effective method to deal with conservative maintenance departments within the municipality (personal communication, 12 July 2023). It is crucial to involve municipal project leaders more comprehensively in the process. When they are included in the decision-making and agree upon the state ambitions, they can help deal with reaching integral design solutions, benefiting the development project (Interviewee 3, personal communication, 12 July 2023; Interviewee 11, personal communication, 2 August 2023).

DECISION-SUPPORT TOOLS

Some interviewees perceive decision-support tools, such as BREEAM certificates, as effective tools to help make decisions. As mentioned by Interviewee 1, development teams could be more easily convinced of the value of certain solutions when the aim is to achieve a certain certificate (personal communication, 7 July 2023). However, according to Interviewee 2, the fundamental drive to create circular projects should come from the stakeholders themselves (personal communication, 10 July 2023).

PROCESS

In the case studies, several crucial moments during the planning phases of the area development process can be identified. These are described in the following paragraphs, first during the initiation phase, and second during the feasibility phase.

INITIATION PHASE

From the interviews, it became clear that two significant actions must be taken in the initiation phase to ensure circular principles are included in the project. These are the establishment of ambitions and the creation of the urban plan.

The development of ambitions at the start of development projects was already explained as an accelerator in the process for circular area development. Interviewees indicate that quantification or practical translations of the qualitative ambitions are essential. "*So, in the initiation phase, you already have to say: 'what is our ambition? Are we in agreement, yes or no? And if we agree, what are the implications of this? So, are we going to capture a certain amount per square meter on the roof, and are we moving towards reusing materials, how are we going to approach this with a municipality?*" (Interviewee 11, personal communication, 2 August 2023).

Furthermore, several interviewees mention the importance of the urban plan development in the initial phase of the process. According to Interviewee 1, the initial feasibility of the project depends on this plan. Therefore, according to Interviewee 1 (personal communication, 7 July 2023), structuring choices should already be made in this plan. "*Some choices are very structuring in nature. I mean, greenery versus parking*" (Interviewee 1, personal communication, 7 July 2023).

According to Interviewee 3, the urban plan "*mainly outlines that robust public space. And ideally, you want to be flexible in the design within that*" (personal communication, 12 July 2023). Thus, ambitions regarding, for example, greenery are established at the beginning and in the urban plan: "*you establish that at the core. And for each sub-plan, you further elaborate on that in an actual green plan*" (Interviewee 3, personal communication, 12 July 2023).

In this plan, circular design strategies regarding implementation themes should be incorporated from the outset. The reason for this is that circular design strategies are often perceived as more expensive or harder to implement.

FEASIBILITY PHASE

During the feasibility phase, the sketch, preliminary, and definite designs are made. This is when the circular ambitions are refined into circular design strategies. To make this more manageable, it is important that functional ambitions are concisely translated into technical aspects. Interviewee 11 emphasizes that specifications should be decided upon and laid down fast: "*Because the longer you wait, the easier it is to push it aside, and the easier it just disappears*" (personal communication, 2 August 2023).

When the design is transformed from preliminary towards a definite design, this is the moment the municipal maintenance department gets involved. However, several interviewees indicate that this is too late in the process. Therefore, it is key to include a strategy towards the municipality earlier in the process.

Lastly, often during the concept preliminary design, preload is already placed on-site, while during the definite preliminary design, the construction preparations are already started. This means that these are lock-in moments for ground works, and strategies for this should be very clear and openly discussed with other stakeholders by that point.

SUMMARY BARRIERS, ACCELERATORS AND PROCESS CASE STUDIES

The research identified several barriers, accelerators, and important moments in the development processes of the three case study projects. These have influence on circularity in the development process. These barriers and accelerators either promote or hinder the implementation of circular design. Furthermore, the process moments indicate the necessity of clarity on specific design themes; otherwise, they might be excluded from the plans. Table 4.4 provides an overview of these identified barriers, accelerators, and lock-in moments, which require attention when re-evaluating the standard development processes to facilitate and enhance the implementation of circular design strategies.

Main barriers in the process are related to the municipal maintenance departments, process duration, communication, team dynamics, and technological limitations. Inclusion of actions to overcome these barriers is crucial.

Moreover, identified accelerators in the process are related to setting ambitions, establishing strategic partnerships, and decision-support tools. Consciously integrating these elements in the process positively influences design strategies.

Identified barriers	
Municipality	• Conservative • Want uniformity in city • Join too late in the process
Process duration	• Ambitions for over 10-20 years • Changes in development team, knowledge gets lost
Communication	• Discussions are held too late • Transparency is missing • Gap during definite design phase between landscape designer
People	• Convincing people takes time
Technical barriers	• Warranties • Soil contamination
Identified accelerators	
Setting ambitions	• Circularity starts at the establishment of ambitions
Strategic partnerships	• Pursuing same goals • Municipal support
Decision-support tools	• Helpful to convince
Process	
Initiation phase	• Flexible urban plan, that is the base for the first feasibility calculation
Feasibility phase	• Concept preliminary design • Definite preliminary design

Table 4.4: Identified barriers, accelerators and lock-in moments for circular area development projects.

4.3. INTERVIEW RESULTS: REQUIRED CHANGES IN THE PROCESS

Nearly all interview participants emphasise the importance of establishing ambitions, both in a general context and especially regarding sustainable and circular strategies, during the initiation phase. Furthermore, they indicate that proactive actions have to be taken regarding the ambitions to ensure inclusion. Solely including these themes in the design process ambitions, is not enough. Interviewee 11 states, "*Because, I notice in many projects that stating an ambition is very easy, but realizing it is difficult*" (personal communication, 2 August 2023). Similarly, interviewee 3 indicates, "*So you see: ambition is one thing, but along the way, you have to tick all those boxes, and that's not possible*" (personal communication, 12 July 2023).

In the previous paragraph, several barriers have been identified that have a negative influence on the exclusion of circularity strategies. Additionally, accelerators for circular strategies and lock-in moments in the process have been identified. To overcome barriers and enhance circularity in projects, the development process regarding area development projects has been partially redesigned, incorporating actions that derived from the analysis to overcome barriers and implement the themes for circular design strategies to their full potential. The following changes are made, starting from the basic development process:

1. In the theoretical background study, the development process and characteristics of area development projects have been identified and explained (paragraph 2.2.). In current literature, this process is either projected as a linear process ending after the operational stage or as a process that reverts back to the initiation phase if areas become outdated, Figure 4.1. However, this projection is missing some crucial elements that should be included for a circular economy. As this thesis aims to identify actions during the design process of area development projects, the framework is based on the life cycle described in the literature. To do justice to the underlying concept of the circular economy, the entire project cycle should be included, emphasizing the whole life cycle of used materials.

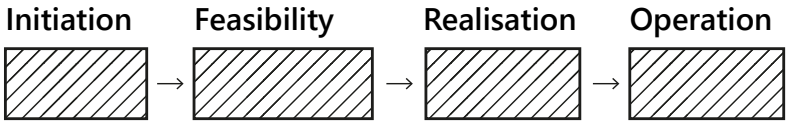


Figure 4.1: Traditional development process.

2. As identified in the theoretical background study, three circular economy strategies can be applied for themes in the built environment: regenerative, adaptive, and looping strategies. During the systematic literature review, it was noticed that the majority of the strategies are related to looping. Furthermore, it is clear that looping resources, materials, and components are important concepts in a circular economy. Although residential areas are in use for many years, it is still crucial to include a symbolic 'End-of-life' phase to highlight the residual value of the used materials in the design and indicate that the operational phase is not the final stage of the process for the materials used, Figure 4.2. Adding this stage to the process encourages stakeholders to consider the end-of-life of materials, components, and buildings during the design stage.

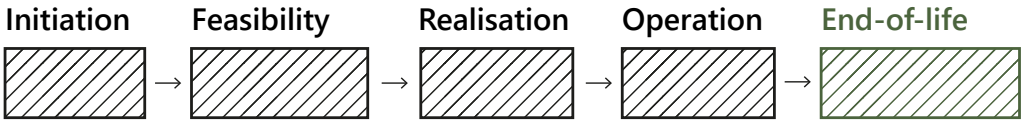


Figure 4.2: Traditional development process including symbolic end-of-life phase.

3. In each phase, one or more sub-phases can be identified. During the circular area development projects, in some of these sub-phases, clear actions are necessary to enhance the successful implementation of circular design ambitions and to overcome barriers. Especially in the design stage, there are multiple sub-designs in which ambitions are further developed and specified. Additionally, during each of these design stages, different themes are more important. Furthermore, during the process there are several important moments at which certain themes and topics should be clear already. It is beneficial to indicate these moments in the framework, Figure 4.3:

- **Initiation phase**: Goals and ambitions, Vision/Structure plan
- **Feasibility**: Sketch design, Preliminary design, Definite design
- **Realisation**: Material selection, Construction
- **Operation**: Use, Maintenance
- **End-of-Life**: Demolition, Material reuse, (re)development

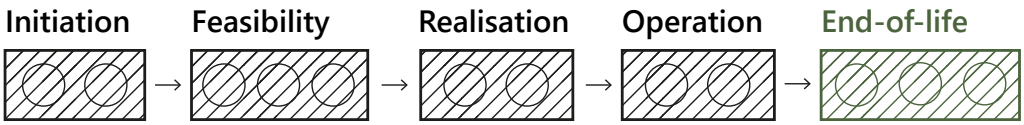


Figure 4.3: Traditional development process, including sub-phases.

4. For circular design strategies, it is important to establish some prerequisite agreements to enhance smooth collaboration and discussions during the process. These are not changes during the process but important topics to consider before thoughts are given about the (re)development designs, Figure 4.4. Including these considerations can improve the successful implementation of circular designs.

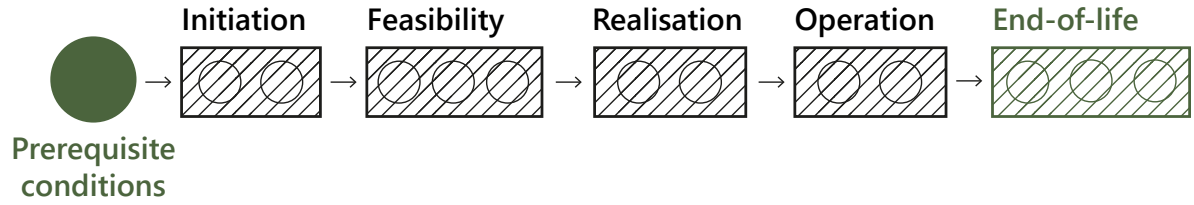


Figure 4.4: Addition prerequisite conditions before start development process.

5. When ambitions, whether for the development in general or for circular design strategies, are established, evaluation is necessary., Figure 4.5 The case studies revealed that aspects are often overlooked if not immediately included, potentially resulting in missed opportunities during the process. However, it is inherent that not every aspect can be defined at the start of the process, as certain themes might need further research. Hence, the evaluation moments should also include the assessment of the established ambitions: are they sufficiently concrete, or do they need further refinement? These evaluation sessions should be scheduled after each sub-design, ensuring the best possible end-result.

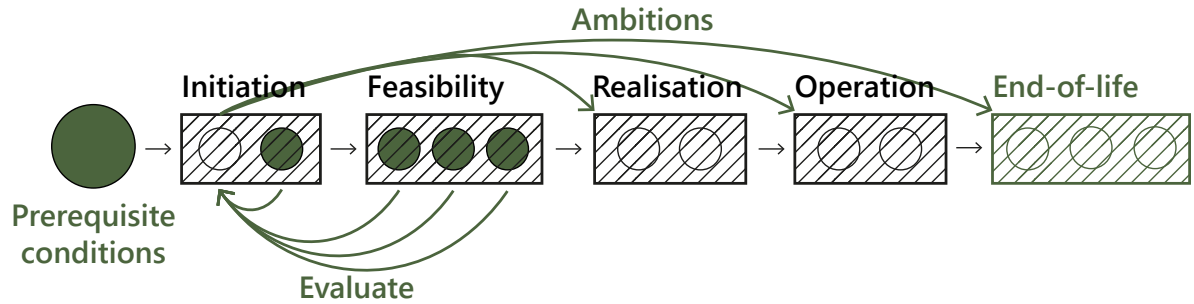


Figure 4.5: State ambitions and evaluate during the design process.

6. The final step that should be incorporated in the area development process is the closure of the end-of-life phase, emphasizing the reuse of resources and materials, Figure 4.6. Visualizing this helps stakeholders implement strategies that design waste throughout the whole process. Future area development projects should be designed with the recovered materials in mind. Afterward, these materials can be physically included in future realisation processes. It emphasises the responsibility to design for future reuse rather than merely considering the materials in their current project.

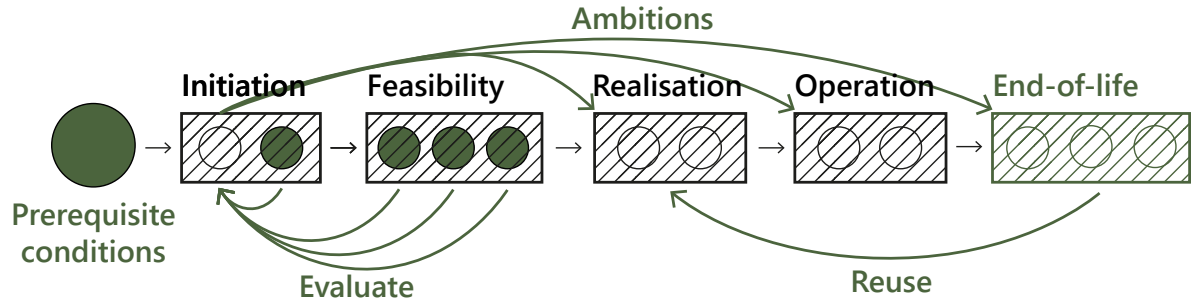


Figure 4.6: Design for reuse after the developments functional lifespan.

4.2.1. CHANGES IN PRACTICE

Figure 4.7 visualises all the required changes in the partially redeveloped process of area development projects. In the following paragraphs, each of these required changes and actions in every planning phase are extensively elaborated. These changes and actions during the process are explained chronologically, aligned with the natural development process of area development projects. This ensures that the findings are presented in a clear and structured manner. The changes were derived from the case study and interview analysis, with the most important empirical findings included in the explanation.

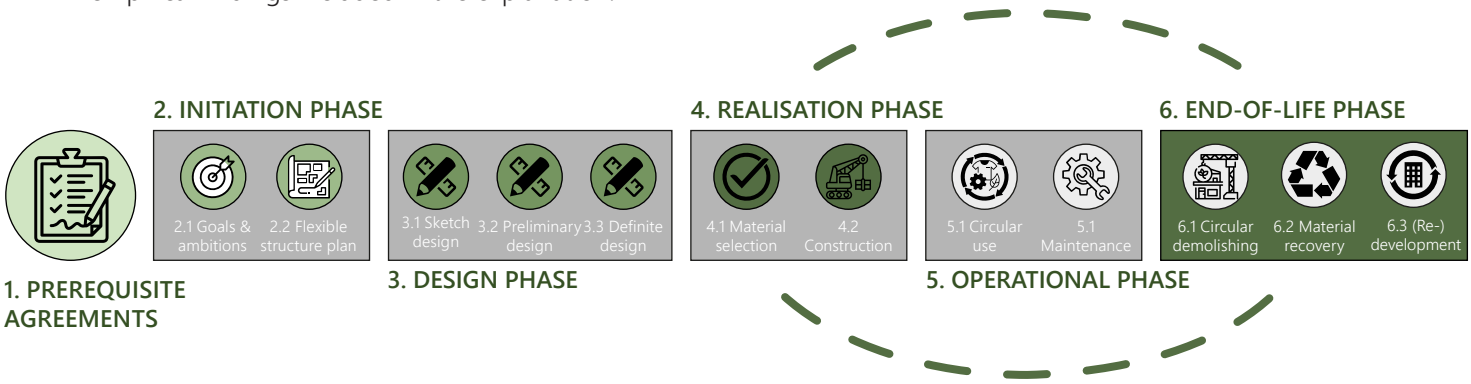


Figure 4.7: Provisional redesign development process for circular area development projects.

1. PREREQUISITE CONDITIONS

From the comparative case study, it becomes evident that the initiation phase of a project holds unique significance in the development process. This is where the foundational goals and ambitions for the area are established, and developers create collaborations. Stakeholder influence is the highest, as emphasized by Interviewee 2: "*if you have a lot of influence, and you make the right choices and set the right goals, then you can have the most impact at the end of the day*" (personal communication, 10 July 2023, Figure 4.8).

Several actions have been identified that must be taken at the very beginning of the development process, given the greatest influence of stakeholders. These actions can be classified as prerequisite conditions, intended to enhance smooth collaboration and discussions during the process. The following paragraphs delve into the details of these actions and their necessity.

A. INCLUSION OF END-OF-LIFE PHASE

Through the comparative case study and interviews, it became evident that the reuse of materials remains a difficult task for both public spaces and buildings. Several reasons explain this difficulty.

A barrier to material reuse in public spaces is related to the hesitant attitude of municipalities. Municipalities, responsible for post-project public space maintenance, prefer standard materials outlined in their public space manual to minimize maintenance costs. Interviewee 10 emphasised this preference, stating, "*They prefer standard elements because they are easier to maintain (...) We know exactly what it costs. For anything new, we don't know the exact costs. So, well, let's not do it*" (personal communication, 31 July 2023). Moreover, concerns about the potential poor quality of reused materials contribute to the resistance. Interviewee 9 mentioned the reluctance of managers: "*So, I can imagine that the idea was suggested, but the managers may not have been keen on it because they would be*

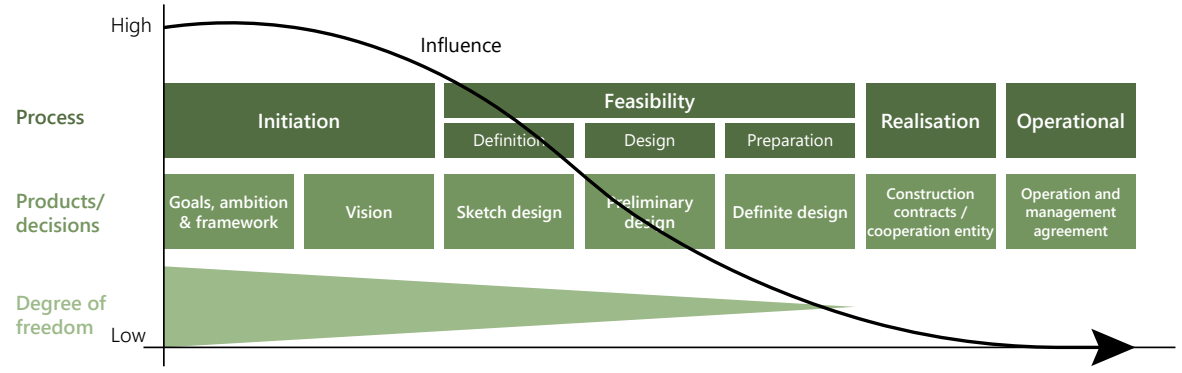


Figure 4.8: Influence during the process. Drawn by Interviewee 2.

taking over potentially damaged materials" (personal communication, 28 July 2023).

In contrast, the situation is somewhat different for buildings. Interviewee 3 indicated that warranties are not provided for reused materials, thus developers "*cannot deliver homes to buyers under warranty*" (Interviewee 3, personal communication, 12 July 2023). This poses a significant barrier for developers in terms of designing with reused materials. Ghaffer et al. (2020) similarly noted challenges related to the availability of reused materials; according to their research, EU Regulation No. 305/2011 prohibits the use of products with uncertified performance.

The addition of the end-of-life phase in the process could raise awareness among stakeholders that the material's life cycle extends beyond project completion. This emphasis on designing for future reuse, even beyond the project life cycle, underscores the need to maintain material and design quality throughout the project's lifespan. Consequently, achieving better-quality materials can be achieved after the development process becomes a feasible outcome.

B. STRATEGIC PARTNERSHIPS

Strategic partnerships have been identified by the systematic literature review as an accelerator for the implementation of circular design strategies. Similarly, many interview participants indicated strategic partnerships as a beneficial factor in the process. Furthermore, interview participants also highlighted that people and poor communication can form significant barriers to a smooth and circular process. Thus, people can either facilitate or impede the implementation of sustainable and circular design strategies in area development projects. "*I believe one thing we may not have mentioned yet is also the team you're in, right? So, the project developer, engineer, architect. That also means a lot*" (Interviewee 11, personal communication, 2 August 2023).

As previously explained, in each of the projects, there were limiting factors due to cooperation with involved stakeholders. For 'Erasmusveld midden' Interviewee 10 indicated the leading role of the architect (Interviewee 10, personal communication, 31 July 2023). In the 'Tuinen van Genta' the constructor preferred the use of certain construction methods (Interviewee 1, personal communication, 7 July 2023). For 'Binck Eiland' subplans of the area were developed by different developers, each holding different values (Interviewee 2, personal communication, 10 July 2023).

Furthermore, Interviewee 2 indicates that circular design strategies require more context, discussions, and involvement from all stakeholders: "*It took quite a bit of time and effort to achieve. Especially due to the other developers, they just didn't understand it, and they thought it was expensive*" (Interviewee 2, personal communication, 10 July 2023). Therefore, the inclusion of companies and individuals that strive for the same norms and values smoothes the process. Interviewee 11 indicates that teams should collaborate integrally on collaboratively established goals: "*If you all express ambitions together in the beginning and work together on them*" (Interviewee 11, personal communication, 2 August 2023).

Therefore, before the project is even initiated, it is important to establish strategic partnerships with parties that are willing to invest the necessary time and effort to develop circular designs. Intrinsic motivation in the organisation and that of the collaborating stakeholders is crucial: "*If you ask someone else who has no interest or authority, it won't happen. So, at the beginning, you need to have clear goals and a shared desire to achieve them, along with making agreements about them*" (Interviewee 2, personal communication, 10 July 2023).

C. MUNICIPALITY

The municipality was identified by interviewees as the most significant barrier in the case study projects, particularly due to the conservative stance of municipal maintenance departments towards circular design strategies. This reluctance often stems from a preference for standard materials, as explained in the 'inclusion of end-of-life phase' paragraph.

Interviewees highlighted that municipal maintenance departments enter the process too late, leading to tensions between the designed plans and the approved materials. Circular design strategies are initially agreed upon with aldermen, project managers, and policy-makers, but conflicts arise during the definite design phase when maintenance departments evaluate the design (Interviewee 3, personal communication, 12 July 2023; Interviewee 7, personal communication, 26 July 2023; Interviewee 10, personal communication, 31 July 2023; Interviewee 11, personal communication, 2 August 2023). Interviewee 11 states, that during the definite design "*it is discussed once more with the maintenance departments, at that point, the administrator already holds the power and can say, 'no, we're not doing this'*" (personal communication, 2 August 2023).

To address this issue, municipal maintenance departments should be involved earlier in the decision-making process. Interviewee 11 emphasised the need to engage them "*at a very early stage to discuss this*

upfront, because maybe not everything is possible, but some aspects might be feasible. In that case, the chance of success is significantly higher" (personal communication, 2 August 2023). However, Interviewee 7 pointed out challenges in early involvement, stating, "*Yes, but when we try that, they don't want to. Because it's still too early. You hear that occasionally: 'yeah, no, I don't have the hours for it,' or 'the project is still unknown,' and whatever else*" (personal communication, 26 July 2023).

Establishing a strategic partnership with the municipality is deemed beneficial for the process and circularity of the project. Interviewee 3 stressed that there is a need for a project manager with authority and mandates to override various municipal maintenance departments to "*make the integral assessment*" (personal communication, 12 July 2023). Without such authority, the municipal project leader functions merely as a "*messenger between you as a developer and those maintenance departments*" (Interviewee 3, personal communication, 12 July 2023). The involvement of a project manager with the power to advocate for established ambitions enhances the implementation of circular design strategies. Interviewee 11 further emphasised the role of the project manager, stating, "*A project manager also has to stand behind the ambitions, because he also has the power to say, 'yes, but dear administrator, we established this at the beginning. We presented it to committees, I don't know what else, so we're just going to do it, period, and you'll figure it out*'" (personal communication, 2 August 2023). Interviewee 8 observed the positive impact of the project leader in the 'Tuinen van Genta' case (personal communication, 26 July 2023).

D. CONTEXT OF THE SITUATION

The developer in the 'Binck Eiland' case showed a significant focus on the local context when acquiring the site. They explored the most circular options for materials available in existing buildings. For instance, reused fire hose reels were transformed into art, and gas from old fluorescent lighting was collected instead of being released into the air. Interviewee 2 highlighted Vink Bouw's commitment to these practices, saying, "*Vink Bouw really delved into how they could do that well*" (personal communication, 10 July 2023). This showcases the importance of assessing the local context for the circular reuse of materials and buildings.

Interviewee 11 suggested that starting with an evaluation of available materials would significantly ease integration into the project. He commented, "*If the municipality had said, 'look at what's available and work with that', it would have integrated much more easily into what you're doing, right? Otherwise, maybe circularity becomes a bit of a side road. You tend to forget it because you're busy with your work, and it becomes an extra thing to deal with*" (personal communication, 2 August 2023). The interviewee also highlighted the need to look inside buildings, emphasizing that the materials inside the building otherwise might be overlooked in the process.

In 'Tuinen van Genta', Interviewee 5 indicated that discussions about reusing crushed concrete materials were initiated too late, resulting in unusable materials as per the municipality's requirements. "*While if you had initiated the discussion earlier, you might have had a viable material*" (Interviewee 5, personal communication, 17 July 2023). According to Interviewee 5, there might have been opportunities to upgrade the material, or explore other possibilities, if this aspect was addressed earlier.

Thus, for redevelopment projects, it is crucial to incorporate a prerequisite regarding site materials in the process. This inclusion emphasises that exiting materials and buildings on-site still have value, and, potentially, can be used in new projects. Integrating this aspect into the process ensures that discussions about this aspect occur earlier, increasing the chances of successful reuse.

2. INITIATION PHASE

The initiation phase lays the foundation for circular design themes by establishing ambitions and developing a flexible urban plan that broadly incorporates these objectives. During this phase, the urban plan's feasibility is evaluated. Thus, including circular strategies within this plan is essential, because these are often perceived as more costly than conventional solutions. Inclusion can help convince sceptical stakeholders about the viability of the ambitions. These crucial elements in the initiation phase are elaborated on in the following sections regarding these topics.

E. AMBITION DOCUMENT; EXPRESS AND TRANSLATE

Many interviewees indicated that defining ambitions regarding circular design themes is the most crucial action in the entire process. Without ambitions, circular aspects are unlikely to be integrated into the design. Interviewee 2 highlights the significant of making the right decisions at the initiation phase, stating, "*At the beginning, when the influence is greatest *Figure 4.8*, you have to make the right choices. This is where we had all the discussions*" (personal communication, 10 July 2023). In the case of 'Binck Eiland', both Interviewee 2 and Interviewee 11 stress the need to outline the implications of these ambitions: how to execute them

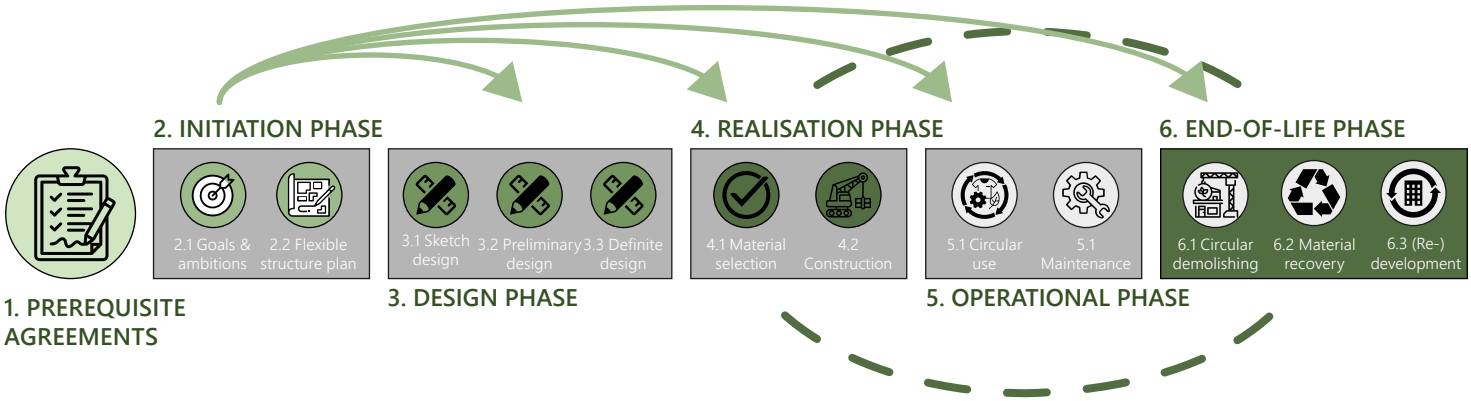


Figure 4.9: Circularity ambitions for each process phase during the design phases.

and what their consequences might be (personal communication, 10 July 2023; personal communication, 2 August 2023). Additionally, Interviewee 2 emphasises the need unanimity in pursuing the defined ambitions, because "*if you don't pursue the same goals, you'll just run into problems there*" (Interviewee 2, personal communication, 10 July 2023). According to Interviewee 1, the more precise the ambitions are formulated, the smoother the process becomes.

Interviewee 1 emphasised that decisions regarding the ambition can be very structuring for the design. Therefore, it is better to make decisions early on in the process: otherwise, they might not be implementable in the project. For instance, in the 'Tuinen van Genta' case, the trade-off between greenery and parking was pivotal; lower greenery ambitions might have excluded underground parking (Interviewee 1, personal communication, 7 July 2023).

To facilitate the circularity in the process, the creation of an ambition document regarding circular design themes could be a beneficial tool. It can function as a guideline for current stakeholders, and also provides a tool for updating new stakeholders during the process. The circular design themes identified in chapter 4.1. can be included in this tool, as these themes were identified as crucial for comprehensive circular area development designs. Interviewee 11 supported this idea, stating, "*Just indeed a document, for example an Excel sheet, where you simply have 20 points stating what we're going to do. These are the consequences and the actions behind them, you know. Of course not for everything, some things can be easily documented. For some things, you still don't know, you have to investigate. But to keep that Excel sheet as a guide. I think that would be very, very useful*" (Interviewee 11, personal communication, 2 August 2023).

Achieving circularity in each phase

Five academic literature sources from the systematic literature review offer insights into circular design across different process phases, outlining which themes reflect circularity at various stages of the process. Generally, the literature differentiates strategies that achieve circularity in the different phases: design, construction, operation, and demolition/End-of-life (Çetin et al., 2021; Foster, 2020; Nußholz et al., 2023; Rahla et al., 2021a; Smitha & Thomas, 2021). Moreover, Eberhardt et al. (2022) distinguish between preventive strategies, focused on design, and management strategies aimed at circularity during construction, operation, and/or end-of-life. Therefore, ambitions set during the initiation of an area development project should encompass strategies targeting circularity in each of these phases as well.

It is recommended to identify significant themes for different phases and clearly state circular ambitions for each phase (design, construction, operation, and End-of-life), as is visible in Figure 4.9. This approach allows for comprehensive ambitions and integral decision-making regarding the best strategies for the overall process.

Circular design themes in relation to the process

Recognising the right time to prioritise and refine various circular design themes is crucial for their integration. During the initiation phase, ambitions often remain abstract due to limited knowledge or uncertainty about final implementation. As the design phases progress, these ambitions become more tangible and manageable, as illustrated in Figure 4.10. This approach allows for more design freedom throughout the process. "*You capture the ambitions early on, and the precise elaboration can come later. When you have the ambitions and references clear early on, you can refer back to them throughout the entire design phase*" (Interviewee 1, personal communication, 7 July 2023).

Hence, the framework needs to emphasise when each circular design theme requires attention to ensure integration. While some sources in the systematic literature review specify when various themes should achieve circularity in broader phases, they lack specification between the design phases.

Based on the case study, an indication can be made concerning important moments regarding the

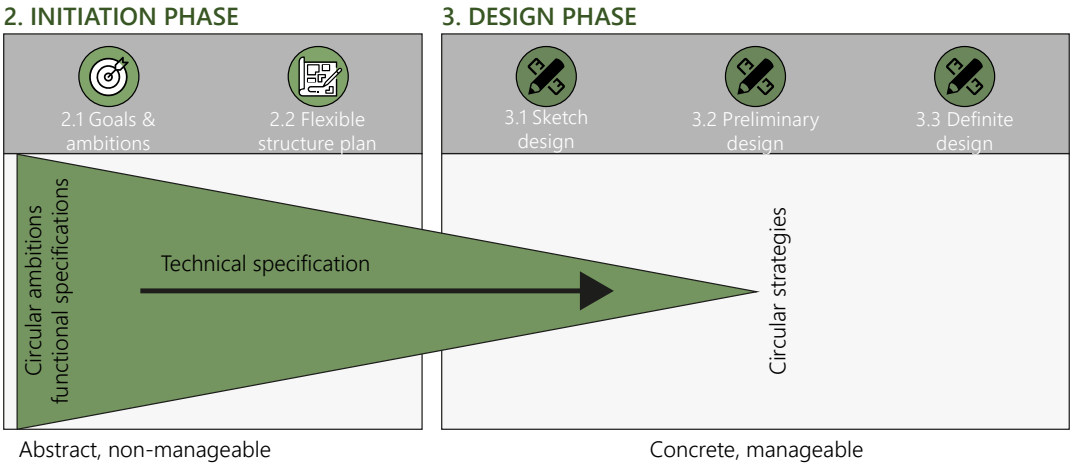


Figure 4.10: Elaboration ambitions, from abstract to concrete.

circular design themes, see Table 4.5. The indication was made based on identified lock-in moments in the initiation and feasibility phases. In the initiation phase, crucial lock-in moments include 'the elaboration of the goals and ambitions', where each theme should be discussed and specified based on its importance for the project. The 'flexible urban plan' plays a crucial role in determining the initial feasibility. Furthermore, for the feasibility phase the 'concept preliminary design' and 'final preliminary design' are essential. When the concept preliminary design is completed, preload is placed on site, indicating groundwork should be finalised. Similarly, upon completing the definite preliminary design, dwellings are ready to be marketed.

F. FLEXIBLE URBAN STRUCTURE, INCLUDING AMBITIONS

The end of the initiation phase is marked by the development of an urban plan, against which feasibility can be assessed. Interviewee 1 and Interviewee 3 emphasised the importance of integrating circular ambitions in this plan. According Interviewee 1, it constitutes "*a layout plan with the spatial program upon which land and property development are based, and financial feasibility is assessed*" (personal communication, 7 July 2023). Thus, to successfully implement circular designs, these ambitions need to be clearly defined. Interviewee 2 highlights the challenges in proving the financial benefits of circular design strategies, stating, "*It is very difficult to prove what circularity yields financially*" (personal communication, 10 July 2023). Therefore, when evaluating the feasibility of the plans, these circular design ambitions should mostly be clear. This moment provides an opportunity to mitigate resistance, through conducting preliminary feasibility calculations on the stated ambitions.

Besides this, flexibility is also necessary during the process. Interviewee 3 stresses the significance of flexibility in the urban plan to cope with the dynamic market and future changes. "*And ideally, you want to be flexible in the design within that*" (Interviewee 3, personal communication, 12 July 2023). While some choices and topics that can be decided upon later in the process, Interviewee 1 states that fundamentally structuring choices should be made early on. Similarly, Interviewee 2 mentioned the challenge of stating ambitions for the project, often set a decade or more in advance of the area's actual use, Figure 4.11. "*The difficulty lies in the fact that you don't know exactly what the technology can do beforehand, what the contractor can do precisely. So, you have to keep looking ahead for a long time: what are the solutions you can choose?*" (Interviewee 2, personal communication, 10 July 2023).

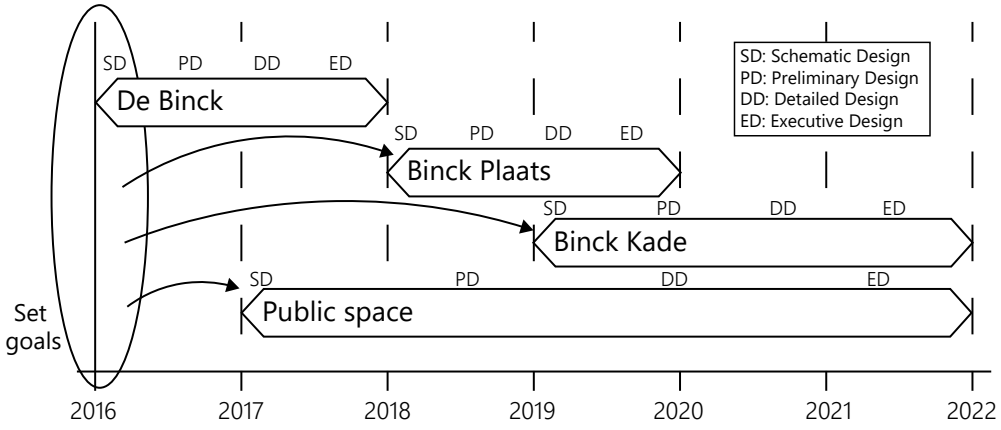


Figure 4.11: Timeline development vs. ambitions in Binck Eiland. Drawn by Interviewee 2.

Table 4.5: Crucial moments during the design process to emphasize themes (highlighted in colour). Abbreviations SD = Sketch design, PD = Preliminary design, and DD = Definite design.

Process phases		Initiation		Feasibility		
Circular design themes		**Goals**	**Urban structure**	**SD**	**PD**	**DD**
1. Urban structure	Robust urban structure					
	Brownfield development					
	Local context					
	Land-use optimisation					
2. Mobility & transportation	Sustainable mobility & transportation					
	Multi-modal transportation					
	Accessibility					
3. Environmental networks	Biodiversity					
	Ecosystem regeneration					
	Public access to green space					
	Ecosystem service provision					
4. Circular water systems	Gray/rainwater collection & storage					
	Preserve and regenerate fresh water					
5. Circular soil systems	Circular soil excavation					
	Soil regeneration					
6. Circular energy systems	Renewable energy					
	Energy efficiency					
7. Circular building design	Building reuse					
	Adaptive & resilience strategies					
	Materials					
	Maintenance					
8. Materials	Closed resource management					
	Resource efficiency					
	Reduce environmental impact					
9. Closed waste systems	Industrial ecology					
	Waste infrastructure					
	R-strategies					
	Environmental management system					
	Design out waste					
10. Social aspects	Culture & heritage					
	Educate					
	Social cohesion					
	Safety					
	Health					
	Well-being					
	Shared strategies					
	Engage community					
	Landscape quality and atmosphere					
	Social equity					
11. Economy	Local products, food and materials					
	Economic growth					

Thus, at this stage, it is crucial to specify the stated ambitions as precisely as possible early in the process without overly constraining the flexibility of the urban plan.

3. DESIGN PHASE

During the feasibility phase, the area designs progress further towards a high-value technical design. Introducing evaluation sessions is beneficial for refining ambitions. These sessions enable an assessment of the design's alignment with established ambitions. They also facilitate the transformation of abstract ambitions into specific goals during the design process. Furthermore, they allow for re-evaluation of ambitions based on changing market needs.

G. EVALUATE AFTER EACH DESIGN PHASE

Through the systematic literature review, it became clear that evaluation as a means to enhance circular strategies is rarely emphasises in current scientific literature, despite Girard & Nocca's (2020, p. 20) statement that "*Evaluation plays a key role in planning processes*", as evaluations can contribute to a better planning process (Oliveira & Pinho, 2010).

Similarly, in the case study research, none of the interviewees mentioned using evaluation as a standard method to consciously review designs in terms of circular strategies. Although several interviewees mentioned that clearly stating ambitions can serve as a helpful reference throughout the design phases, none indicated incorporating it. When asked about implementing evaluation moments, Interviewee 11 agreed that this should be integrated into the process (personal communication, 2 August 2023).

Evaluation sessions after each design phase (see Figure 4.12) are valuable for assessing designs regarding the stated ambitions. Additionally, these sessions offer an opportunity to reassess and clarify themes if they were not clearly specified during the initiation phase, ensuring their inclusion and preventing oversight.

Thus, evaluation sessions focusing on the set ambitions should be included after each design phase, covering:

A. Evaluation of designs based on set ambitions
B. Re-evaluating abstract ambitions
C. Evaluate if ambitions remain satisfactory

H. HIGH-VALUE TECHNICAL DESIGN

Many of the interview participants highlighted the importance of clearly defining all design strategies before transitioning from preliminary to definite designs. Interviewee 1 highlighted the necessity, stating, "*But then you are talking about decisions during a preliminary or definite design, and then it needs to be clear, or else it won't be easily incorporated*" (personal communication, 7 July 2023). Notably, Table 4.5 does not emphasise any themes during the definite design phase. Interviewee 6 indicated that the period between the preliminary and definite design might involve trimming down ambitions and designs: "*So, actually, between preliminary design and definite design, that's where the stripping down happens, causing certain things not to be achieved*" (Interviewee 6, personal communication, 19 July 2023). Therefore, the elaboration of the design themes should be done early in the design process, as noted by Interviewee 11: "*Because the longer you wait, the easier it is to push it aside and the easier it just disappears*" (personal communication, 2 August 2023).

At this phase, municipal maintenance departments become involved, as explained in section 'C. Municipality'. Steps should have already been taken to ensure smooth discussions with these departments.

Moreover, the literature background points out several defining moments during the design phases where decisions already need to be clear. These occur at the conceptual preliminary design and the definite preliminary design. Preload is added on-site after the conceptual preliminary design is finished, while actual site preparations begin after the definite preliminary design is finished. Hence, a clear understanding of the urban structure, as well as considerations about the use or circular demolition of existing structures, should be established at these stages.

Current literature highlights several themes essential to achieve circularity in the design phase. These are circular building design, maintaining and increasing green space, and energy (Foster, 2020; Nußholz et al., 2023; Smitha & Thomas, 2021). Building reuse strategies are emphasized in all three research studies. Foster (2020) expands on new building and material strategies, and smith & Thomas (2021) also mention a strategy aimed at easy maintenance. Therefore, ambitions related to these aspects should be clearly established to achieve circularity in the design. Table 4.6 visualises the emphasis of these themes in relation to the process phases. However, the other themes should also be critically reviewed, as each development process differs.

4. REALISATION PHASE

During the realisation phase, the material selection and used construction methods are the most important factors to implement circularity.

I. MATERIAL SELECTION

The material selection is typically done by contractors, due to their knowledge and expertise

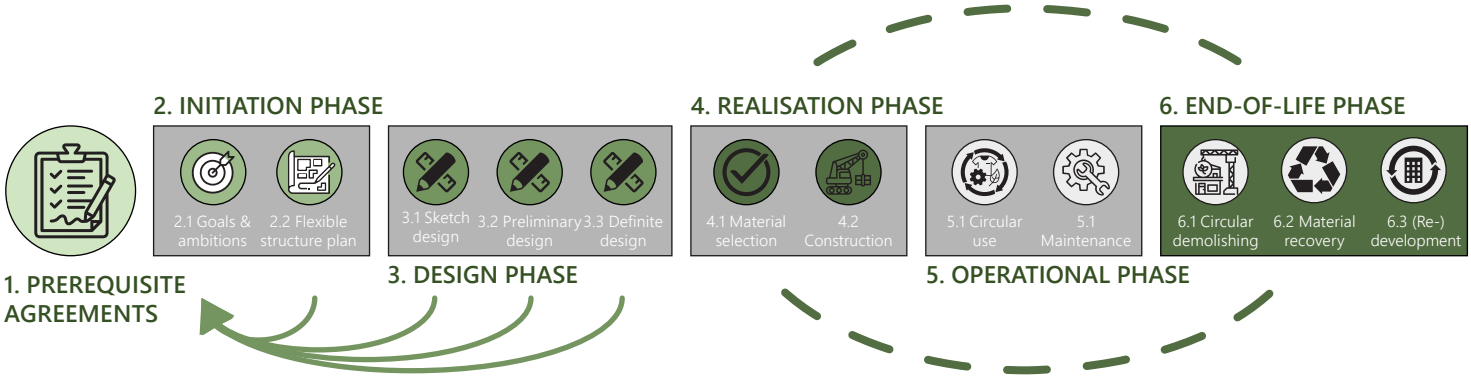


Figure 4.12: Circularity ambitions for each process phase during the design phases.

in making well-informed assessments regarding the best material for the projects. Nonetheless, it is possible to discuss sustainable characteristics of possible materials, ensuring implementation of circular materials. Interviewee 11 indicated that contractors usually take charge of material selection: "*That's what the contractors do in this case, they can make a good assessment. But they did involve us in considerations like: I can get this here now, can I use it? We would ask: how far does it come from then?* (personal communication, 2 August 2023). This indicates that stakeholders can still influence the material selection if they remain involved.

During the material selection, the circular design themes related to materials are the most important (Foster, 2020; Nußholz et al., 2023; Rahla et al., 2021a; Smitha & Thomas, 2021). The important themes according to literature are visible in Table 4.6.

J. SUSTAINABLE CONSTRUCTION METHODS

During the construction phase, using sustainable construction techniques is imperative. Current literature indicates considerations of, for example, sustainable building techniques and equipment, and limiting environmental disturbance should be (Foster, 2020; Nußholz et al., 2023; Rahla et al., 2021a). Furthermore, advanced technologies, such as BIM, should be employed to facilitate more efficient and sustainable processes (Rahla et al., 2021a). Additionally, R-strategies should be used on site, and waste should be limited (Smitha & Thomas, 2021). Lastly, updating the project information with as-built information is essential for future processes (Rahla et al., 2021a).

Table 4.6 provides an overview of the relevant themes for the construction phase, as presented by current literature.

Process phases	Initiation		Feasibility			Construction		Operation	End-of-life
Circular design themes	Goals	Urban	SD	PD	DD	Material	Construct		
1. Urban structure									
2. Mobility & transportation									
3. Environmental networks									
4. Circular water systems									
5. Circular soil systems									
6. Circular energy systems									
7. Circular building design									
8. Materials									
9. Closed waste systems									
10. Social aspects									
11. Economy									

Table 4.6: Crucial moments during the design process to emphasize themes (highlighted in colour) and significant themes to achieve circularity in each process phase (highlighted in light colour). Abbreviations SD = Sketch design, PD = Preliminary design, and DD = Definite design.

5. OPERATION PHASE

All of the identified circular design themes, found through the systematic literature review, are in some way important to achieve circular use of the area in the operational phase of the project. The identified themes are integral in facilitating, e.g., circular energy, water, and waste systems (Foster, 2020; Rahla et al., 2021a). Furthermore, making intensive or efficient use of space holds significance (Nußholz et al., 2023), as do strategies that incentivise residents to recycle, reuse resources, or design out wase entirely (Rahla et al., 2021a; Säumel et al., 2019; Smitha & Thomas, 2021). The literature further emphasises social strategies, sustainable mobility options, and strategies regarding environmental networks (Foster, 2020). All significant themes for this phase are highlighted in Table 4.6.

6. END-OF-LIFE PHASE

The themes identified for the end-of-life phase strategies are mostly related to circular demolition strategies, that focus on reusing resources, materials, and components (Foster, 2020; Nußholz et al., 2023; Rahla et al., 2021a; Smitha & Thomas, 2021). Additionally, themes related to building renovation, adaptation, or selective deconstruction are significant for stating ambitions (Nußholz et al., 2023). Rahla (2021a) further indicates the importance of CE training for construction teams, water and energy-efficient construction equipment, and ensuring safe work environments as significant themes during this phase.

Table 4.6 provides an indication of the significant themes for ambitions regarding circularity in this phase.

4.4. PHASE-WISE META-GUIDELINES FOR CIRCULAR AREA

This section presents the triangulation of the findings of the literature and comparative case study findings discussed in the previous paragraphs. It elaborates on the development of phase-wise guidelines for circular area development processes.

Figure 4.13 illustrates the phase-wise meta-guidelines, developed through the identification of essential actions during the process to overcome barriers and enhance accelerators in the process, and circular design themes for area development projects. These actions and themes are presented within the traditional development process, as outlined in the literature background in Chapter 2 and observed in the case study projects. The added actions (guidelines) facilitate smoother processes and boost the integration of circular designs. The following paragraphs elaborate on these guidelines and rationale, drawing from both the systematic literature review and comparative case study.

From the systematic literature review, it became evident that ambitions related to the project's end-of-life are significant for creating a circular economy. The case study further revealed that the current market is not yet suited for reusing materials due to issues like the absence of warranties for reused materials and hesitance among municipalities to reuse materials, as the possibility exist that it is damaged. Therefore, integrating a symbolic end-of-life phase into the process is crucial for initiating a transition towards circular principles. Through these guidelines, stakeholders become aware of the possibilities during redevelopment or demolition, enabling the establishment of ambitions for this phase, ensuring increased reusability of materials

The communication and involved individuals within the process were identified as a significant barrier in the comparative case study. On the contrary, strategic partnerships were recognized as an accelerator of circular processes by both the literature review and case study. Hence, the conscious inclusion of strategic partnerships, with individuals and companies that are willing to create circular designs is crucial. Stakeholders sharing a similar mindset ensure smoother processes, reducing time spent on circular strategy discussions.

Moreover, interview participants indicated that municipalities could pose the greatest barrier to implementing circular design strategies in public spaces. This is because circular design strategies often differ from municipal standards. Additionally, the municipal maintenance departments usually join the process during the elaboration of the preliminary design towards the definite design. This is when choices regarding circularity should be finalised, meaning that the municipality misses the rationale behind strategies, limiting their commitment to the circular designs. Thus, creating a strategy for municipalities before the project start is crucial:

- The municipal maintenance department should be involved earlier in the process, to ensure they hear and understand the rationale behind the circular designs.
  - a.The 'Tuinen van Genta' project shows that visiting reference projects with the municipality can take away doubts and enthuse them about interventions. However, interviewee 6 indicated that municipalities, especially in the big cities, do not have time for the project yet at that stage.
- The municipal project manager should be included more during decision-making during setting ambitions.

Furthermore, attention to the context of the site and available materials is essential early in the project. A proactive approach prevents discussions about material reuse from occurring too late in the process, as experienced in the 'Tuinen van Genta' project.

The value of setting ambitions concerning sustainable and circular themes was emphasized by many interviewees. The visualisation of the eleven design themes with 42 corresponding sub-categories serves as a comprehensive helpful tool in the guidelines, promoting a thorough consideration and inclusion of circular design themes. This visual trigger encourages development teams to consider each theme and set ambitions regarding these topics, resulting in comprehensive designs instead of solely quantifiable or tangible strategies (Bosone et al., 2021).

The case studies revealed that not every theme is equally important, depending on the project's characteristics. For example, the economy theme was only included in the 'Binck Eiland' case, and reusing buildings was only applicable in redevelopment cases like 'Binck eiland' or 'Tuinen van Genta'. While the 'Erasmusveld Midden' case provided more space for environmental themes, due to it being a greenfield development. The guidelines ensure that circular design themes, including intangible themes, are not regarded as side issues, but as essential design elements.

The literature exploring these themes and strategies, along with the project life-cycle of construction and development projects, identified five main aims for ambitions. These encompass strategies focused on circular design, material selection, construction methods, operational, and end-of-life cycles (Foster, 2020; Nußholz et al., 2023; Rahla et al., 2021a; Smitha & Thomas, 2021). Therefore, the guidelines incorporate:

- Visual representation of eleven circular design themes with corresponding sub-themes
- Emphasis on establishing ambitions regarding circular design themes for the five future phases; design, material selection, construct, operation, and end-of-life.
- Indication of refinement times in the design process for each theme.

Additionally, the interview participants emphasised the significance of integrating flexibility into project plans, particularly during the initiation phase. Given that area development projects take a considerable amount of time, and are influenced by market dynamics, flexibility is crucial.

- A flexible urban structure helps manage uncertainties.

The urban structure is used to establish the projects' feasibility by the end of the initiation phase. Hence, the inclusion and refinement of ambitions regarding circular themes are important. Circular strategies are often perceived as costly, and ensuring the feasibility of these strategies and ambitions increases the likelihood of acceptance by the development team.

Nonetheless, sometimes it is impractical or too complex to establish ambitions for each theme. Additional research may be necessary to establish what is desired when the project is delivered. Hence, evaluation sessions are included in the guidelines. Both in the literature and case study reviews highlighted the value of evaluation.

Evaluation sessions can:

- Ensure designs are in line with the ambitions.
- Re-evaluate the clarity and firmness of the set ambitions.
- Assess ambitions based on future market needs, potentially allowing for higher circular ambitions.

When these steps are integrated into the process, a high-value circular technical design is created.

Incorporation of all of these guidelines into the design process, the potential for generating circular designs is increased. Figure 4.13 provides a visual representation of these combined changes in a conceptual framework for the phase-wise guidelines in circular area development projects.

Guideline	Addressed barrier	Included accelerator
A. Inclusion end-of-life phase	Technical barriers	n.a.
B. Establishing strategic partnerships	Municipality Communication Team dynamics	Strategic partnerships
C. Strategy for the municipality	Municipality	Strategic partnerships
D. Context of the situation	Technical barriers Communication	n.a.
E. Ambition document: express and translate	Municipality	Setting ambitions
F. Flexible urban structure	Project duration	n.a.
G. Evaluate after each design phase	Project duration	n.a.
H. High-value technical design	n.a.	n.a.
I. Material selection	n.a.	Decision-support tools
J. Sustainable construction methods	n.a.	n.a.

Table 4.7: Solved barriers and implemented accelerators through additional actions in the process

4.4.1. SOLVED BARRIERS AND INCLUDED ACCELERATORS

The integration of the guidelines into area development processes serve to address barriers and enhances accelerators. Each of the guidelines targets specific barriers or accelerators and emphasise moments or opportunities to boost circularity within the process. Table 4.7 provides an overview of the guidelines in relation to addressed barriers or included accelerators.

A. Inclusion end-of-life phase – This addresses technological limitations of warranty problems. By including the end-of-life phase, designers become aware of the opportunities for materials post-project lifecycle potential, facilitating a transition towards a circular economy and higher-quality materials.

B. Establishing strategic partnerships – This emphasises the importance of forming strategic partnerships, addressing communication, municipal, and team dynamic barriers by indicating the need for partnerships from the project outset.

C. Strategy for the municipality – Encourages the development team to establish a strategy regarding the municipality, potentially involving closer collaboration with municipal maintenance departments or project managers.

D. Context of the situation – By consciously considering the context of the situation, this guideline addresses technical and communication barriers. Discussions about difficult topics are initiated earlier in the process.

E. Ambition document: express and translate – This guideline focuses on setting circular ambitions, aligning with the ambitions accelerator.

F. Flexible urban structure – Addresses uncertainties associated with long project durations.

G. Evaluate after each design phase – Offers evaluation sessions, increasing flexibility in dealing with the long project duration.

H. High-value technical design – This guideline does not address any specific barriers or accelerators, but signifies the end of the design process, emphasising the necessity of clarity in decisions at this stage.

I. Material selection and J. Sustainable construction methods – Indicate moments when extra sustainability can be integrated if the project team chooses to influence these factors.

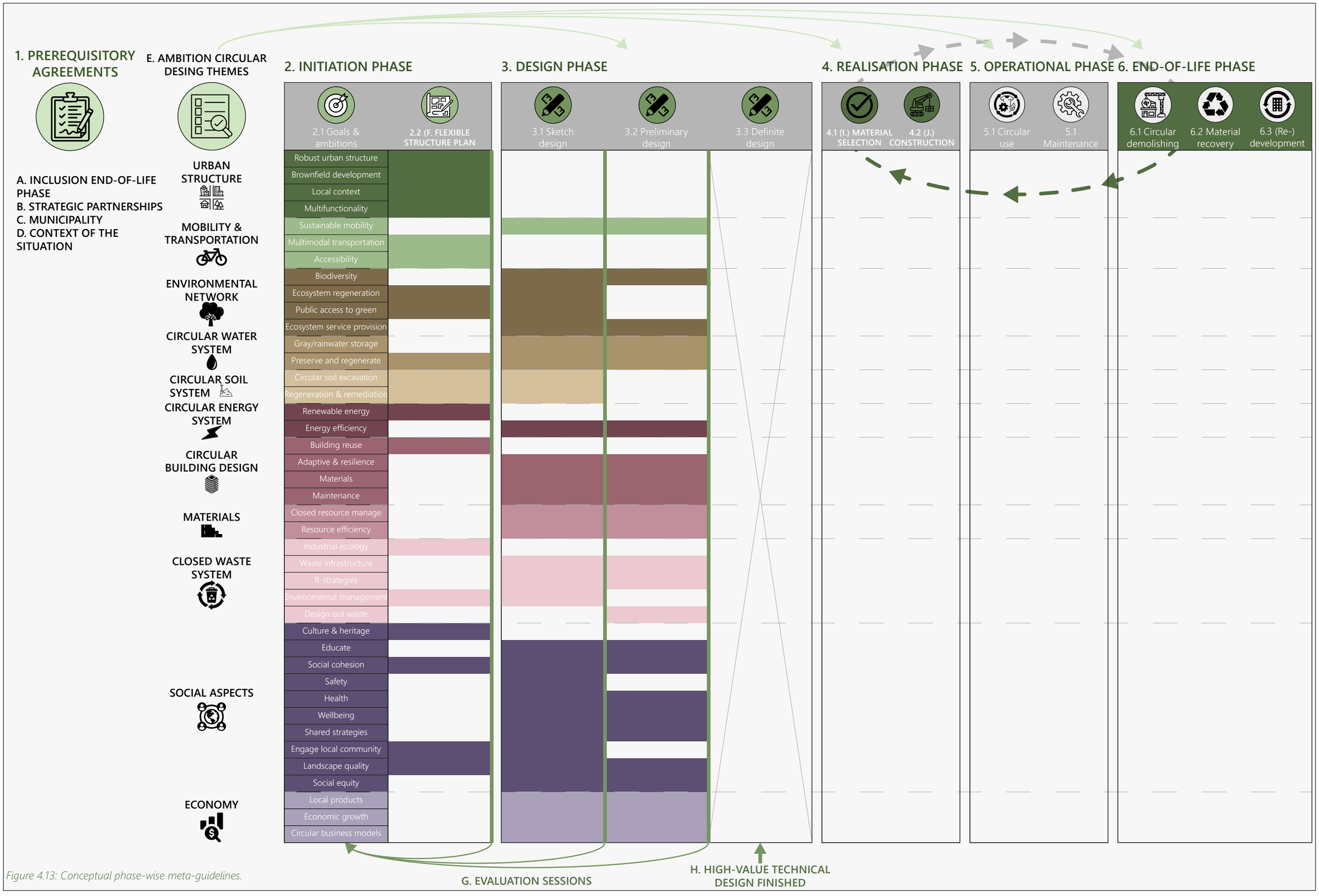


Figure 4.13: Conceptual phase-wise meta-guidelines.

4.5. VALIDATION OF THE GUIDELINES

After the development of the conceptual guidelines, illustrated in Figure 4.12, two validation sessions were held with experts from different disciplines in the field. The validity and credibility of the results was evaluated. Participants were asked their professional opinion regarding each of the research process, the required actions during the process, and the design of the guidelines.

Prior to the session the conceptual guidelines and an explanation of the research findings were sent to the participants. At the start of the session, the aim of the session was explained together with an explanation of the research objective. Subsequently, the research process was explained, followed by a discussion about the credibility of the included case study projects. Lastly, the conceptual guidelines were explained thoroughly, which was followed by a discussion about each of the added actions in the process and design of the guidelines.

4.5.1. RESEARCH PROCESS

During the validation session, a detailed explanation of the development and research process was given to the participants. The main aim of this explanation was to confirm the validity of the investigated case study projects. Furthermore, the experts were asked for their opinion on generalising results based on these specific cases.

The experts concurred that the projects include a broad variety of diverse origins for the initiatives. Each of the included projects is characterised by varying land policies, ensuring inclusion of differences related to different project characteristics. For example, due to the different origins, different obstacles and objectives are included. Furthermore, as indicated by the experts, the origin of the initiative also influences the manner in which ambitions are dealt with, creating differences between the various projects. Additionally, the experts noticed the inclusion of both greenfield and brownfield development as a valuable characteristic. The difference in ambitions, objectives and visions for both types of developments is valuable to include in the research.

The primary criticism raised by the experts was regarding the absence of cases that represent projects in which the municipality takes on an active land policy. The included cases mainly represent projects in which private parties have a leading role, while municipalities mainly take on a facilitative role. Therefore, it is important to be aware of the fact that differences between these types of area development projects are not included in the final result. Furthermore, participants indicated that the similar scale of these cases was sufficient for the results. However, very large scale area developments, such as the development of a whole new village, include a more complex process. The included cases limit the inclusion of this.

Therefore, additional research should be conducted in order to generalize the conclusions for broader-scale and municipal initiated active land policy projects.

4.5.2. REQUIRED ACTIONS DURING THE PROCESS

After the research process discussion, the final guidelines were explained and discussed step by step. Each of the identified changes to the process was elaborated on, after which the experts' opinion was asked. Valuable discussions resulted from this. The validation regarding the identified changes in the process are elaborated in Table 4.10. The most important statements and findings from the sessions are explained, furthermore, necessary changes are explained as well.

Furthermore, participants identified changes that can improve the guidelines when adopted, these are explained and elaborated on in Table 4.7.

Overall, participants mentioned that several of the changes compose a huge challenge for the process. Mainly because the market is not advanced enough yet. Meaning that certain changes are harder to implement or achieve. For example, the inclusion of the end-of-life phase and thinking needs, according to the participants, an systematic change in the whole market. Furthermore, flexibility is a difficult concept. When do you need to make it concrete? For larger project scales, this poses an even greater challenge. Furthermore, the development processes never stops, therefore, it is hard to estimate when evaluation moments should be included.

Nonetheless, participants see the overall value of the identified changes: "*I think you're bridging the gap between, let's say, half or three-quarters of the Netherlands, who are mainly focused on the project-based approach to a task, and, to put it simply, a few scientists who are saying, 'Let's do more circular things.' Those are two different worlds that you're trying to bring together, and I think that's very valuable.*" (Personal communication, 26 November 2023)

Phase	Required action	Validation
1. Prerequisite agreements	a. Visualisation of End-of-Life	Upon elaborating this change in the process, participants agreed that it is too much visualised at the beginning of the process and left of the model. This encompasses an change that should influence each phase of the process. "*Nobody is going to say, "whatever happens, I'm going to do it circular" in a completely unknown context. But if you say, "I'm going to create a program, set ambitions, and include circularity in those ambitions," then it becomes part of the equation. It becomes an ingredient in your mix.*" (Personal communication, 26 November 2023) Other than this, there is nothing wrong with this change, therefore, it was excepted. However, its visualisation should be changed.
1. Prerequisite agreements	b. Strategic partnerships	Overall, this change was clear, and participants agreed upon its importance. However, it was highlighted that again this is visualised too early in the process: "*this can indeed span across your phases. It can be related to the client or contracting party, as you might have a client with ambition and courage. However, it often comes down to technical knowledge and companies that have experience, but by that point, you're further along in the project.*" "*Indeed, those partners – in each phase, you need to refresh those partners*" (Personal communication, 26 November 2023)
	c. Municipality	Clear, no changes necessary. The municipality of Leiden agreed on the importance of including the municipality in the early phases of the project to achieve circularity: "*We have roadmaps for circularity in the public space, and one of the key aspects is that from the beginning, you have various roles together to determine what the ambition is.*" (Personal communication, 6 October 2023). These roles include the municipal maintenance departments
	d. Context of the situation	It was not immediately clear what this action entailed. Therefore, this action should be remained for clarification. *'Available site material evaluation'* more directly highlights the need to look at available materials on site.
2. Initiation phase	e. Ambition document	Clear, no changes necessary The only comment made about this, was regarding the visualisation of the important themes in each of the phases of the process; "*At a certain point in the initiation phase, circularity keeps coming up. You choose your materials, for instance, with the aim of being able to reuse them later on. In the visualization, perhaps, we're currently very focused on it because it's right at the forefront. But you might use arrows or colours to indicate the themes recurring in the later stages.*" (Personal communication, 26 November 2023)
	f. Flexible urban structure	Clear, no changes necessary.
3. Design phase	g. Evaluate at each stage	Clear, useful and necessary change: "*It's important to have those common threads in your project and to keep conducting evaluations, asking questions like, 'What choices have we made?', 'Do we still have the same choices in the next phase?', or 'have they suddenly been discarded?' This ongoing evaluation is crucial for a project's success.*" (Personal communication, 26 November 2023) Additionally participants agreed that the change management topics should also be evaluated.
	h. High-value technical design	Clear, no changes necessary
4. Realisation phase	i. Material selection	Clear, no changes necessary
	j. Sustainable construction	Clear, no changes necessary

Table 4.6: Validation sessions outcomes

Phase	Suggested change	Validation
1. Prerequisite conditions	0. Change management	Experts from the field commonly agreed that the prerequisite conditions should be described as the change management for a circular area development process. "*Isn't point 1 essentially your 'experimental phase' and 'change management,' leading to point 6 eventually? So, in the next phase, you skip directly to 2 because it's already your standard policy.*" (Personal communication, 26 November 2023) Furthermore, the field experts found that its visualisation at the front of the process is incorrect, as these encompass changes that should influence the whole process.
	e. R&D	Participants found the addition of an R&D change in the prerequisite conditions necessary to highlight the importance of research to change. To achieve circularity working methods and design methods should change: "*I believe that R&D should have a more prominent position because people need to be very conscious about their products and do things differently than they do now. The market is still very small in this regard.*" (Personal communication, 26 November 2023)

Table 4.7: Suggested changes and additions

4.5.3. DESIGN OF THE MODEL

The first comment that were made regarding the design of the guidelines, was about the positioning of the actions: "*What visually triggers me is that everything is on the left.*" (Personal communication, 26 November 2023). Participants are of opinion that, the prerequisite conditions should be called 'change management' and should have a more integral position, from which it can align with each phase of the process: "*Then, you come back to that integral beam, change management, which should be at the top, where you can continuously align it throughout the entire process.*" (Personal communication, 26 November 2023)

Furthermore, participants mention that not each change is as visible as they should be. For easier practical implementation, this should be changed in the final design of the guidelines.

Lastly, during the discussions participants mentioned they would like to see which circular design themes are important to achieve circularity in each specific phase.

When asked if the model should be divided into two separate models to improve its readability, experts had mixed reactions. Some thought it might make it more manageable: "*If you do separate them, you place more emphasis on the moments, which I think I've heard you say, and which we've collectively concluded, are important. So, you pause at each phase for that evaluation and the change in the context of that phase*" (Personal communication, 26 November 2023). While others thought it would separate the findings too much: "*Then you start seeing it separately, not as a whole, I think you shouldn't want that.*" (Personal communication, 26 November 2023).

4.5.4. FINAL GUIDELINES

Based on the feedback gained through the evaluation sessions, several changes were made to the guidelines. These changes aimed to simplify and clarify the guidelines, as the content was generally accepted and found useful. The final guidelines are visualised in Figure 4.14.

The additional '1. Prerequisite conditions' were changed to '0. Change management'. The reason for this change is that experts recognised these guidelines as becoming 'normal' in the future. While these currently require conscious attention, focus group participants stated that they expect these topics to become standard practices through future policies. Thus, after using the guidelines for a few projects, these actions should become standard practices, and there will be no need to emphasize them further.

Additionally, focus group participants emphasise the importance of research and development (R&D), especially concerning circular working and construction methods. They stressed the importance of R&D for working methods in each project phase. The addition of R&D also helps to address the technical barrier, which was not previously addressed in the guidelines.

To clarify the content of the 'Context of the situation' guideline, its label was changed to 'Available site material evaluation'. This phrasing more directly conveys the meaning, emphasising the need to evaluate the materials available on-site and determine what can be reused to achieve circularity.

Furthermore, the topics related to change management are now visualised above the process. This adjustment was made because focus group participants felt that the 'prerequisite conditions' were visualised too prominently at the beginning of the process. However, these topics should influence the start of each new phase repeatedly. For example,

starting each new phase requires the inclusion of new stakeholders for different topics. Therefore, new strategic partnerships are necessary at the beginning of each phase.

Focus group participants found the design of the guidelines unclear, as the added actions were somewhat hidden in the information. To clearly highlight the additional actions during the process, a vibrant yellow colour was added. Yellow was chosen because it stands out among the other colours used.

Arrows indicating evaluation sessions were also replaced with yellow indicators. Similarly, the arrows indicating ambitions for the different phases were removed for clarity and to maintain consistency in the guidelines. Instead, the need for ambitions in relation to each phase is disclosed in the legend, and important themes for each phase are indicated using the same colour as the themes bit with transparency.

A conscious decision was made not to separate the circular design themes from the guidelines. This choice was based on the additional information the circular design themes provide in the guidelines, detailing the themes in relation to the development process. It emphasises the specific timing for refining the design themes. Furthermore, it illustrates which themes are crucial to achieve circularity at different stages of the process.

All of these changes aim to enhance the overall clarity of the guidelines.

STEP-WISE USE OF THE GUIDELINES

The phase-wise guidelines, as visualised in Figure 4.14, can be used to transform the traditional area development process into a circular process, aimed at designing circular residential areas. These guidelines follow the traditional process but incorporate specific moments and topics that require attention to facilitate circularity. By emphasising these moments and topics, the guidelines ensure that opportunities are maximized. This is especially valuable during the project's initiation phase, where it is essential to consciously establish the foundation necessary for circular area development projects (e.g. municipal involvement, strategic partnerships, and the inclusion of circular economy principles throughout the end-of-life phase). Additionally, the guidelines emphasise the value of evaluating and reflecting on the process to track prior decisions.

The guidelines can be applied by following the standard development process. At any point in the process, the figure and guidelines can be reviewed and used to determine the actions necessary to facilitate circular principles.

If the guidelines are applied from the beginning of the process, it is advisable to review the **change management** principles. These principles are a valuable tool for identifying the requirements for smoother processes. The change management topics encompass overarching principles that can and should be reflected upon at each stage of the process. For instance, when new stakeholders need to be involved, new strategic partnerships should be established. Or when transitioning to a new phase, adjustments in R&D may be necessary.

Subsequently, the **initiation phase** starts. As indicated by the guidelines, this phase involves setting goals and ambitions. The guidelines offer a list of potential significant circular design themes for the project, which can help the development team establish initial objectives for circular design, circular materials, circular construction, circular area use, and the circular end-of-life of the project.

As the development process progresses, the guidelines offer assistance in indicating the necessity of a flexible urban plan at the end of the initiation phase. Important themes that need refining for this guideline are highlighted in the visual. Similarly, during the **design phase**, the guidelines indicate which themes should be elaborated upon during the sketch design and the preliminary design-phase. During each of these phases.

Furthermore, the guidelines recommend the use of evaluation sessions during each of these stages. This indication assists the team in aligning and keeping track of or even improve the set goals. Ensuring that the project remains aligned with the initial decisions.

By the end of the design phase, the guidelines indicate that decisions regarding circular themes should be well-defined after the preliminary design is completed. This is where the high-value technical design, incorporating the refined circularity goals, is established.

Furthermore, during the **realisation phase**, the guidelines indicate the importance of influencing material selection for the most circular materials emphasise the need for sustainable construction methods.

In the lengthy duration of area development processes, these guidelines provide valuable support to development teams, enabling them to keep track of previously made decisions. After months or years of collaboration and individual work, it can be challenging to maintain clarity of what has happened and what has been decided upon. These guidelines assist the team in **harmonizing** and **centralising** decisions and information throughout the process.

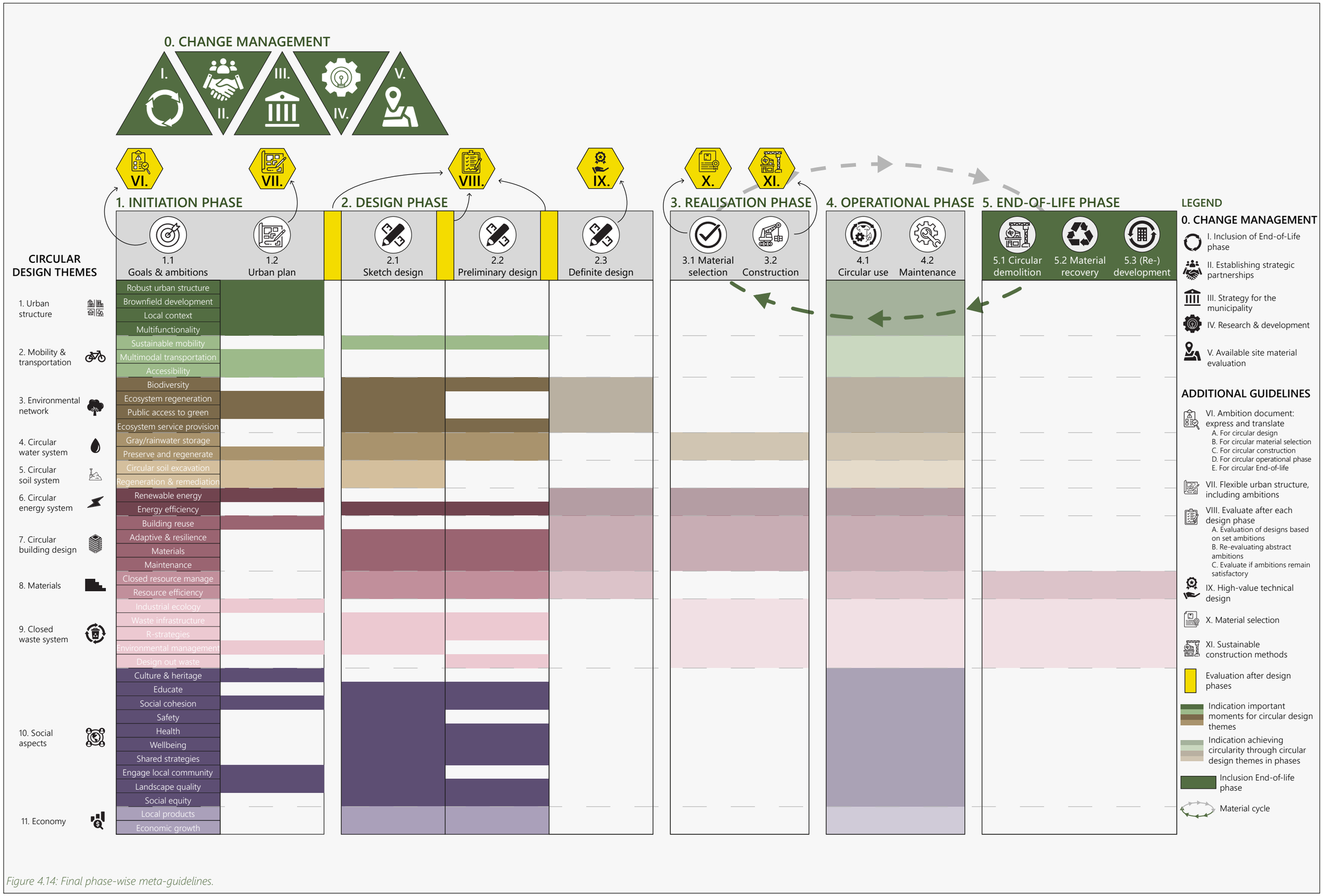


Figure 4.14: Final phase-wise meta-guidelines.

CHAPTER

05

DISCUSSION

5. DISCUSSION

In this chapter the research findings are discussed. Paragraph 5.1. elaborates on interpretating the research findings and their relationships. Paragraph 5.2. provides the relationship of the findings to previous studies and paragraph 5.3. places the findings within the broader academic context.

5.1. RESEARCH FINDINGS

The objective of this thesis was to gain insight into thThe objective of this thesis was to gain insight into the implementation of circular design themes and interventions during area development projects. This objective was achieved through the development of the phase-wise meta-guidelines. Overall, the guidelines consist of the development of eleven actions during the standard area development process. If implemented these guidelines provide tools to overcome barriers, enhance accelerators and be prepared for lock-in moments. Furthermore, it elaborates on eleven circular design themes that should be included according to the current literature. The guidelines serve as a connecting bridge, uniting the practical approach of project-based thinking with the principles of the circular economy, creating a change in the process, that will lead towards easier circular designed area developments.

During the interviews, it became clear that practitioners lack a clear and common definition what circular area developments entail. It was repeatedly noticed that practitioners often link circular area development, solely, to the closing of the material cycle by reusing materials in the area. Upon sharing initial results from the systematic literature review, often a surprised reaction was given about the included themes: e.g., "*So that it's also adaptive and flexible. That's a broader and pleasant definition, better than just material reuse*" (Interviewee 3, personal communication, 12 July 2023). The consequence of this gap is visible in the elaboration of circularity in projects, which is solely promoted through and focused on the amount of reused materials e.g., 95% material reuse in Park070 in Voorburg (BPD, 2023b); 80% of reused materials in the office renovation for Alliander (Dura Vermeer, 2023). This was also recognized by the focus group participants; currently circularity is about who is best at presenting it to the market, it is not yet about the content (Waalpartners civil engineering, personal communication, 26 November 2023).This focus on reusing materials is also most likely due to the emphasis on important frameworks, such as the one from EMF, on reusing materials and resources. Similarly, the material theme for circular building design receive a lot of attention. However, in the systematic literature review, the inclusion of other themes is also emphasized. Indicating a big gap between literature and science, which the guidelines solve.

Additionally, almost all interview participants highlighted the value of ambitions and team dynamics in the process, but also mentioned they should have specified them better. Due to lack of specificity themes and topics often were forgotten. In the Binck Eiland case interviewees mentioned, circularity would already be improved if it was a fundamental element of the plan. Through the use of the guidelines, all circular design themes, depending on project characteristics, will be fundamentally addressed at the initiation phase of the process. Furthermore, almost all case studies have shown how unwilling stakeholders are a limiting factor for the implementation of circular ambitions, highlighting the importance of establishing partnerships with willing companies and people.

Furthermore, in many of the case study projects, it was noticed that the greatest barriers in the process are related to the municipality and other stakeholders. The reason for this might be simple; municipalities want uniformity in their cities. Besides this, municipal maintenance departments are the ones who have to pay for future maintenance of the areas. Resulting in them preferring new materials, as this results in less maintenance costs. Eventually, these departments are the ones who have to approve the final designs, providing them with power over the project. Also resulting in a significant barrier for unconventional, deviating from the standard, solutions. This possibly provides a new valuable insight to current literature, as none of the reviewed sources identify this as a barrier.

Considering these observations alongside the developed guidelines, three key additions have a pronounced positive impact on facilitating smoother circular area development processes. These are as follows; 1. Stating circular ambitions regarding the circular design themes; 2. Establishing strategic partnerships; and 3. Establishing an ambition regarding the municipality. Therefore, only implementing these changes would already be beneficial for the circular design of areas.

In the following paragraphs, the relationships and interpretation of the results are described. The meaning and purpose of several of the guidelines are explained.

5.1.1. CHANGE MANAGEMENT

The newly introduced actions, categorised as change management, play a crucial role during the transition towards adopting circular economy principles and practices in the area development process. However, their necessity diminishes once the

industry becomes acclimated to the new standards, such as innovative manufacturing or construction techniques. Because these actions primarily relate to practices and topics that are not yet commonplace in the construction sector. Thus, they are intended to facilitate and initiate the transition in the realm of area development processes.

It is expected that in the future circular practices are integrated in the standard industry methods and included in policies. Therefore, it is crucial to already identify the right solutions to avoid potential negative externalities later. Especially for area development project, due to the long life span of developments, negative externalities are visible and noticeable for a long time. When the market has matured circular economy principles will also by default included in, e.g. partnerships, as all companies work with circular methods. Furthermore, R&D regarding circularity will have matured, and the inclusion of end-of-life thinking will be standardized. Additionally, municipalities will be used to circular practices and designs, and, therefore, need less convincing. When this has happened, these actions have lost their purpose and can be left out in the process. However, until this has happened, the guidelines provide guidance in achieving circularity in these elements, safeguarding the future of circular area developments.

5.1.2. FLEXIBILITY VS. CLARITY

Integrating circular economy principles into existing processes and working methods is a challenging task. The standard working methods are not yet suited for the principles behind the circular economy. For example, the For example, the Erasmusveld midden case study has shown that designating an area development to be sustainable, does not guarantee sustainability in the design.

Effective implementation of circular principles requires clear guidance for practitioners without compromising on flexibility for creative and innovative solutions. Consequently, the guidelines offer both the essential clarity and the desired flexibility through a series of guidelines in the process. The following paragraphs elaborate on which guidelines incorporate both flexibility and clarity.

CIRCULAR DESIGN THEMES

The guidelines provide a comprehensive overview of currently significant design themes for circular area developments. The significance of each of these design themes varies from one project to another, as each project possesses unique characteristics. Hence, some aspects will hold more importance than others. This diversity in focus is also evident in the case study projects, where the balance and emphasis on various aspects differed for each project, leading to distinct outcomes.

For example, in the Binck Eiland project, due to its characteristic as a redevelopment project, the focus has been on the reuse of the existing structure and materials. Although the addition of green facilities has also been implemented to its full potential, it is not the main focus of the project. Furthermore, less emphasis has been placed on, for example, the energy design theme. Reasons for this relate to the fact that three different developers were involved, each developing their own subplan. Additionally, for the Binck subplan, higher insulation rates were harder to achieve, as it had to deal with the buildings' characteristics. Furthermore, at the time, the plans of the municipality to construct a heat network were not matured enough to include in the development plans, resulting in a less energy-efficient plan than was desired.

The Tuinen van Genta project is defined by the historical context of the development site. It has a rich industrial history, leading to soil pollution, which became a significant constraint in the project development. Furthermore, during the development of the design, it was already clear that projects delivered after 2020 could not use gas as a heating source. Therefore, sustainable energy sources were a significant theme in this plan. In addition, the inclusion and cooperation of neighbours was a significant topic. The rich history of plan-making in the area, which had all failed in the past, left the site vacant for years. Therefore, neighbours were in need of clarity.

The Erasmusveld midden case, which revolves around a greenfield development, places emphasis on different circular design themes compared to the other developments. The inclusion and maintenance of green space is an important topic for this case. Furthermore, in the past, there were high sustainability goals set for this development area, which also influences decision making in a way.

Finally, through the different cases, the importance of the economic theme evidently varies. The Tuinen van Genta and Erasmusveld midden cases are clearly characterised as residential area developments, meaning that business or economy-related topics are of less value. While Binck Eiland is located in the city centre; therefore, economic topics are more relevant. Furthermore, the question arises if flexibility, multifunctionality or adaptable strategies are necessary for primarily residential buildings, as most residential buildings are in use for a long period of time. In the Netherlands, typical rowhouses are

often in use for decades, resulting in long life spans. Therefore, for these developments the focus should be on prolonging lifespan strategies, when compared to office or apartment buildings, which might use its functionality over time.

Thus, the circular design themes provide guidance for the start of the development and, thereby, also clarity to the development teams. Nonetheless, the guidelines are flexible enough to let the case characteristics determine the importance of each of the themes.

DESCRIPTIVE AND PRESCRIPTIVE THEMES

Besides this, the eleven circular design themes can be broadly categorised as either descriptive or prescriptive in nature. Descriptive themes relate to abstract or unclear topics that are often challenging to quantify, e.g., social, while prescriptive themes deal with topics where standardised solutions are typically applied, for example, energy.

The developed guidelines provide a comprehensive tool that offers both clarity for descriptive themes and additional flexibility for prescriptive themes. By explicitly addressing descriptive themes, the guidelines bring transparency to the process and engage stakeholders through a conscious evaluation of the relevance of these themes in the context of their project and the circular economy. This mitigates the risks of exclusion that result from the vagueness of these themes.

Furthermore, the guidelines enhance flexibility for prescriptive circular design themes, as they encourage stakeholders to consciously rethink these themes, resulting in more creative, sustainable, or unconventional solutions.

As a result, the guidelines effectively create a scenario in which every topic can be incorporated into the project, while stimulating creativity for standard themes.

FLEXIBLE URBAN STRUCTURE

Another element of the guidelines that provides additional flexibility in the process is the emphasis on the need for a flexible urban structure at the end of the initiation phase. However, this tension between flexibility and clarity remains a challenging topic in practice. The level of tension also varies, depending on the project's scale. For smaller cases, such as the case study projects researched in this thesis, this tension is much less present than for large-scale projects.

For small-scale projects as the cases included in this research, it can be said that after the initiation phase, the urban structure should largely be clear. In the feasibility phase, the focus shifts to design of the area. By the time the concept preliminary design is completed and preload is added to the site, certain design themes and the definite urban structure should be clear. When the definite preliminary design is finished, every other theme should also be clear, as the selling process will start.

For small and medium-scale developments, significant changes to the structure of the area are typically not possible once the initiation phase is completed. However, large-scale developments have to deal with more uncertainty of the market. Large-scale development often deal with several sub-processes for each development phase, that are designed at different times. This possibly influences the space needed for certain facilities, e.g., schools, playgrounds, sport facilities, etc. During large-scale developments in the first phases less space is needed for these facilities, however as the development phases progress, the demand for such facilities increases as well. Thus, when implementing certain facilities, space should be included to enable expansions in the future. However, then the following question arises: how much space? Therefore, the tension for a flexible urban structure, and what this exactly means is most likely a lot higher for large-scale developments.

EVALUATION

Through the case studies, it became evident that evaluation sessions are rarely conducted throughout the process. However, it became clear that inclusion is very valuable for the project. It is key for ambitions to be included to their full potential in the design. Through evaluation sessions, designs can be reviewed based on the set ambitions, resulting in better implementation of design strategies regarding circularity. Moreover, evaluation sessions introduce greater flexibility into the process. If further research is required for certain themes, there is now room to do so. In later phases, ambitions can be evaluated to see if they are specific enough; if that is not the case, abstract ambitions can be further specified. This way, the guidelines provide stakeholders with more flexibility throughout the process.

However, it was noted during the validation sessions that incorporating evaluation sessions presents challenges. Field experts explained that development processes are illustrated in literature as if they consist of recurring phases, which is partly true. However, in practice, the development process never truly pauses after each phase. "*We're working on a moving train, and when a moment is taken for evaluation, which rarely happens, but when it does, you have to step back*

in the areas where you haven't upheld your ambitions." (Waalpartners, Personal communication, 26 November 2023). Therefore, it is difficult to incorporate evaluation moments. Nonetheless, experts agreed that it is necessary and valuable to include. Therefore, this addition to the process is particularly valuable, especially when transitioning to circular practices, as it helps address the tension between clarity and flexibility.

5.1.3. MATERIAL SELECTION AND CONSTRUCTION METHODS

The guidelines highlight material and construction method selection as important moments during the development process for the transition towards circular practices. These moments emphasize the need for sustainable or circular choices. Thus, the development team should encourage contractors to use sustainable construction materials and equipment.

For building materials, the type of material is already determined at this point. However, transport distances can still be influenced and the reuse of existing materials can still be encouraged. Likewise, in the case of construction methods, the development team can promote energy and water-efficient equipment and techniques.

At this stage, tension may arise when choosing the final material supplier. Reusing materials could lead to increased transport distances. Therefore, it is crucial to make the best integral choice for the project during this phase.

Similar to the change management activities, these are moments that require extra attention during the transition. However, when circular practices become more common, and the market becomes accustomed to them, materials and construction management will automatically incorporate circular economy principles.

5.1.4. TRIANGULATION FOR VALIDATION

Carter et al. (2014) identified four different types of triangulation methods for qualitative research. This study employed two of these: method triangulation and data source triangulation. Method triangulation can be described as the use of multiple methods for data collection about the same phenomenon, and data source triangulation can be defined as the collection of data from different types of people.

In this research, method triangulation for qualitative research was chosen to provide a multi-perspective view of the research topic. Both academic knowledge about circular design themes and practical knowledge about the process of circular area development were considered essential. These domains often lack integration, creating a gap between academia and real-world practice. Hence, in this research, academic knowledge regarding circular design themes (retrieved from 53 academic sources) was objectively investigated in the case study projects. This approach facilitated an objective interpretation of the case study findings. Besides this, the case studies helped validate the importance of the circular design themes found through the literature review.

As data sources, both in-depth interviews and a focus group session were conducted. Carter et al. (2014) emphasize the benefits of using both methods to enhance the validity, as both data sources can yield different results. According to Carter et al. (2014), in-depth interview participants are more likely to discuss sensitive and diverse topics, aligning with the aim of the case study process interviews. Focus group participants are more likely to identify problems, aligning with the aim of the validation session. Together, both these data sources enhance the viability of the guidelines.

Hence, through data source and method triangulation for qualitative research, a broad body of knowledge is compiled and synthesised by the guidelines. This results in a comprehensive overview combining both academic and practical knowledge. The use of different sources and methods brings both breadth and depth to the findings (Thurmond, 2001). Ultimately, this provides a valuable tool for both academics and practitioners by offering transparency regarding scientific knowledge to practitioners and insights into the circular area development process.

5.2. RELATION TO PREVIOUS STUDIES

The results of this research contribute to a clearer understanding of the existing academic literature on circular area development for both practitioners and academics. The theoretical framework provided in Chapter 2 considers theory regarding the circular economy in relation to the built environment and the characteristics of (sustainable) area development. The outcomes are discussed in relation to the theories regarding these topics.

Firstly, the literature background on the circular economy and the circular economy in the built environment revealed that many different frameworks have been established. All of these frameworks implement similar circular economy strategies in general. Williams (2021a) has generalised these strategies into three themes: adaptive, regenerative,

and looping strategies. Similar forms of these strategies have been identified throughout the circular design themes for area development. For example, circular building design can consist of adaptive strategies (e.g., design for adaptation), regenerative strategies (e.g., renewable energy generation and usage), and looping (e.g., R-strategies for materials). The combination of these strategies eventually creates the highest possible circular design of the building. A similar finding was provided by Williams (2021a), who indicates that the three types of strategies should be applied in tandem.

Furthermore, several researchers have indicated a connection between the benefits of implementing circular economy principles and sustainable development (Amenta & van Timmeren, 2022; Bîrgovan et al., 2022; Bosone et al., 2021; Cerreta et al., 2020; Säumel et al., 2019; Smitha & Thomas, 2021). The research findings have shown that there is still an apparent gap between literature and practice in the definition and related benefits of circular designs. While the results yielded through the systematic literature review did include sustainable, social, and economic factors, the interviewees' perception of circular designs often focused only on the reuse of materials. Literature has indicated in the past that social values are less integrated into the definition of the circular economy (Geissdoerfer et al., 2017; Kirchherr et al., 2017), and while this gap seems to have been lessened in academic literature, it is still very much present in practice. Measures regarding the social aspect are still implemented in project designs; however, the drive behind these interventions is not related to circular economy principles. The reason for its implementation is more related to the general value it creates for area development projects.

Lastly, literature regarding area development generally describes four different reoccurring phases (Heurkens, 2017; Kersten et al., 2019; Van 't Verlaat & Wigmans, 2011b). These development phases align with the general phases found in the case study projects. Therefore, these were used as the basis for the guideline development. Due to the case study projects, mostly organic approaches to area development are included in the results, meaning that the guidelines specifically focus on organic approaches. Municipal initiatives or municipal active land exploitation developments might include different activities or actions during the process. Furthermore, the circular design themes that were found through the systematic literature review are in line with the general aim of area development projects. Area development in the Netherlands generally focuses on the upscaling of an area through a design. Similar to this aim, most of the circular design themes are related to circular design elements, while only one of the themes is related to a circular economy. Several academics distinguish between circular design and circular functioning or operating of an area (Askar et al., 2021; Van den Berghe & Vos, 2019; Williams, 2021b). Consistent with these theories, the developed guidelines and the end result focus on the circular design aspects of an area, and circular functioning of an area is left out of scope.

5.3. POSITION IN THE ACADEMIC LANDSCAPE

The output of this research is the creation of phase-wise meta-guidelines. These meta-guidelines contribute to the existing academic knowledge on the circular economy, specifically the literature on circular economy application in the built environment.

The guidelines provide additional depth to the academic knowledge that connects ambitions to the project life cycle. This academic knowledge is often limited to the design, construction, operational, and end-of-life phases (Belaud et al., 2019; Çetin et al., 2021; Foster, 2020; Giorgi et al., 2019; Nußholz et al., 2023; Rahla et al., 2021a; Smitha & Thomas, 2021). To elaborate on this knowledge, the guidelines highlight important windows of opportunity during the initial phases of the project to enhance and implement these ambitions. Furthermore, they provide a harmonised overview of the circular design themes for the built environment, specifically area development projects. Therefore, they offer a comprehensive approach for both practitioners and researchers in the context of circular area development projects and knowledge.

Furthermore, they emphasize the importance of stating ambitions regarding those circular design themes and life cycle phases. Additionally, they allow flexibility during the process through the included evaluation sessions that indicate the moments to evaluate the stated ambitions, meaning that not every ambition theme has to be clear if it is not possible.

Lastly, the guidelines elaborate on the circular area design theory through the knowledge they provide on all circular design themes that should be considered for circular area development. However, they do not delve into circular area functioning.

CHAPTER

06

CONCLUSION

6. CONCLUSION

In this chapter the research questions employed to conduct the research are addressed. Hereafter, the main research question is answered. Following this, paragraph 6.2. explains the research limitations of this thesis, and chapter 6.3. highlights areas the require further refinement or research based on the findings.

6.1. RESEARCH INSIGHTS

In this research the objective was to investigate how area development processes can be improved in order to enhance and integrate circularity themes and interventions. In the first sections the sub-questions employed to conduct the research are answered. Following this, the main research question is answered, drawing upon the insights from the sub-questions.

6.1.1. CONCLUSION SUB-QUESTIONS

1. What are the essential themes or elements that should be considered when developing a circular area development project?

In total, a systematic literature review revealed eleven key themes for circular design strategies to be implemented. Implementing strategies on all of these aspects of area development ensures comprehensive coverage of circularity in area development projects. These themes should, therefore, be used as guidance for stating circular ambitions in the process. The identified themes are; 1. Urban structure, 2. Mobility & transportation, 3. Environmental networks, 4. Circular water systems, 5. Circular soil systems, 6. Circular energy systems, 7. Circular building design, 8. Materials, 9. Closed waste systems, 10. Social aspects, and 11. Economy.

Additionally, several source retrieved through the literature review, analyse the strategies in combination with project life-cycles in the built environment. These articles illuminate what strategies should be possible or used in the design, material selection, circular construction, the operational or use phase, and, lastly, the end-of-life phase. This indicates that ambitions and goals have to be set during the initiation of area development projects to enable circularity in those phases.

Lastly, four overarching accelerator themes have been identified, which can be utilised throughout the project to facilitate decision-making or enhance the general process. These are; 1. Process, 2. Governance, 3. Technology, and 4. Decision-support tools. The actions related to the process and governance accelerators are topics such as circular business models and strategic partnerships, ensuring a smoother process. The topics related to technology and decision-support tools include helpful tools that have the ability to enhance circularity.

2. What actions are necessary in the different planning phases of area development to facilitate and enhance circular design strategies in the projects?

Several actions have been identified that can possibly facilitate and enhance circular design application in area development projects. First, to ensure smoother processes and to enhance circular design strategies implementation, prerequisite conditions should be implemented. These prerequisites do not concern actions during the process, but concern important topics to consider before the project is initiated.

First, it is important to include the **end-of-life phase** in the visualization of the process, this encourages stakeholders to consider the project end-of-life. Secondly, **strategic partnerships** should be established, ensuring that stakeholders strive towards the same goals. Third, the **municipality** should be included earlier and more thoroughly in the process and rationale behind strategies. Doing this can reduce resistance towards innovative interventions. Fourth, the **context of the site** should be considered immediately (e.g. what is available on site, can the site be used for something else during the design process?).

Furthermore, some actions have been established that should be taken during the process to enhance circular designs. First, during the initiation phase **ambitions** should consciously be established for the different future phases; design, material selection, construction, operation, and end-of-life. Furthermore, during the initiation phase a **flexible urban plan** should be created that considers the circular ambitions that have been stated. Third, **evaluation sessions** should be held, to evaluate and re-evaluate the stated ambitions and designs. Fourth, ambitions are elaborated and specified into a **high-value technical design** throughout the process, until the **preliminary design phase**, meaning that every aspect regarding the circular themes should be clear before this moment.

Considering and including these actions during development processes increase the chance of successful circular design strategies being implemented. Eventually, incorporating objectives and aims of the circular economy in areas.

3. What are the implications of the identified changes for the planning process of future area development projects?

The main implication of the identified changes is that circular design themes and strategies are included as a design requirement during the planning phases, rather than a side issue. Barriers, identified through the case studies, can be more easily overcome, enhancing

circularity in designs. Furthermore, especially the action regarding stating clear ambition, can enhance comprehensive designs that consider circularity in every aspect of areas.

6.1.2. MAIN RESEARCH QUESTIONS

The main research question this thesis addresses is as follows:

"How can circularity themes and interventions be integrated in the different phases of the planning process of urban area development?"

Phase-wise meta-guidelines were developed that include necessary actions to enhance and facilitate circular design strategies, themes and interventions to be implemented throughout the process. The creation of **ambitions** regarding all identified themes, seems to be the most significant action to ensure circular design themes and strategies are considered in area development processes. Furthermore, the creation of an **ambition document** that is **(re-)evaluated** during the process ensures knowledge stays in the project and with stakeholders. It can be used as a tool to explain the project rationale and ambitions to newly involved stakeholders.

Additionally, the case studies showed the value and necessity of **strategic partnerships** to accelerate and include circular aspects in designs. Strategic partnerships can reduce resistance within design teams, as willingness of development teams are of vital importance to the outcome.

Furthermore, to reduce the municipal barrier that is present, the **municipal maintenance department and project manager** should be **included more intensively** throughout the process. The municipal project manager might be able to take integral choices and push circular design strategies through. Intensive inclusion during the design process, ensures they are aware of the rationale behind design interventions. Eventually increasing the chance of success.

Stakeholders should also be aware of the **critical lock-in moments during the design phases**, as these moments require certain information to be clear. These are the **definite preliminary design**, as this indicates the moment the high-value design should be finished. Each ambition should clearly be elaborated as design interventions in this plan. Then, if accepted by the municipality, they will be included in the designs. Furthermore, the **concept preliminary design** indicates the moment site preparations are started and preload is added on site. This is a lock-in moment for certain themes, as it should be clear what happens with for example the soil and existing buildings.

6.2. RESEARCH LIMITATIONS

Similar to other researches, this research also acknowledges some limitations, that effect validity and reliability of the outcome. Limitations related to the research methods were discussed in chapter 3, the limitations discussed in this paragraph are related to the execution of the empirical research.

The research was conducted in collaboration with Waalpartners BV as part of a research internship. The interview participants were almost all contacted through the company. This ensured a smoother process during the research, however it is prone to bias. As participants might not be completely objective. However, this was not noticed during the interviews, as everyone was comfortable enough to provide critical insights into the process, pointing out things that went wrong or could have gone better, without being influenced by specific stakeholders.

Furthermore, the aim was to include different stakeholders in each projects, to get a clear view on improvements without bias from one viewpoint. For the Tuinen van Genta and Binck Eiland this was achieved, interviews were conducted with the municipality, developers, landscape designers and civil engineers from each case. However, for the Erasmusveld midden case, only interviews were conducted with the developer and civil engineers, as the landscape designer and municipality were not as involved anymore. Especially, the municipal project manager had been changed quite a lot. The municipality of The Hague had been contacted, however no reaction was received. This might result in a result bias towards their perception.

Additionally, three case study projects have been included to conduct the comparative case study review. Although efforts had been made to include project with similar scales, but different origins, locations, and land policies. Still projects in which the municipality has an active role, instead of facilitating are missing in this review. Generalisation for large-scale and/or municipal active land policies can not be made.

Another challenge during this research was to harmonise a large body of knowledge regarding circularity themes for built environment projects in order to create a comprehensive overview. Additionally, the sources retrieved for the systematic literature review were only found through the Scopus database, potentially excluding relevant articles in other databases. The included exclusion criteria result in comprehensive but not all-inclusive results.

Additionally, the research is based on the Dutch concept of 'gebiedsontwikkeling' in the Dutch

construction industry. Therefore, results are limited to the Dutch context and cannot with certainty be applied in other countries. Besides the context, area development projects deal with many different variables and characteristics. Meaning that each area development project is different. For this reasons the guidelines are meant as 'meta-'guidelines, indicating that they are not rigid.

In this regard, this research has included the general process of area development, as highlighted by the 'Reiswijzer Gebiedsontwikkeling' of the Dutch government (Kersten et al., 2019). However, when specifically looking at the civil engineering or construction side of the process, the process might deviate slightly. Furthermore, if different forms of collaboration emerge, the schedule might be different, for instance, when the builder is also involved in the development.

Lastly, due to time constraints it is not possible to test the effectiveness of the guidelines in real-life situations.

6.3. RECOMMENDATIONS FOR FUTURE RESEARCH

Regarding the research findings, certain recRegarding the research findings, certain recommendations can be made for possible future research areas. This research is characterised by time and resource constraints, therefore, through follow-up researches more knowledge on this topic can be created. Several follow-up themes or 'gaps' have been identified that could be further investigated.

This research has focussed on small-scale residential area development processes. Large-scale developments encompass different project characteristics influencing the process. Especially regarding circular design theme implementations. Large-scale developments either include many developers or have an active municipal involvement, influencing how decisions are made. Therefore, research into large-scale development is necessary to generalise results regarding these processes.

Moreover, the evaluation element seems understudied in the literature, but also has limited application in practice. Therefore, research into this aspect during circular designs, might be of value for both practice and academic literature. Furthermore, experts in the field indicated that it is difficult to find a moment to evaluate on the project when it is still in progress. Therefore, research into this could help practice with better application of evaluations, also benefiting circular projects.

Furthermore, the guidelines created in this research do not imply how stakeholders can be made responsible for stated ambitions. The idea now is that stating the ambitions with the whole design team provides already incentive. However, the circular area design can be enhanced if stakeholders are given a sense of responsibility over certain ambitions, ensuring their implementation further. For example, the effect of different collaboration forms in relation to the guidelines could be interesting. A lot of information is already available about collaboration forms in relation to the circular economy. However, the effects of collaboration forms on this framework was not included in this research.

Furthermore, the gap between the municipality and project goals and ambitions could be investigated from the view point of municipalities. Municipalities are perceived by stakeholders as very conservative. Thus, research aimed at finding solutions or tools that can help municipalities with the implementation of circular projects.

Similarly, the use of technology to accelerate and enhance circularity and sustainability throughout processes was the least emphasised in the case studies. A potential gap between literature and practice might be present. Furthermore, the last couple of years technologies are advancing rapidly, meaning that this topic is very interesting for both researchers and practitioners in the coming years.

In general, the readiness of the market is an important topic for further research. The transition to circular principles remains challenging. These guidelines try to address this challenge through the inclusion of change management elements. However, as was also indicated in the focus group session, the market is far from where it should be to ease the implementation of circular design themes and principles. For example, as indicated in the research, reusing materials is almost impossible, due to the lack of warranties.

Lastly, circular area functioning is not considered in this research. However, this seems to be an emerging topic, as circular area functioning ensures actual circular economies within cities or neighbourhoods. As indicated by the two redevelopment case studies, transformation of inner-city previously industrial sites is expensive, due to the polluted soils. Creating circular functioning areas might be a better solution for these areas. Furthermore, sometimes companies are willing to pay more for these inner-city industrial sites, take for example ASML and DSM who are investing hundreds of millions in the development of their own 'campus' (economieredactie, 2023; Omroep Brabant, 2023). This could indicate shifts in the bid-rent theory of Alonso (1964).

CHAPTER

07

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CHAPTER

08

APPENDICES

8. APPENDICES

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APPENDIX A – BIBLIOGRAPHY

Terms	Definition
(Urban) area development	involves public and private activities and disciplines that are needed for the development of broader regions; area development determines the coherence of urban developments and influences how and where urban development will be created. (Van 't Verlaat & Wigmans, 2011a)
Biodegradable	Materials capable of fully decomposing and being re-absorbed into the biological cycle. (Platform CB'23, 2020)
Brownfield development	The development of already developed land (Strutt & Parker, 2019).
Built environment	General concept that is related to 'all structures built by man to support human activity' (Portella, 2014, p. 454). This includes every physical element that is part of villages, towns or cities, such as buildings, public spaces, all infrastructure, etc.
Circular action(s)	Practices or activities that are designed to promote CE principles. Such as the looping, ecologically regenerative, and adaptive actions. (Williams, 2021b) Also, see Circular activity(ies)
Circular activity(ies)	Also, see Circular action(s) In an area circular activities are activities that enable CE or circularity. Such as: • the colocation of industries for industrial symbiosis; • the storage of construction recyclables for future projects; • urban farming enables the closure of the food waste loop and ecological regeneration. (Williams, 2020)
Circular area design	Circular area design stands for the focus on sustainable (material) design and waste avoidance, or in other words how circular built environment is created. (Van den Berghe & Vos, 2019)
Circular area design	Circular area design stands for the focus on sustainable (material) design and waste avoidance, or in other words how circular built environment is created. (Van den Berghe & Vos, 2019)
Circular area functioning	Circular area functioning is the whole '(circular) socio economy' (Van den Berghe & Vos, 2019, p. 5). Meaning that a full circular economy is created within a neighbourhood, city or region.
Circular buildings	buildings that are designed, planned, built, operated, maintained, and deconstructed in a manner consistent with CE principles. (Bucci Ancapi et al., 2022)
Circular built environment	a system embedding the principles of CE across all its functions, establishing an urban system that is regenerative, accessible and abundant by design. (ARUP & EMF, 2018)
Circular business model	How the organisation adds value as part of the circular economy. (Platform CB'23, 2020)
Circular development	Systems and constructions that alter/influence cities' systems of provision, enabling circular practices of inhabitants to develop. (Williams, 2021b)
Circular economy	An economic system that optimises the use and value of resource flows without hampering the functioning of the biosphere and the integrity of society. This means protecting biological and technical material security and preserving the environment. (EMF, 2013; Platform CB'23, 2020)
Circular intervention(s)	An overarching word, referring to activities, actions, policies, programs, etc. that are related to enabling or promoting the CE. (Superti et al., 2021)
Circular measure(s)	See Circular intervention(s)
Circular policy(ies)	The way policies' visions and goals are operationalised; for CBE this means tools/ regulations to transition towards a sustainable built environment. (Bucci Ancapi, 2021) Sub dived in regulation, financial incentives, provisioning, and capacity building policies (Bucci Ancapi et al., 2022)

Circular strategy(ies)	An activity carried out intending to contribute to a circular economy. Examples of circular strategies are lifetime extension; increasing adaptive capacity, or R principles. (Platform CB'23, 2020)
Downcycling	Process of converting secondary raw materials, components or products (from reuse or recycling) into new materials, components or products, typically of lesser quality, reduced functionality and/or lower value compared to their original intended purpose (e.g. due to contamination and mixing of materials). (Platform CB'23, 2020)
Greenfield developments	Opposite to brownfield development. Development of an area on previously undeveloped land.
Process management	The management of area development processes. (Heurkens, 2017; Van 't Verlaat & Wigmans, 2011a)
Sustainable development	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Balance environmental quality, economic development and social equality. (Geissdoerfer et al., 2017; WCED & United Nations, 1987)
Swale	Dutch: Wadi. A green drainage channel, implemented in urban areas. Wadi's store water, help purify it and facilitate water infiltration in the ground, contributing to a sustainable water management system in neighbourhoods. (Boogaard, 2020)
Urban development	the spatial changes of various locations within a region (Van 't Verlaat & Wigmans, 2011a)
Urban planning	planning the development of larger or smaller areas of towns or cities. (Franzen et al., 2011)

APPENDIX B – SUMMARY OF CIRCULAR ECONOMY MODELS

The world's economy has previously always been based on linear processes; extract, produce, consume, and dispose of goods (Sauvé et al., 2016). In this system, the environmental and social impacts of waste were ignored, and priority was given to economic growth. Furthermore, non-renewable materials are used to produce goods, while in the past decades, the amount of materials needed is exceeding the amount of materials the planet can replenish in one year, resulting in material scarcity (Earth Overshoot Day, 2023; EMF, 2013).

Due to the characteristics of this system and their associated consequences, such as climate change and resource scarcity, there is increased awareness of the need for change (Sauvé et al., 2016). The circular economy provides a possible system change, as it aims to separate economic growth from resource consumption (Sauvé et al., 2016), by producing durable goods that are simple to repair, reuse or recycle (EMF, 2013), as visible in Figure B.1.

Since CE was first introduced, both academic and practitioners have come up with models, frameworks, and strategies to explain and apply circular practices. These models will be explained in the following paragraphs, in order to understand what CE means for the built environment.

CIRCULARITY MODELS

Available CE models promote, among other things, efficient use of water, energy and materials, in order to lessen negative effect on the environment. Examples are the butterfly model, the frequently applied 9R framework and resource strategies. The next paragraphs explains these commonly used models.

THE BUTTERFLY MODEL

The EMF (2020) visualises the ideal CE as a butterfly diagram, shown in Figure B.2. The butterfly diagram distinguishes between the flows in a technical cycle and biological cycle (EMF, 2015, 2020), indicating 'value circles' in each cycle (Gillott et al., 2023). In a fully circular economy, material cycles are closed, and the concept of waste is eliminated. Waste is avoided through the aim to recirculate resources as long as possible at their highest possible value.

With the biological and technical cycles, a separation is made between consumable and usable materials. The model provides strategies to achieve a circular economy. These are important to consider for implementing CE in the built environment.

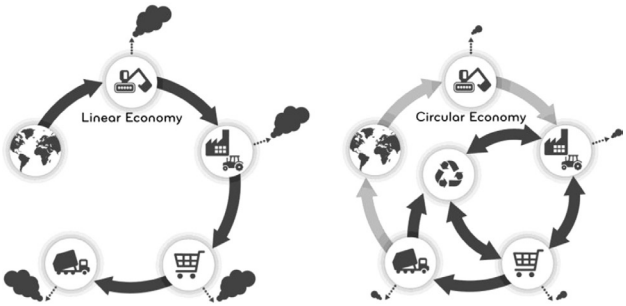


Figure B.1: The linear economy vs. the circular economy. Source: (Sauvé et al., 2016).

REDUCE AND PRESERVE

The overall principle of the circular economy is the preservation and enhancement of natural resources and controlling non-renewable resource stocks (EMF, 2015). Reducing materials and goods needed and preserving those goods as long as possible is the ultimate aim. In the butterfly model these principles are visualised by the sharing principle in the technical cycle, as it can significantly increase usefulness and value (EMF, 2020, 2023b). The 'renewable flow' and 'stock management', and 'minimizing systematic leakage and negative externalities' principles also illustrate reduce and preserve principles (EMF, 2015).

For the built environment strategies such as 'rethinking' if buildings or public spaces are needed or multifunctionality of the area are possible reduce strategies (Cellucci, 2021; Çetin et al., 2021).

TECHNOLOGICAL CYCLE

In the technical cycle the concept of 'consumption' is replaced by 'use' (EMF, 2023b). After being 'used' the materials are recovered and restored in the system. The key objectives in this cycle is to close and narrow the resource loops. The process consists of several loops. Each loop is aimed at preventing materials from becoming waste, ensuring their continuous use. The inner loops represent the strategies in which most of the materials' value is retained, meaning that the inner loops should be prioritised (EMF, 2023b). This system works best if product designs are aimed at these strategies.

Maintain and prolong

Designing to prolong the lifespan of a building and area is another way to maximize and preserve its value (EMF, 2017, 2023b). Designing for easy maintenance is highly important, to keep the area and buildings in good condition.

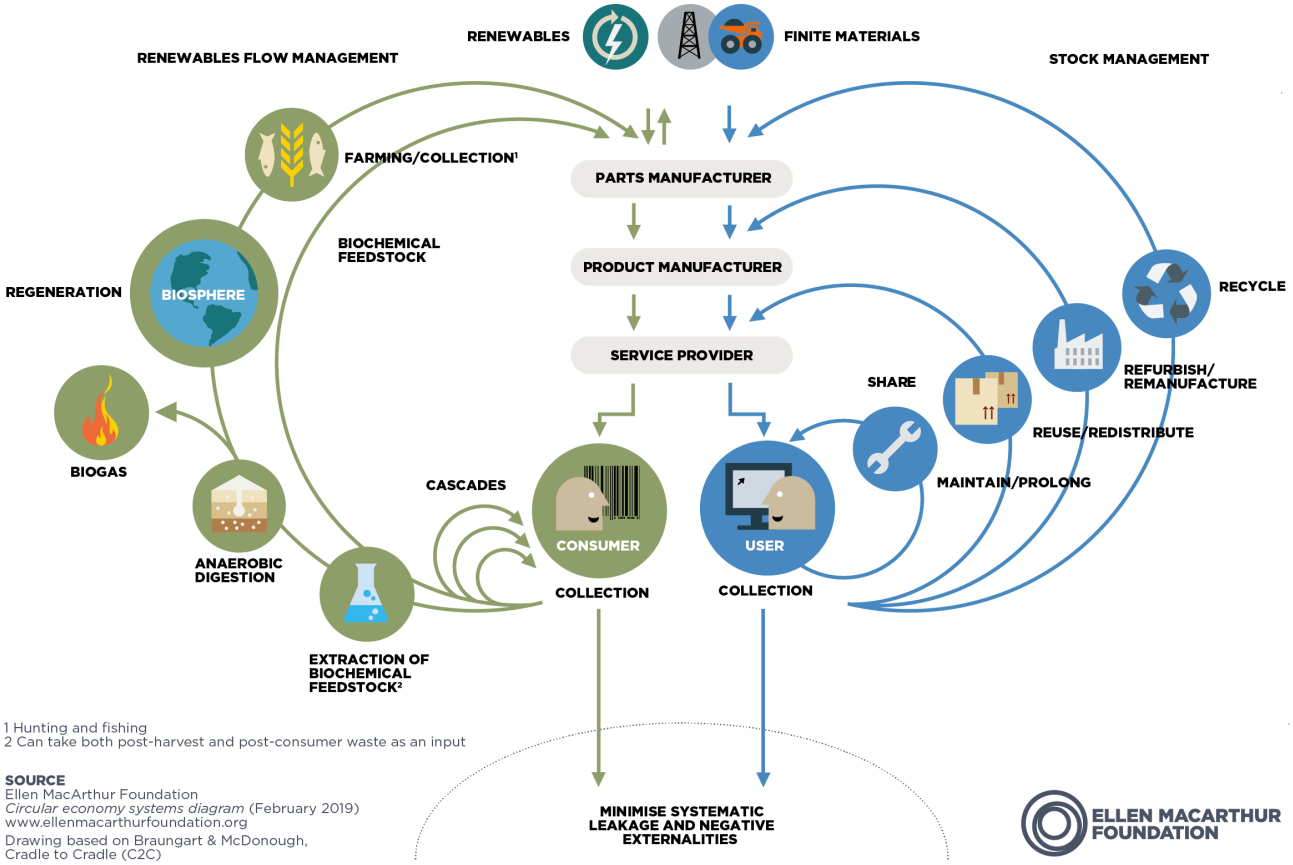


Figure B.2: Circular economy outline. Source: (EMF, 2015)

Reuse and redistribute

Designing for reuse and redistribution of components and goods is the next loop in the butterfly model. It emphasizes that component value is increased if it is possible to reuse or redistribute it. For the built environment this could mean the reuse of existing buildings.

Refurbish and remanufacture

Products that are too outdated to be kept in use move to this cycle. It involves the repairing, replacement or re-engineering of components (EMF, 2023b).

Recycle

Recycling is seen as the last resort in the circular economy (EMF, 2020, 2023b), as most of the value is in the product itself, not the materials separately. In a circular economy, it is important all materials are designed to be recycled, to avoid waste.

BIOLOGICAL CYCLE

In the biological cycle, materials that can biodegrade and can be safely disposed of are involved (EMF, 2023a). These are mainly things such as food, that can be consumed. But also bigger biodegradable materials, such as cotton and woods, are also in this cycle (EMF, 2020). The idea for these materials is the same as in the technical cycle; prolong their functional lifetime and maintain the highest possible value at all time.

The concept of regeneration is the fundamental principle of the biological cycle. This principle emphasizes actively improving the environment, rather than reducing harm (EMF, 2023a).

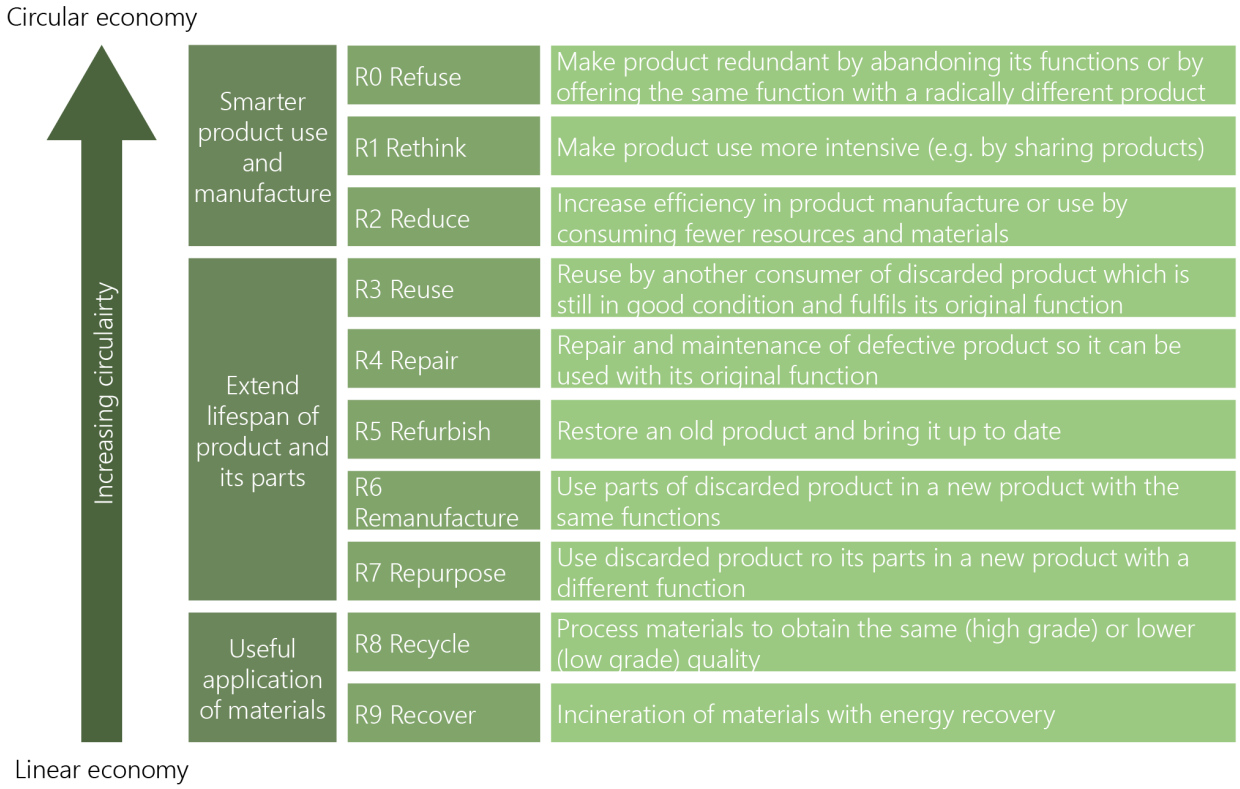


Figure B.3: 9R framework. Source: (Kirchherr et al., 2017; Potting et al., 2017).

9R FRAMEWORK

Multiple R-frameworks have been used by both academia and practitioners for decades (Kirchherr et al., 2017; Potting et al., 2017). According to Potting et al. (2017), all R-frameworks are similar to one other; the main difference lies in the number of circularity methods. Typically, the strategies are ordered in a hierarchy; from high circularity to low circularity. The principles of the R-framework are grounded in CE research, such as that of the EMF (2015): the butterfly model. Furthermore, authors often refer to it as the 'how-to' and core principle of CE, e.g. Potting et al. (2017) state that including circularity principles in product chains generally results in less natural resource consumption; positively impacting the environment.

The most nuanced framework is the one of Potting et al. (2017), Figure B.3. The framework of Potting et al. (2017) divides the R-strategies into three categories, as is visible in Figure B.3. These are 'smarter product use and manufacture', 'extend lifespan of products and parts' and 'useful application of materials'. These categories are explained in the next paragraphs.

SMARTER PRODUCT USE AND MANUFACTURE

Refuse (R0), rethink (R1) and reduce (R3) are the strategies in the framework that decrease the resource consumption and amount of materials in the product chain (Potting et al., 2017). Such strategies have the most impact on the amount of resources used. These strategies especially emphasize the design of efficient products that minimal amounts of resources or reevaluating the necessity of products altogether.

EXTEND LIFESPAN OF PRODUCTS AND PARTS

Strategies R3 to R7 emphasize strategies that are aimed at extending the lifespan of components and products (Circle economy, 2021). Each strategy is focused on improving or maintaining the value of the product and resources (Potting et al., 2017).

USEFUL APPLICATION OF MATERIALS

The last category is about making the material useful again when all of the previous strategies are not possible anymore. The strategies included in this category are recycling (R8) and recovery (R9). Although these strategies are the least effective according to the waste hierarchy theory, they are the ones that are most commonly included in policies (Kirchherr et al., 2017).

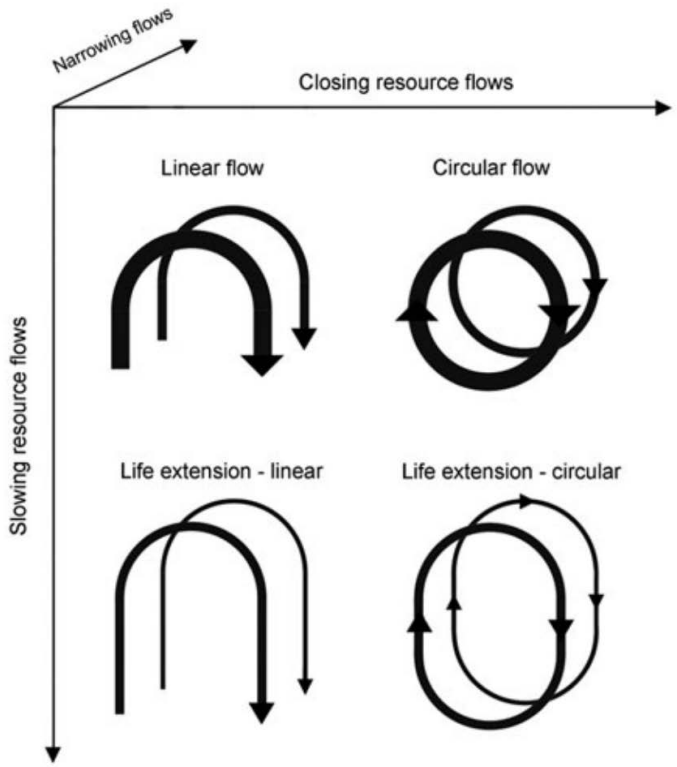


Figure B.4: Categorization of linear and circular approaches for reducing resource use. Source: (Bocken et al., 2016)

RESOURCE STRATEGY

Models such as the 10R-framework and the butterfly diagram show a propensity to emphasize on looping strategies, while ignoring the value of the material stock (Gillott et al., 2023). Stahel and Clift (2016) do emphasize the concept of stock management in their explanation of a 'performance economy'. This concept is broader than most interpretations of the CE, as stock management is the core of the business model, as costs are associated with each flow (repair or loss). The aim is to preserving and enhancing the existing stock and maximising the services they provide humans, instead of reusing materials.

Bocken et al. (2016) build on the theory of Stahel (1981, 1994, 2010), categorizing CE strategies according to the path resources take through a system. Stahel already distinguished between 'slowing' and 'closing' resource loops (Stahel, 1981). Bocken et al. (2016) make a third distinction; narrowing resource flows, Figure B.4.

Slowing the resource loops is achieved through strategies that aim at prolonging the useful lifespan of materials and products, maximizing its utility (Bocken et al., 2016; Stahel, 1981). Furthermore, strategies concerning slowing are potentially the most impactful, but hard to achieve in the current economy, as it requires to shift the focus from volume to value (Bocken et al., 2021).

Closing the resource loop are strategies such as recycling, as it merely closes the resource loop between production and post-use waste (Stahel, 1981).

The third, new, category 'narrowing' emphasizes the use of less resources and energy for the same products (Bocken et al., 2016).

Konietzko et al. (2020) further includes the regenerate dimension to consider two more factors that are crucial for 'cleaner production'; the reduction of hazardous and toxic substances, and the need for more renewable resource and energy use. This concept emphasizes resource loops that sustain natural ecosystems and the use of renewable materials (Konietzko et al., 2020). It is about improving the environment instead of using it (Bocken et al., 2021).

APPENDIX C – SYSTEMATIC LITERATURE REVIEW

The systematic literature review was conducted in a couple successive steps. First, the keywords for the article search were chosen carefully based on the sub-research question that corresponds with this review. Searches with these keywords were analysed through bibliometric networks that were created by VOSviewer. Hereafter, the systematic literature review was conducted and documented according to the PRISMA guidelines. This Appendix provides a further explanation about this process, starting with the VOSviewer analysis.

VOSVIEWER ANALYSIS

The keywords were carefully chosen based on the second sub-research question (SQ2), which states as follows;

*SQ 2 Which **circularity actions** can contribute to **circular area development**?*

The most important topics of the research question are (1) "circular actions" or (2) "circular area development". Furthermore, the general topic of this thesis is the implementation of a circular economy in area development. This should also be considered during the search.

Based on these variables, possible important keywords were identified, these are visible in Table 1. Based on these keywords several article searches were conducted, beginning only with experimenting with the first two variables. This way a legit base for further research was made. These searches were analysed with bibliometric network mas created by VOSviewer

Through the VOSviewer analysis, it became clear that both 'urban planning' and 'built environment' together with 'circular economy' were the most important keywords. 'Urban planning' and 'built environment' encompass important relationships to different subjects within the research field, thus, including these is important. On the other hand, it became clear that 'circular cit*' has less influence.Furthermore, VOSviewer shows that the 'circular economy' is a more dependent keyword than 'sustainable development'.

Table C.1: Keywords systematic literature search

General topic	Circular area development/circular areas	Circularity strategies/actions
Circular economy	Circular built environment	Policy/ policies
Sustainable development	Circular city/cities	Intervention/interventions
	Circular area development	Strategy/strategies
	Sustainable urban planning	Measure/measures
	Construction industry	Business models
	Urban planning	Action
		Activity

The last step before the systematic literature search could start, was including the third search category. A decision for the final keyword combination in the last category was based on the definitions used in the respective articles.

A decision for either 'action' or 'activity' was made based on how the found articles interpreted the terms. The final combination can be found in Table 2.

Table C.2: Scopus search 7.

General topic	Circular area development/circular areas	Circularity strategies/actions
Circular economy	Built environment	Measure*
	Urban planning	Action
		Strateg*

The search was conducted on the 24th of May 2023. The records included 258 articles after exclusion criteria were implemented and duplicates removed.

CODING OF CIRCULARITY THEMES

As described in the methodology, the data found in the systematic literature review was documented in Excel. The next step involved coding the data and dividing them in sub-themes. Furthermore a division was made between strategies for areas and buildings. This step is visible in Table 3, column two.

Hereafter, Atlas.ti was used to further refine the codes in categories and themes, these codes are visible in Table 3, column three.

Table C.3: Illustration of documented text, strategies, and themes were meticulously documented in Excel, including first round of coding and Atlas.ti refinement of codes.

Documented data		**First round coding**		**Atlas.ti, round two, refining codes**	
Amenta, 2022		**Coded theme**	**Code category**	**Coded theme**	**Refining codes**
1	Rethinking of the structure of peri-urban areas, its relations and functionalities, as an 'in-between' territory	Rethinking of structure	Structure (area)	Urban structure	Urban structure (area)
3	Regeneration of waste scapes, based on the idea to re-build as cradles of encounter and shared eco-services	Regeneration of wastescapes (abandoned sites)/ regeneration of waste scapes (waste infrastructure)	Structure/waste (area)	Brownfield development	Urban structure (area)
4	Proximity to nature	Proximity to nature	Nature (area)	Public access to green space	Environment (area)
5	densification	Densification	Structure (area)	Densification	Urban structure (area)
6	EU: REPAiR --> 'Co-Exploring', 'Co-Design', 'CoProduction', 'Co-Decision' and 'Co-Governance'	REPAiR □ co-creation, co-design	Process (area)	Collaboration, cooperation	Process (area)
7	eco-innovative solutions and strategies	Environmental/ green network	Nature (area)	Environmental networks	Environment (area)
9	Solutions based on a deep understanding of the local context	Understanding of the local context	Structure (area)	Local context	Urban structure (area)
10	Bottom-up and inclusive approaches	Integrating bottom-up and inclusive actions	Social (area)	Collaboration, cooperation, shared strategies, social equity	Social, process (area)
Askar, 2021					
1	Design for adaptability	Design for adaptability (also flexibility)	Circular building design (Building)	Design for adaptability and flexiblity	Circular building design (Building)
2	Design multipurpose facilities for shared and alternative use	Design multipurpose facilities for shared and alternative use	Circular building design (Building)	Multi-use of space	Circular building design (Building)
3	Design for longevity and durability	Design for longevity and durability	Circular building design (Building)	Design for longevity and durability	Circular building design (Building)

4	Design for deconstruction and disassembly	Design for deconstruction and disassembly	Circular building design (Building)	Design for deconstruction and disassembly	Circular building design (Building)
5	Standardization and modularity	Standardization and modularity	Circular building design (Building)	Standardization and modularity	Circular building design (Building)
6	Material passport	Material passport	Materials (Building)	Material passport	Materials (Building)
7	Design for resilience	Design for resilience (for long-term climate change)	Circular building design (Building)	Passive design	Circular building design (Building)
8	Design standards	Design standards	Circular building design (Building)	High design strandards	Circular building design (Building)
9	Circular Building (CB) strategies		Circular building design (Building)		Circular building design (Building)
Augiseau, 2021					
1	Waste management	Waste management	Waste (area)	Waste management	Waste (area)
2	Maintenance	Maintenance	Maintenance (Building)	Maintenance	Maintenance (Building)
3	Evaluation of the situation	Evaluation of the situation	Process (area/ Building)	Evaluate	Process (area/ building)
4	Urban mining	Urban mining	Materials (Building)	R-strategies	Materials (Building)
5	Limitation of urban sprawl	Limitation of urban sprawl	Structure (area)	Densification	Structure (area)

After the code refinement with the use of Atlas.ti, the codes for area's and buildings were combined in one list. It was concluded that the building level was at the same level as the identified themes for the area, such as environment, social, and urban structure.

APPENDIX D – SEMI-STRUCTURED INTERVIEWS

INFORMED CONSENT FORM (FROM HREC APPLICATION)

Graag nodig ik u uit om deel te nemen aan een onderzoek genaamd "Circulair area development: Framework for circularity strategies during the planning phases of area development". Ik (Karlijn van Velzen) voer dit onderzoek uit als afstudeerder van de masteropleiding Construction Management and Engineering aan de TU Delft. Dit zal ik doen in samenwerking met Waalpartners bv.

Het doel van dit onderzoek is het in kaart brengen van circulaire gebiedsontwikkeling in de praktijk. Met name de volgorde van invloedrijke keuzes binnen het proces is enorm nuttig om in kaart te brengen. Met deze informatie kan onderzocht worden hoe circulariteit beter kan worden toegepast in gebiedsontwikkelingsprojecten.

Dit interview zal ongeveer 60 minuten in beslag nemen. De data zal gebruikt worden om inzicht te krijgen in hoe er met ambities op het gebied van de circulaire economie/circulariteit wordt omgegaan, hoe circulariteit in de praktijk wordt toegepast en welke belangrijke en invloedrijke keuzes hiermee gepaard gaan.
U wordt gevraagd om tijdens het interview meerdere open vragen te beantwoorden. Hierbij zal ik u vragen zoveel mogelijk voorbeelden te noemen.

Zoals bij elke online activiteit is het risico van een datalek aanwezig. Wij doen ons best om uw antwoorden vertrouwelijk te houden. We minimaliseren de risico's door persoonlijke data zo snel mogelijk te verwijderen. Van het interview zal een video- en/of audio-opname worden gemaakt. Deze zal na afloop worden getranscribeerd en met u worden gedeeld. Het transcript kunt u doornemen en controleren op eventuele fouten of onderdelen die anders geformuleerd moeten worden. Wanneer het transcript naar wens is, zal de opname verwijderd worden en het transcript geanonimiseerd. De niet-geanonimiseerde data zal opgeslagen worden in aparte mappen in mijn persoonlijke OneDrive en zal zo snel mogelijk verwijderd worden. Vanuit de geanonimiseerde transcripten zullen quotes worden opgenomen in het rapport. Deze transcripten worden niet openbaar toegankelijk gemaakt, omdat ze geen onderdeel uitmaken van mijn publiek beschikbare thesis. Uw naam- en contactgegevens zullen meteen na afloop van het onderzoek vernietigd worden.

Uw deelname aan dit onderzoek is volledig vrijwillig, en u kunt zich op elk moment terugtrekken zonder reden op te geven. U bent vrij om vragen niet te beantwoorden.

Als u mee wilt doen aan dit interview, wilt u dan de onderstaande verklaring invullen en ondertekenen?

Met vriendelijke groet,

Karlijn van Velzen

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICPANT TASKS AND VOLUNTARY PARTICIPATION		
1. Ik heb de informatie over het onderzoek gedateerd _____ gelezen en begrepen, of deze is aan mij voorgelezen. 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. Ik begrijp dat mijn deelname aan het onderzoek de volgende punten betekent: • Dit interview wordt opgenomen (in video en/of audio) • Een handmatige transcript zal worden gemaakt • De opnames van het interview zullen 10 werkdagen na het versturen van het transcript verwijderd worden, tenzij hier nog aanmerking op zijn • De transcriptie geanonimiseerd zal worden en quotes hieruit gebruikt kunnen worden in het rapport • De oorspronkelijk niet-geanonimiseerde transcriptie zal verwijderd worden direct na het anonimiseren.		
4. Ik begrijp dat mijn deelname aan het onderzoek niet gecompenseerd wordt		
5. Ik begrijp dat dit onderzoek naar verwachting in oktober 2023 eindigt.		
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)		
7. Ik begrijp dat mijn deelname betekent dat er persoonlijke identificeerbare informatie en onderzoeksdata worden verzameld, met het risico dat ik hieruit geïdentificeerd kan worden.		
8. Ik begrijp dat binnen de Algemene verordering gegevensbescherming (AVG) een deel van deze persoonlijk identificeerbare onderzoeksdata als gevoelig wordt beschouwd, namelijk: • Naam • E-mailadres • Andere contactgegevens		
9. Ik begrijp dat de volgende stappen worden ondernomen om het risico van een databreuk te minimaliseren, en dat mijn identiteit op de volgende manieren wordt beschermd: • Data wordt zo snel mogelijk geanonimiseerd en verwijderd • Niet-geanonimiseerde data wordt in een aparte map opgeslagen		
10. Ik begrijp dat de persoonlijke informatie die over mij verzameld wordt en mij kan identificeren, zoals naam, contact informatie en beeld- en geluidsopnames, niet gedeeld worden buiten het studieteam.		
11. Ik begrijp dat de persoonlijke data die over mij verzameld wordt, vernietigd wordt uiterlijk ten laatste bij het publiceren van het rapport		
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		
12. Ik begrijp dat na het onderzoek de geanonimiseerde informatie die opgenomen is in het rapport, mogelijk gebruikt kan worden voor verder onderzoek		
13. Ik geef toestemming om mijn antwoorden, ideeën of andere bijdrages anoniem te quoten in resulterende producten.		

Signatures

_____ _____ _____

Naam deelnemer Handtekening Datum

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

_____ _____ _____

Naam onderzoeker Handtekening Datum

Contactgegevens van de onderzoeker voor verdere informatie:
Karlijn van velzen – k.vanvelzen@student.tudelft.nl

INTERVIEW PROTOCOL

[Bedankt] Allereerst wil ik u graag bedanken voor het meedoen aan dit interview. Graag wil ik u nog een keer vragen of u het goed vind of dit interview wordt opgenomen?

[Introductie] Ik zal om te beginnen mezelf even voorstellen; Ik ben Karlijn en studeer construction management and engineering aan de civiele techniek faculteit van de TU Delft. Voor het afronden van mijn master, ben ik bezig met een onderzoek naar circulaire gebiedsontwikkeling.

[Onderzoek] Zoals u misschien wel weet, heeft de Nederlandse overheid de ambitie om voor 2050 een volledig circulaire economie te creëren in Nederland. Hierbij speelt circulaire gebiedsontwikkeling ook een grote rol. Hiermee kunnen namelijk duurzame gebieden, die leefbare en toekomstbestendig zijn, worden ontwikkeld. Echter is er helaas nog weinig duidelijk over wat het precies inhoud en welke circulaire aspecten wanneer toegepast kunnen worden.

[Doel] Met mijn onderzoek wil ik duidelijker in kaart brengen hoe circulaire gebiedsontwikkeling in de praktijk kan worden toegepast. Hiervoor is informatie over de volgorde en invloed van keuzes m.b.t. circulariteitsstrategieën enorm nuttig. Met deze informatie kunnen circulariteitsstrategieën in het proces gewaarborgd worden, aangezien er duidelijk kan worden gemaakt wanneer in het proces discussies en keuzes over bepaalde maatregelen belangrijk zijn.

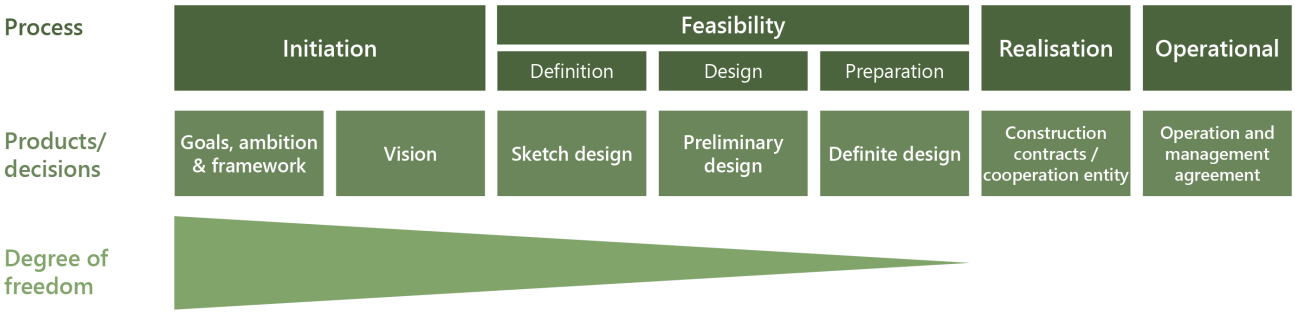
Voorafgaand aan dit onderzoek heb ik een aantal vragen opgesteld, deze wil ik graag aan u stellen. Als u eventuele aanvullingen of extra informatie heeft die u belangrijk vindt, is dat meer dan welkom. De vragen bestaan uit drie delen; algemene vragen, vragen over het proces van het project en vragen over toekomstige projecten.
Heeft u hier verder nog vragen over, anders dan kunnen we beginnen.

Algemene vragen
1. Kunt u kort iets vertellen over het project? Wat was uw rol/functie binnen het project?
2. In welke fases was u betrokken binnen het project?
3. Waren er vanaf het begin af aan al ambities ten aanzien van circulariteit en duurzaamheid? En hoe werd er met deze ambitie omgegaan?

Circulaire strategieën
1. Wat voor circulaire en duurzaamheidsmaatregelen zijn (tot nu toe) verwerkt in het project?
    a. Welke van deze maatregelen zijn het meest belangrijk voor het project?

In de theorie over gebiedsontwikkeling wordt het proces over het algemeen verdeelt in vier fases: de initiatie-, haalbaarheids-, realisatie-, en de exploitatie- en beheerfase, zie figuur 1 (Infomil, 2023; Kersten et al., 2019). Deze fases worden ook in mijn onderzoek gebruikt. Deze fases zijn van belang voor de volgende vraag.
2. Wanneer tijdens de initiatie en ontwerp fases van het project kwamen deze maatregelen ter spraken?
    a. Wanneer kwamen maatregelen voor het eerst ter spraken?
    b. Wanneer zijn definitieve keuzes gemaakt?
    c. Wanneer hebben de belangrijkste discussies plaats gevonden?
3. Is er ook over niet-fysieke onderwerpen nagedacht in het project?

Figuur D.1: Phases, deliverables, and degree of freedom. Based on (Kersten et al., 2019)



Toekomst van circulaire projecten

1. Komt dit project overeen met jouw definitie van circulaire gebiedsontwikkeling?
2. Wat zou er anders kunnen worden gedaan in het proces om meer circulariteit/duurzame aspecten toe te kunnen passen?
    a. Bijvoorbeeld eerder in discussie gaan over bepaalde onderwerpen of bepaalde keuzes eerder maken?
3. Heeft u zelf ook ambities met betrekking tot circulariteit en duurzaamheid? Zo ja, kon u die verwerken in het project?
4. Zijn er nog vragen/opmerkingen vanuit uw kant?

[Einde] Heeft u nog opmerkingen of informatie die u wilt delen die handig zijn voor dit onderzoek? Heel erg bedankt voor uw tijd en openheid. Mochten er dingen onduidelijk zijn of als u vragen heeft kunt u mij bellen of mailen. Het transcript van dit interview zal ik nog met u delen zodat u de kans heeft om het te corrigeren.

APPENDIX E – CASE EXPLANATION

This Appendix provides a thorough explanation of the three cases used for the empirical review. The development process and included circularity aspects are explained of the selected cases, Binck Eiland, Tuinen van Genta and Erasmusveld midden.

First, a brief description of the cases and the development process is given, before circular aspects of the cases are explained with more detail.

BINCK EILAND

Binck Eiland, located within the Binckhorst neighbourhood in The Hague, is part of the broader urban area development of the Binckhorst. In the early 20th century, the Binckhorst was primarily characterised by its polder landscape, Figure E.1. However, during the second half of the 20th century, the neighbourhood's characteristics transformed, giving way to industrial and business activities.

In the early 21th century this neighbourhood, along with eight other regions, had been designated by the municipality of The Hague as a potential development area for residential purposes (Gemeente Den Haag, 2005). The former industrial site is slowly transforming into a dynamic mixed-use area, combining residential and commercial functions. The municipality envisions creating an area that is green and water-rich, and attractive for both work and living (Gemeente Den Haag, 2023a). According to the environmental plan (Dutch: omgevingsplan) of the municipality, the development can accommodate 5,000 dwellings and approximately 80,000 square meters of businesses.

The Binck Eiland is one of the pioneering developments aligning with the area's new vision. Located on the former state printing office terrain (SDU-terrain), 234 dwellings and approximately 600 square meters of office space are realised. The overall project consist of three partial plans: the Binck, Binck Plaats, Binck Kade, Figure E.2.

Figure E.1: Binckhorstlaan 1904. Source: (Haags Gemeente archief).

DEVELOPMENT PROCESS

The municipality initially aimed to transform the area in a relatively short period of time, into a sustainable and high-quality residential, work and living area (Gemeente Den Haag, 2011). However, due to the economic crisis of 2008, the intended cooperation with major market players did not materialise. Therefore, the traditional approach; a large-scale integrated area development with active land policy, was no longer viable (Gemeente Den Haag, 2011). Thus, the municipality decided to take another standing in the project, details of the development approach are visible in Table E.1.

In 2011 the municipality decided to invest in the regional accessibility of the area, to increase its investment potential and stimulate market parties to invest. For this reason, the construction of the Rotterdamsebaan was realised, improving the regional accessibility of the area.

In 2014, the Binckhorst area was also included as a pilot project for the 'crisis en herstel' law in the Netherlands. With this law municipalities can create land-use plans with extended scopes, making initiatives from market parties easier to implement. This law has also made the redevelopment of office space (The Binck) on Binck Eiland possible.

Development combination 'Binck Zuid' obtained the location in June 2016, after which the three participating developers jointly created an overall concept (VORM, 2016). At the end of 2017, the plans were applied for an environmental permit and a zoning amendment, which was granted in 2018. Hereafter, the sub-projects were constructed and delivered in phases.

De Binck project was the first constructed project, as a transformation of the office building was relatively easy to create, due to the 'crisis en herstel' law.

Figure E.2: Binck Eiland. Source: (Frisia Makelaars & WVK Makelaars, 2018)

Table E.1: Project characteristics Binck Eiland.

Project	Binckhorst	Binck eiland
Development strategy	Organic	Integral
Scale	Large	Small
Office space	80,000 m^2	600 m^2
Dwellings	5000	234
Development approach	Gradually	Phased
Plan type	Strategic	Blueprint
Role of municipality	Facilitative	Facilitative
Development and management	Mixed	Sequential

CIRCULAR DESIGN ASPECTS

This paragraph elaborates on the circular design aspects that are implemented in the Binck Eiland project. These design aspects are identified based on the circularity themes found in paragraph 4.1, the systematic literature review.

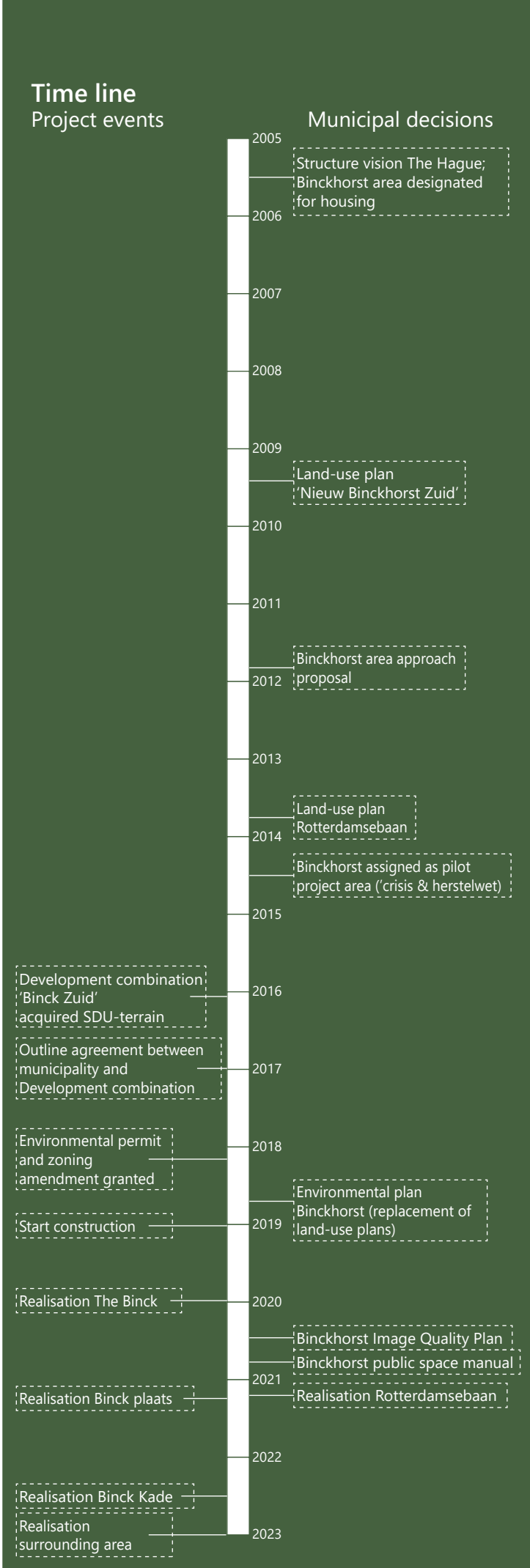
BUILDING DESIGN

The circularity of this project started with the reuse and transformation of the former office building on the location. The crisis and recovery law made it possible to transform the area and building relatively quickly. Simultaneously with the plans for the building transformation, agreements were closed for the demolition of the factory building and the stripping of the office building. This is when the idea arose to demolish the buildings according to circularity principles. The building was disassembled, numbered and stored in containers for future reassembly at another location. Unfortunately, no information about the reassembly process is available online, making it impossible to verify.

Lightweight construction strategies were also applied in the design of the dwellings in Binck plaats, ensuring the use of less materials and dematerialisation. However, other strategies, such as multifunctionality, flexibility and adaptability are not needed in every design. During the design of office buildings, these are important factors. However, residential buildings are very durable, and, therefore, need less flexibility or adaptability (Interviewee 2, personal communication, 10 July 2023). Still, flexible materials are used inside the residents, which ensures a flexible, customisable house.

Furthermore, the design standards of the buildings are high, achieving energy-neutral buildings for new constructions and almost energy-neutral redevelopments. For the transformation higher performances than this were not possible, as the old façade could not be changed.

For the material selection in the buildings several circular strategies were implemented. R-strategies



were applied to the building components and materials on site. The concrete floor of the old factory hall was crushed and reused as materials for the new concrete of the foundation. Furthermore, during the process the use of materials that are circular and/or locally produced were preferred.

URBAN STRUCTURE

During the development process, another circularity aspect was implemented through the multifunctional use of the old SDU terrain. During the design process, several temporary users were located in the building. Examples are the storage of election campaign material, training facilities for drones, and military training.

MOBILITY & TRANSPORTATION

The design includes car-free zones, indoor parking facilities and adaptable strategies. Each parking space is adaptable to convert to electric charging stations.

ENVIRONMENTAL NETWORKS

An ecozone, which could potentially positively influence the biodiversity in the city and area, was included in the design. However, due to the municipality granting the land to other landowners in the area, this element was eventually excluded from the plans.

Furthermore, a significant environmental element in the plan was the communal rooftop garden, situated atop the indoor parking facility. Major discussions were held about the choice between native and exotic plant species, considering their biodiversity impact. Eventually, native plants are applied, as these benefit biodiversity better. However, the landscape designer argued that, due to climate change, summers have become increasingly dry, diminishing the likelihood of survival for native plants.

CIRCULAR ENERGY SYSTEMS

For the energy supply of the buildings solar panels were placed atop the buildings, providing the developments with renewable energy sources. This is combined with technologies such as heat-cold storage and heat recovery systems, extremely effective insulation, and balanced ventilation systems in buildings. Together, these interventions ensure the Binck plaats buildings achieve an EPC 0 (VORM, 2018).

The renovation, however, was not connected to sustainable heating techniques. It was technically infeasible to create a heat-cold storage system for the entire area, also the planned district heating was not yet available in the area. Therefore, gas heating is still applied in the area.

Nonetheless, low-temperature underfloor heating is applied in all buildings, increasing the building's adaptability to sustainable sources.

CIRCULAR WATER SYSTEMS

The initial intention was to store and infiltrate water using swale systems. However, the municipality did not allow these to be included in the designs. Consequently, creative thinking was necessary. Eventually, a reversed swale system was applied, not infiltrating the water in the ground, but allowing the rainwater to drain into the open water, the Trekvliet.

Additionally, the communal garden has the capacity to store water in its substrate and all residences surrounding the communal garden are equipped with water retention fences. These can store rainwater, that can be used by residents to water their plants later on.

CIRCULAR SOIL SYSTEMS

Initially, the idea was to maintain a closed soil balance for the development. However, due to the extensive addition of vegetation in the development, some extra soil had to be brought in.

Besides this, due to the industry-rich history of the Binckhorst, a lot of ground is contaminated. The same applies to Binck eiland. After soil investigations were conducted, some contamination was found, these had to be remediated.

SOCIAL ASPECTS

Several social aspects are integrated into the project. Starting with the communal garden, which acts as a stimulator for social cohesion. It is a place where people meet, maintain the garden together, and grow vegetables.

Furthermore, some elements in the process and design are meant to educate the residents. For example, each resident received a piece of art made out of reused ceiling plates; a form of repurposing old materials and showing circularity to residents. The rooftop includes gutters that show excess water flowing off the roof, creating awareness about the water system among the people.

Sustainable consumption is also stimulated by the project, through sharing strategies. Garden equipment, such as lawnmowers are stored in the communal greenhouse.

ECONOMY

The developer in this project had from the beginning the ambition to create space for a local sustainable entrepreneur.

Furthermore, the developer has requested the construction companies to use local materials as much as possible, to reduce transportation emissions. Residents produce food and vegetables in their local garden.

MATERIALS

A lot of ideas regarding reuse of materials and components in the public space were thought of, however, only a few made it to the realisation phase. Mainly the measures that are located on the terrain of the residents are included. The reason for this mostly being the resistance from the municipality.

TUINEN VAN GENTA

Located between the Teteringsedijk and the railway in Breda, the inner-city redevelopment project 'Tuinen van Genta' is situated. Until approximately 2000, this former industrial site served as the home for warehouses and transshipment activities to the railway by businesses in Breda, such as Loda (Lodalientje dish soap), Molenschot (weighing tools), Genta (cigar factory) and others.

The Teteringsedijk, together with the Hoge Steenweg, historically served as an old medieval route to the city of Breda. At the beginning of the 20th century, Breda showed strong growth in economic activities, where the agricultural plots made way for industry and housing (Gemeente Breda, 2020b). Partly due to the construction of the railway, the city was able to grow and became attractive for industrial companies. The old buildings of Loda, hold positive value due to its cultural heritage. However, due to the irreparable damage to the building, it was demolished. The municipality of Breda (2020b) describes the Genta building as a hidden gem as it lays almost unnoticed on the location.

In 2008 the municipality of Breda (2008) created a structure vision for business and industrial sites in Breda. They envision the transformation of all industrial sites surrounding the railway, into predominantly residential functions. Whilst the industrial buildings were oriented away from the railway, the municipality intents for the new developments to be oriented towards the railway (Gemeente Breda, 2020b). In the area vision of the Brabant park area, the municipality indicates that there is space for 200 dwellings on this industrial site.

DEVELOPMENT PROCESS

Since the buildings were demolished in 2009, the site has been vacant, causing frustration among the neighbourhood (BN de stem, 2011). As early as 2007, plans were formulated and discussed by developers and the municipality of Breda. However, the location has an unfortunate history with bankruptcies, criticism of the neighbours and the difficult context on the location, causing the project to be delayed until 2024.

Table E.2: Project characteristics Tuinen van Genta.

Project	Tuinen van Genta
Development strategy	Integral
Scale	Small
Office space	-
Dwellings	190
Development approach	Phased
Plan type	Blueprint
Role of municipality	Facilitative
Development and management	Sequential

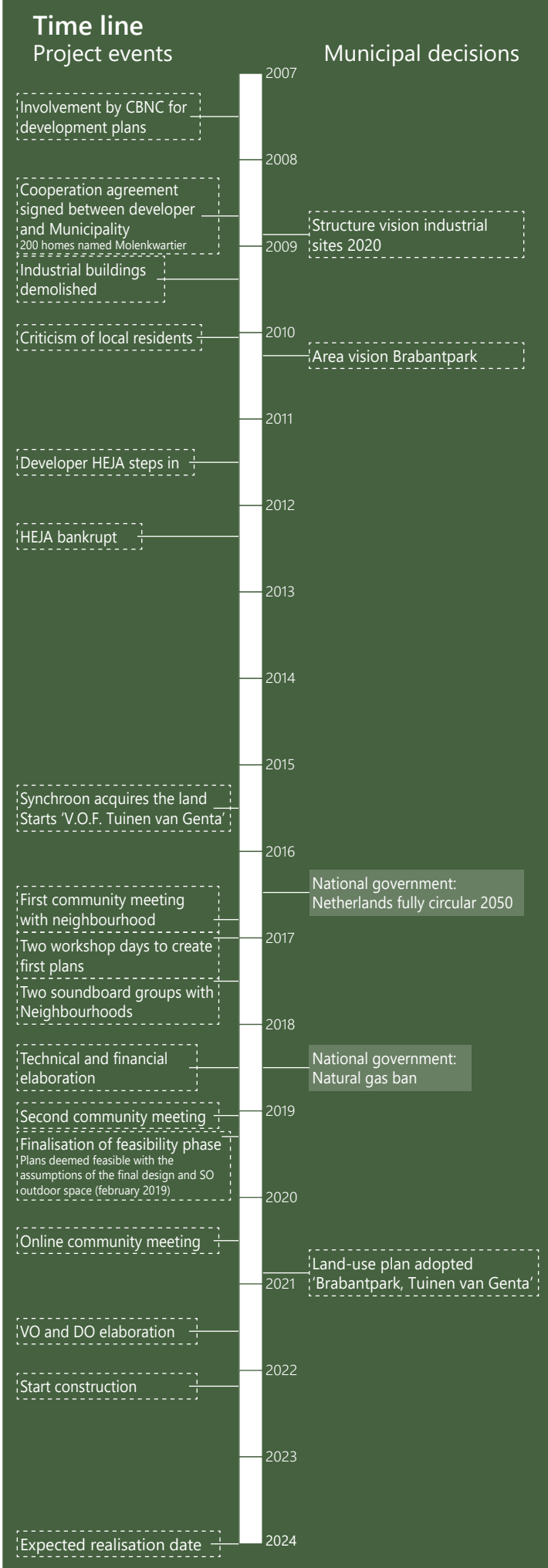


Figure E.3: Urban development plan. Source: (Inbo et al., 2019).

The first developer to attempt the transformation of the location was CBNC (BN de stem, 2007, 2009). They envisioned the construction of 220 dwellings under the name 'molenkwartier' on the terrain, and had even entered into a collaboration agreement with de municipality in 2008 (BN de stem, 2009). However, due to delays and bankruptcies, the plans did not materialize (Lensink, 2015).

Around 2010, HEJA became the second developer to pursue the project (BN de stem, 2011). However, in 2012, HEJA filed for bankruptcy (AD, 2012).

After HEJA's bankruptcy, the site remained vacant for quite some time. It was only in 2015 that developer Synchroon dared to start work on the transformation. Due to the history of the location and previous plans, Synchroon decided to take a different approach and disregard all previous plans; the 'tuinen van Genta' were born (De Wijde Blik, 2016). They began by engaging the neighbourhood and asking what they wanted the area to look like. Participation with local residents plays a major role in the outcome of this project (De Wijde Blik, 2016). Through three community meetings and two soundboard groups, the community was kept informed and could give solicited and unsolicited advise. The urban development plan was created in two workshop days with the architects, developers, municipality, and other stakeholders (De Wijde Blik, 2019; Interviewee 1, personal communication, 7 July 2023).

At the end of 2019, the participation process was completed, and the resulting plans were ready for technical and financial elaboration (De Wijde Blik, 2019). The municipality also approved the completion of the feasibility phase. It was concluded that the plans were feasible according to the principles of the 'Definitief Ontwerp Tuinen van Genta' and 'SO buitenruimte februari 2019'. Subsequently, in 2020, the land-use plan was adjusted and adopted (Gemeente Breda, 2020a, 2020b).

CIRCULAR DESIGN ASPECTS

The 'Tuinen van Genta' development contains significantly less circularity aspects when compared to the Binck Eiland project. This is mainly due to the fact that in 2015, when the development process started, circularity was not yet an important topic (Interviewee 1, personal communication, 7 July 2023). Therefore, the project ambitions were not focussed on topics such as this. Nonetheless, there are circularity aspects in this project that are included intuitively, this paragraph will shortly elaborate on these aspects.

BUILDING DESIGN

One of the circularity aspects in this case is the reuse of the old building of the old Genta cigar factory. The municipality considered this building important to renovate (Interviewee 1, personal communication, 7 July 2023). However, due to the quality of the building, only the façade could remain in place and a new structure was necessary. "*The only thing we do is that we responsibly reuse a site, that we breathe new life into it, and that we repurpose a historic building, as far as that was actually still possible.*" (Interviewee 1, personal communication, 7 July 2023).

Furthermore, the energy efficiency of the buildings is an important topic, as the buildings are not connected to gas, but to sustainable energy sources. Consequently the buildings are energy neutral with an EPC (Energy Performance Coefficient).

Furthermore, the contractor preferred to use prefabrication systems for the buildings. Therefore, the construction follows a quite efficient building method according to very traditional techniques. However, these techniques are not material efficient, as for example whole bricks are used instead of brick strips, creating a heavier structure.

URBAN STRUCTURE

The area was characterised by vacancy and polluted soil for a long period of time. Therefore, a part of the circularity is also included in the redevelopment of this wastescape in the city of Breda. The development ensures that this area becomes part of the city again and that the space is in use again.

MOBILITY & TRANSPORTATION

As a result of the ambition to incorporate as much greenery as possible, the decision was made to provide parking facilities underneath the buildings (Interviewee 1, personal communication, 7 July 2023). This way, more space was available for green facilities and cars are eliminated from the streets. This decision was included in the development from the beginning of the process.

Furthermore, the plans are characterised by one way streets. This decision reduces the width of the roads and thereby also reduces the impermeable surface area.

ENVIRONMENTAL NETWORKS

From the beginning the implementation of green facilities in the area had been an important topic. Both the existing residents and municipality found this topic important (De Wijde Blik, 2016). During the first concept plans a lot of attention has been given to this topic, resulting in a plan that provides a lot of space for communal gardens.

Several communal gardens are implemented, together with a park along the rail ways and a field of gras in front of the old Genta pant. The railway landscape is the most ecologically diverse landscape in the area (Interviewee 4, personal communication, 17 July 2023).

CIRCULAR ENERGY SYSTEMS

The decision was made to use renewable energy and circular heating sources for the energy demand of the buildings. Air source heat pumps are connected to solar panels on the roofs, creating energy neutral buildings (Interviewee 1, personal communication, 7 July 2023).

CIRCULAR WATER SYSTEMS

To create a circular water system, several swales are included in the plans to retain and infiltrate water in the area. Rainwater can infiltrate the swales through dedicated sewage systems designed for rainwater. However, rainwater is not collected and stored for use of the communal or private gardens. This is something that could have added to the circular water system in the area. Interviewee 4 says about this: "*In hindsight, I think we missed something there, in the reuse of rainwater for the garden and that garage.*" (Personal communication, 17 July 2023).

The municipal requirements for water storage have increased significantly in the past few years. According to interviewee 5 the plans in this development allow for a little bit more than 7 millimetre water storages, while current legislation demand for 60 millimetre water storage (Interviewee 5, personal communication, 17 July 2023).

CIRCULAR SOIL SYSTEMS

The area is marked by a lot of heavy soil pollution from its history as former industrial site. The polluted soil was a big problem for the development plans surrounding the area. The most sustainable way to deal with this pollution was to create a protective layer on top of the polluted soil. The polluted soil does not have to be moved or sealed, which prevents costs, while at the same time a safe environment is created.

CLOSED WASTE SYSTEMS

Existing structures were crushed and partly reused for the base layer for the construction roads and partly reused in new concrete (Interviewee 1, personal communication, 7 July 2023).

SOCIAL ASPECTS

Quite a few social aspects had been included in the designs. The communal gardens have the potential to enhance social cohesion within the neighbourhood, much like the communal garden in Binck Eiland had a positive effect on the social cohesion of that community.

Furthermore, the local community has extensively been included during the plan making process. Their opinion has been included in the designs, making sure they are satisfied with the designs. Several community evenings have been organised to keep them up to date and ask for their opinions (De Wijde Blik, 2016, 2017a, 2017b, 2019, 2020).

Furthermore, future residents have been included in the designs of the communal gardens. Interviewee 4 noticed that these people are excited about this feature of the designs: "T*hey really bought it consciously*" (personal communication, 17 July 2023).

ERASMUSVELD MIDDEN

The third case study project, 'Erasmusveld midden', is a component of the greater 'Erasmusveld' area development. This area development is situated in the 'Wateringse Veld' neighbourhood in The Hague. In 1994, the municipality, in collaboration with Bouwfonds, initiated the development combination Wateringse Veld (OCWV) (Gemeente Den Haag, 1994). Together, they created plans for the redevelopment of the Wateringse Veld area, envisioning the creation of 7,000 dwellings.

Historically, it has been urban fringe area of The Hague that is now undergoing a transformation accommodating approximately 1,000 dwellings. The area is envisioned to be a new sustainable, climate-resilient, and ecologically friendly neighbourhood between the surrounding post-war and Vinex districts. Therefore, the municipality of The Hague (2023b) aims to collectively integrate and consider the following themes in the development plans; (1) green and ecology, (2) traffic and parking, (3) community and communal spaces, (4) underground infrastructure and water, (5) waste streams, (6) energy, and (7) public space designed to be climate-resilient. Furthermore, a water-rich, green strip called 'the ecological ribbon' is created as an integral part of Erasmusveld. This recreational green path connects the different sub-projects, including Erasmusveld midden.

In Erasmusveld Midden 370 dwellings are constructed, including both apartments and dwellings. Erasmusveld midden consists of two parts; the residential building 'Leyhof' and 'de Velden' with five courtyards with ground-bound homes and two residential blocks, see Figure E.4 (right).

DEVELOPMENT PROCESS

In 2008, the municipality of The Hague established the masterplan 'Erasmusveld-Leyhofzone' (Gemeente Den Haag, 2016). However, due to the economic crisis in 2008, the municipality decided to shift their role within the developments from participative to facilitative. Nonetheless, the development combination Wateringse Veld stayed in place in a slimmed-down form to complete the planned developments (Gemeente Den Haag, 2016).

Furthermore, in 2010, the former Minister of housing in the Netherlands designated the Erasmusveld as an 'excelent area', requiring the buildings and plans in the area to meet the Energy

Performance Coefficient (EPC) requirements for excellent areas (Staatcourant, 2010). In 2016, the excellent area pilot was discontinued, and the ambition of Nearly Energy Neutral (Bijna energie neutraal - BENG) was adopted (Gemeente Den Haag, 2016). These decisions have shaped the plans, aiming to make it one of the most sustainable regions in the Netherlands.

In light of this a manifesto sustainable Erasmusveld was made and signed by all stakeholders that were creating developments (Gemeente Den Haag et al., 2015). Consequently, sustainability is the guiding theme in Erasmusveld, the design is meant to create a change in the lifestyle; people will consciously live different and more sustainable (BPD, 2023g). In 2016 a Allonge agreement, on top of the existing agreement from 1995, was made between the municipality The Hague and the developer of 'Erasmusveld midden'. The OCWV acquired the lands and proceeded with the plans. Based on the urban plan, created by the OCWV, the municipality changed the land-use plan in 2016 (Interviewee 3, personal communication, 12 July 2023).

Hereafter, the developer has retaken possession of the lands, and has started executing the plans.

Figure E.4: Urban development plan (right) & preliminary design (left). Source: (RRog stedenbouw en landschap, 2020)

Table E.3: Project characteristics Erasmusveld and Erasmusveld midden.

Project	Erasmus veld	Erasmusveld Midden
Development strategy	Organic	Integral
Scale	Medium	Small
Office space	-	-
Dwellings	1,000	370
Development approach	Gradually	Phased
Plan type	Strategic	Blueprint
Role of municipality	Facilitative	Facilitative
Development and management	Mixed	Sequential

The environmental permit for the Leyhof building was granted in 2020, construction started in 2021 and in 2022 the building was realised. This building has won two sustainability awards for buildings: (1) the SKG Award 2021 and (2) the 'Haagse' woonprijs (BPD, 2021, 2023g). The building consists of 108 energy-efficient apartments and 3-story family homes (BPD, n.d.).

The subpart 'de velden' started construction in 2023 and is expected to be finished at the end of 2024. Here 125 energy-efficient family homes are spread over five fields, surrounded by green (BPD, n.d.).

Construction of the two apartment complexes with affordable homes also started in 2023 (BPD, 2023a; Woonzorg, 2023). These buildings are also expected to be finished at the end of 2024. In total 136 affordable apartments are created here.

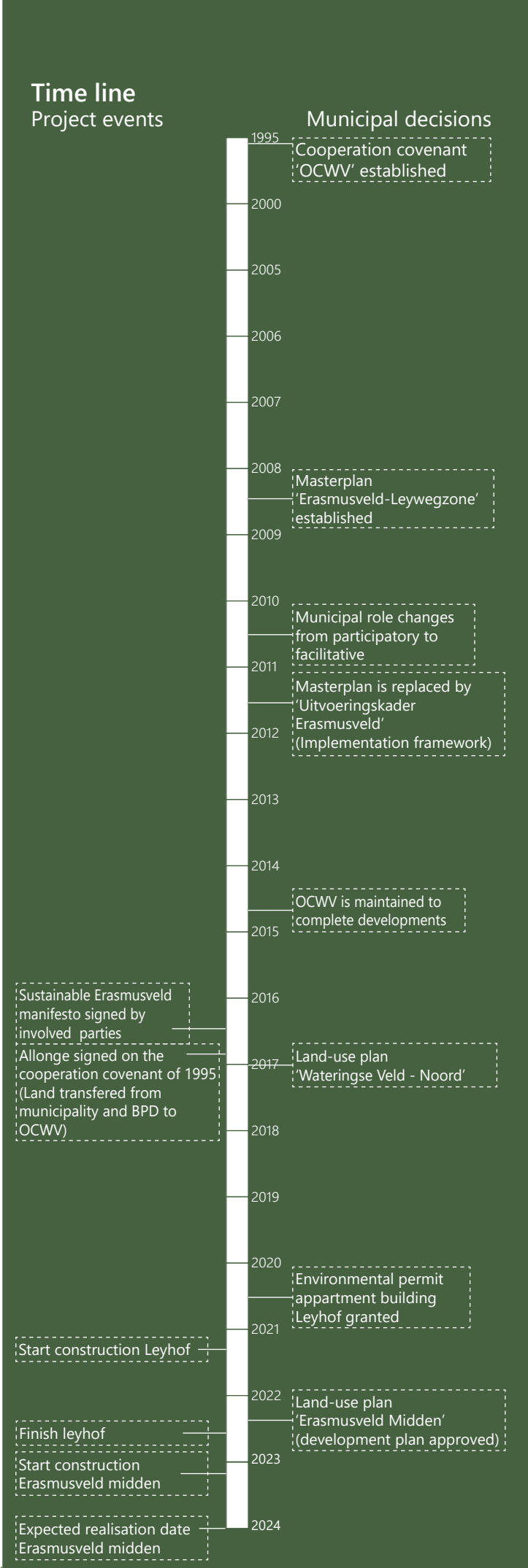
CIRCULAR DESIGN ASPECTS

In the past, the development of the Erasmusveld area was marked by the government to become one of the most sustainable neighbourhoods in the Netherlands (Staatcourant, 2010). This is evident in the design of the area, which includes, among other features, green and climate-adaptive facilities.

BUILDING DESIGN

The buildings in the development are all newly constructed. Reuse of existing buildings was not an option, since the site had no prior structures. Nonetheless, several circularity aspects have been included in the designs, to create constructions that function in the most circular way possible now and in the future.

For example, all buildings all have low EPC scores, include high design standards, and design interventions such as green roofs (BPD, 2023g). Furthermore, material passports are created to ensure it is possible to reuse the materials in the future, after the building's life span (BPD, 2023c). Shared facilities are implemented in the Leyhof building, creating the possibility to multi-use and share space.



URBAN STRUCTURE

In the Proeftuin Erasmusveld development, circularity is integrated into the urban structure in several ways: through densification, shared spaces, and the multi-use of space throughout the design process.

The development is located in within the contours of the existing city, preserving space outside of the city (BPD, 2023c). Furthermore, this neighbourhood is compact, with a relatively high density and compact buildings (BPD, 2023c). In between the existing city a new neighbourhood is created, limiting urban sprawl surrounding The Hague.

Additionally, the neighbourhood stimulates the use of shared space by minimizing private outdoor space, for example, smaller private gardens, and large collective inner gardens and shared pavilions (BPD, 2023c).

Moreover, during the design process, instead of leaving the site empty, the site served as an experimental garden, providing space for tiny houses. For a duration of two years, five tiny houses were situated at the location (BPD, 2023g). This allowed for experimentation with sustainable ideas, from which a lot was learned. Urban farming, self-sustaining renewable energy systems, water purification, and waste reduction were tested. Lessons learned in the experiment are also included in the designs for the area.

MOBILITY & TRANSPORTATION

Sustainable mobility is promoted in the area, through the availability of shared vehicles, electric charging stations and less parking spaces (BPD, 2023c). Additionally, the parking spaces are located at the edges of the development and smaller roads are implemented in the plans, creating more space for green facilities.

ENVIRONMENTAL NETWORKS

In the designs, a lot of space is reserved for nature. Many green facilities are implemented and space is created for animals, through for example nesting boxes and bat routes through the area (BPD, 2023f). Furthermore, for the vegetation a diverse mix of trees, shrubs and herbs is used, and several measures have been taken to increase and enhance the biodiversity in the area.

CIRCULAR ENERGY SYSTEMS

To increase the circularity of the energy systems used in the area, the energy demand of buildings is reduced. For example, the buildings are efficiently oriented to the sun, optimizing the use of daylight and solar warmth. Furthermore, the buildings are equipped with high insulation values. These measures make sure energy losses are minimised and heating demands are decreased (BPD, 2023d).

Furthermore, circular heating systems and solar panels are incorporated in the designs to ensure sustainable energy usage. Each building has solar panels in combination with a green roof to ensure its efficiency.

CIRCULAR WATER SYSTEMS

In the development plans attention has been given to the water storage capacity of the area, several measures have been implemented. First of all, water is a fundamental element in the area, both functionally, ecologically and aesthetically (BPD, 2023f). A stream is implemented in the ecological zone. Additionally, several swales and other water retention facilities are implemented in the plans. Ground-based houses are provided with their own rainwater tank, to store water. The green roofs also have the ability to store some water.

Additionally, water-saving faucets and showerheads are included in the houses, making sure water is used efficiently and not wasted.

CIRCULAR SOIL SYSTEMS

A circular intervention in the area was the aim to work with a closed soil balance for the site. Soil was moved within the site to create the hight differences in the development. However, this was not fully possible, as soil had to be brought away. Interviewee 10 says the following about this: "*If we truly wanted to work with a closed soil balance, we had to raise the ground level even higher. That simply wasn't feasible.*" (personal communication, 31 July 2023).

CLOSED WASTE SYSTEMS

Waste separation facilities have been strategically placed in the area to facilitate recycling. According to the website, there will be separate containers for textiles, plastic, metal packaging, glass, and paper (BPD, 2023c). Furthermore, organic waste can be composted and reused in the communal vegetable gardens. Furthermore, underground containers are added to maintain quality in the area.

SOCIAL ASPECTS

The development also provides the space for outdoor recreation with playgrounds and sport equipment (BPD, 2023e). Additionally, various vegetable gardens and greenhouses will be integrated in the development. The presence of these communal gardens and public spaces aim to enhance the social cohesion in the area, while also promoting the residents' health.

CIRCULAR ASPECTS OVERVIEW PER CASE

Table E.4 provides the in the previous paragraphs analysed circular design strategies in each of the case studies.

Table E.4: Circular design themes in case study project summarizes. ✓/✗ indicate the inclusion or exclusion of the circular design theme, if both are filled in it means certain parts are implemented but not for the whole project. Furthermore, ? means it is unsure if the theme is implemented.

Themes	Categories (code groups)	Binck eiland	Tuinen van Genta	Erasmusveld midden
1. Urban structure	Robust urban structure (densification, evolvability & versatility)	✗	✗	✓
	Brownfield development	✓	✓	✗
	Local context	✗	✓	n/a
	Multi-functionality (land use optimization)	✓	✗	✓
2. Mobility & transportation	Sustainable mobility and transportation	✓	✗	✓
	Multi-modal transportation infrastructure	✓	✓	✓
	Accessibility	✗	✓	✗
3. Environmental networks	Biodiversity	✓	✓	✓
	Ecosystem regeneration and remediation	✓/✗	✓	✓
	Public access to green space	✓	✓	✓
	Ecosystem service provision	✓	✓	✓
4. Circular water systems	Gray/rainwater collection and storage	✓	✓	✓
	Preserve and regenerate fresh water	✓/✗	✓	✓
5. Circular soil systems	Circular soil excavation	✗	✗	✓/✗
	Soil regeneration and remediation	✗	✓/✗	✓
6. Circular energy systems	Renewable energy	✓	✓	✓
	Energy efficiency	✓	✓	✓
7. Circular building design	Building reuse	✓	✓	-
	Adaptive and resilience strategies	✓	✓	✓
	Materials	✓/✗	✗	✓
	Maintenance	✗	✗	✗
8. Materials	Closed resource management	✓	✓	✗
	Resource efficiency	✗	✗	✗
	Reduce environmental impact	✗	✗	✓
9. Closed waste systems	Industrial ecology	✗	✗	✓
	Waste infrastructure	✓	?	✓
	R-strategies	?	✓/✗	✓/✗
	Environmental management system	✗	✗	✗
	Design out waste	✗	✗	✗
10. Social aspects	Culture & heritage (local context/identity)	✓/✗	✓	n/a
	Educate	✓	✗	✗
	Social cohesion	✓	✓	✓
	Safety	✗	✗	✗
	Health	✗	✗	✓
	Well-being	✗	✗	✓
	Shared strategies	✓	✓	✓
	Engage community	n/a	✓	n/a
	Landscape quality and atmosphere (liveability)	✓	✓	✓
	Social equity	✗	✗	✓
11. Economy	Local products, food and materials	✓	✗	✗
	Economic growth	✗	✗	✗

APPENDIX F – COMPREHENSIVE OVERVIEW OF CASE STUDY ANALYSIS AND FINDINGS

A comprehensive summary of the case study analysis and main findings is provided in this Appendix. Of each case, the identified barriers and accelerators, and processes of the cases are described. The themes found in the systematic literature review are used as guides for the analysis.

In all case studies, it was observed that interview participants were familiar with CE principles; however, their understanding often remained limited, as they tended to employ a narrow definition. Frequently, only the reuse of materials, components and buildings is perceived as circular design, neglecting other crucial aspects, including social themes.

BARRIERS, ACCELERATORS, AND PROCESS OF BINCK EILAND

This paragraph will elaborate on the empirical findings of the Binck eiland case study, using the findings from the interview and document analysis. Firstly, the circular design aspects of the project are described. Hereafter, the identified barriers and accelerators and the process of the project are described.

BARRIERS

During the analysis of the empirical results, several topics could be identified as a barrier to the implementation of circularity strategies. Stakeholders perceived these things as holding back the implementation of circular strategies. These are explained in the following paragraphs.

MUNICIPALITY

One of the most mentioned themes is the barrier between the municipal management public space of The Hague and other involved stakeholders.

The municipal management is perceived as very conservative by the interviewees. Innovative ideas are almost always disapproved, except if they are listed in the public space manual of the area (Dutch: handboek openbare ruimte, HOR), but even that is no guarantee. There are several examples of interventions, such as the reuse of materials or green structures, that were rejected and, therefore, did not make it into the designs, even for projects within the municipality. For example, swales, for water retention and drainage, were disapproved several times in this project, but also within municipal projects (Interviewee 2, personal communication, 10 July 2023; Interviewee 7, personal communication, 26 July 2023; Interviewee 9, personal communication, 28 July 2023). Whilst these are included in the HOR Binckhorst, meaning that the municipality has the ambition to include swales in this neighbourhood (Ingenieursbureau Den Haag, 2019).

Furthermore, interventions such as the reuse of granite boulders or concrete slabs were disapproved by the municipality and the reason why is often unclear for the interviewees. This became clear during the interviews in which statements such as the following were not uncommon; "*Interviewer: But why is that not allowed by management? They just don't want it? Interviewee: They just don't want it. That's often what we have discussions about, and they say, 'No, we just want new things.'*" (Interviewee 7, personal communication, 26 July 2023)

During the process the municipal management department considers how materials and public spaces work in practice. This often causes the municipality to be more cautious of new or reused materials. It is not certain how these materials will work, how long they will last and how soon they must be replaced. After the project finish, the municipality will become owner and responsible for the public space. Matters such as the following play a major part in the decision-making process; "*Also, the advantages and disadvantages of, for example, a Stelcon slab with a steel wall. When you reuse it, if the steel wall is slightly off, people can trip over it or a tire can get damaged. Those kinds of discussions arise.*" (Interviewee 11, personal communication, 2 August 2023). This is also why the project leader from the municipality states; "*So, I can imagine that the idea was suggested, but the managers may not have been keen on it because they would be taking over potentially damaged materials.*" (Interviewee 9, personal communication, 28 July 2023). It potentially explains the reluctant attitude of the municipality.

Another reason could be their involvement during the process. Interviewee 7 identified the following: "*They are often not even involved in the initial phase. Often, you're only dealing with policymakers and aldermen. Well, they want all sorts of things.*" (personal communication, 26 July 2023). Meaning that they are not there when these ideas arise and are discussed. Interviewee 11 notices; "*the problem arises that by the time it is discussed with the municipal manager one more time, for example in the preliminary and final design phase, that manager already has the power and can say, 'no, we're not going to do that.'*"(personal communication, 2 August 2023).

Circular materials that are recorded in the HOR Binckhorst, such as circular wooden benches, are applied in the projects (Ingenieursbureau Den Haag, 2019; Interviewee 9, personal communication, 28 July 2023). However, the amount of reused materials in the public space is therefore limited.

The participants do notice a different attitude in other municipalities, but also mention that the problems are the same, just not as defining as in projects in The Hague. Indicating this is a general problem in more projects. Interviewee 7 states; "*But I have been in consultation there twice, where municipal administrators were also present, from the policymakers. They also indicated that it is quite difficult internally to achieve things. But they have more extensive and bigger ambitions.*" (personal communication, 26 July 2023). Interviewee 11 states; "*Because the municipality, like Rotterdam, is doing these kinds of developments daily, and it all works. The municipality of The Hague, however, finds it a bit more challenging.*" (personal communication, 2 August 2023).

All together, the municipality is one of the most influential stakeholders in the process. They have great influence on the final design, the use of circular interventions and the reuse of materials. Interviewee 7 states: "*The municipality of The Hague could approach it differently. They are still influential parties that can significantly impact the design and process.*" (personal communication, 26 July 2023)

Table F.1: Additional research findings clash municipality and other stakeholders.

Interviewee 2 – Developer	Interviewee 9 - Municipality	Interviewee 7 – Civil engineer	Interviewee 11 – landscape designer
"We always had higher goals than the municipality. That is challenging because the municipality has to be convinced of why we made certain choices. Why those are possible and how it is going to happen." "Municipality is often thinking about how they are going to manage it? can they manage it? Are they familiar with the technology?" "Practice has some kind of 'knowledge and technological advantage'. The municipality does not know the technique yet, and also do not know if they can work with it in the future. Then you have to convince them of the ideas." "So we can come up with things together that are very good within Binck Zuid. But they also have to be feasible and accepted as a good solution by a contractor and by the municipality."	"I can imagine that the municipal management indeed works according to certain manuals and guidelines. But, of course, they often have their reasons for doing so." "The advisory committee tend to have more fixed or perhaps more traditional views." "We also experience it on several projects, including our own projects; when we are designing public space. During the design phase we are sometimes blocked by the 'advice committee for public space' (ACOR) from implementing certain measures because they don't align with a particular policy they follow. Swales are an example of this." "They could provide advice for an alternative, for what could work. But they often don't do that; it's sometimes more about rejecting than advising. (...) If I were to want and be able to change something in the municipality, it would probably be that advisory committee. I'd like to make it more innovative." The municipality's public space manual dictates how the public space should look. It also specifies what materials to use.	"Circularity and sustainability, those are certain ideas and agreements that may not be known to the management, or they just don't want to deviate from their standard. That's why quite a few things didn't work out. And that's just a shame." "They cannot explain that, and they stick to their position and are not open to other ideas." "They just don't want it. That's often what we have discussions about, and they just say, 'No, we just want new things." When you want to use new materials, that are not in the handbook, you need to get permission. "The larger the municipality, the more difficult it becomes, especially if the municipality is not very ambitious." "The policymakers do want it, and the aldermen definitely want it too. But those at lower levels don't want it. Or they say, 'Yes, as long as it's not in our area, let our streets remain the traditional streets, but we won't go along with it.'"	"But we also notice that the municipality struggled with sustainability. Municipalities like Rotterdam, they do these kinds of developments daily, and it all works out. The municipality of The Hague still finds it a bit challenging." "But I do find The Hague to be quite traditional in that sense." "But it gave me the feeling that they prefer traditional zoning plans and just drawing up plots. You know what I mean?" "The municipality has played a somewhat negative role in sustainability in this process. (...) when you ask for more details, you don't really get an answer. Even if you point out that there are neighbourhoods where they have used grass concrete. If you mention that, they say, 'Yes, that's true, but that's a different department.'" "I have the impression that The Hague is quite a conservative municipality in this regard."

TECHNICAL BARRIERS

The project included several technical barriers that made it more difficult to implement circular principles. Among others the technical limitations that come along with the reuse of old buildings and contaminated soil.

The contaminated soil especially plays an crucial and limiting role in the implementation of circular water or soil systems. The municipality is less likely to allow swales in areas that were previously contaminated: "*The soil there is very contaminated. So, swales (swales) can't easily be implemented in the Binckhorst. It's possible, but then you'd have to remediate the soil. That can be expensive, so it's often not chosen.*" (Interviewee 9, personal communication, 28 July 2023).

Furthermore, the technical characteristics of the reused building made it impossible to create an energy neutral building. There were two reasons for this: "*Because you can't adjust the insulation value of the facade, which really wasn't possible in this case, and we couldn't use a WKO source for the entire project at that time. It was simply not technically feasible.*" (Interviewee 2, personal communication, 10 July 2023). Eventually this resulted in a less energy efficient building for the renovation, when compared to the new constructions, which are all energy neutral and gas-free.

TIME

The development encompassed a very long process of about 7 years, from 2016 till 2022. During the interview with the developer of this project this was one of the main pointers about the goals and design phases. Figure F.1 illustrates the drawing made by the developer to explain this process. The main take away from this drawing is that the designs, ambitions and goals had to be set at the very beginning in 2016 while sub-projects were only delivered at the end of 2022 or later. In this regard, interviewee 2 said the following: "*That makes it sometimes difficult because you're setting goals here [pointing at 2016] for something that might only be implemented five years later, and that's when the discussions really come to the forefront. Can it actually be done at that point?*" (personal communication, 10 July 2023).

To create results that fit the values in 7 years time interviewee 2 stated: "*We had to look ahead in time a lot to make this happen.*" (personal communication, 10 July 2023). Interviewee 9 also states the importance of looking forward in time: "*You have to think about how the world will look in 2022.*" (personal communication, 28 July 2023). Nonetheless, the transformation project was still connected to gas, which is no longer in alignment with the current trend of disconnecting projects from gas sources.

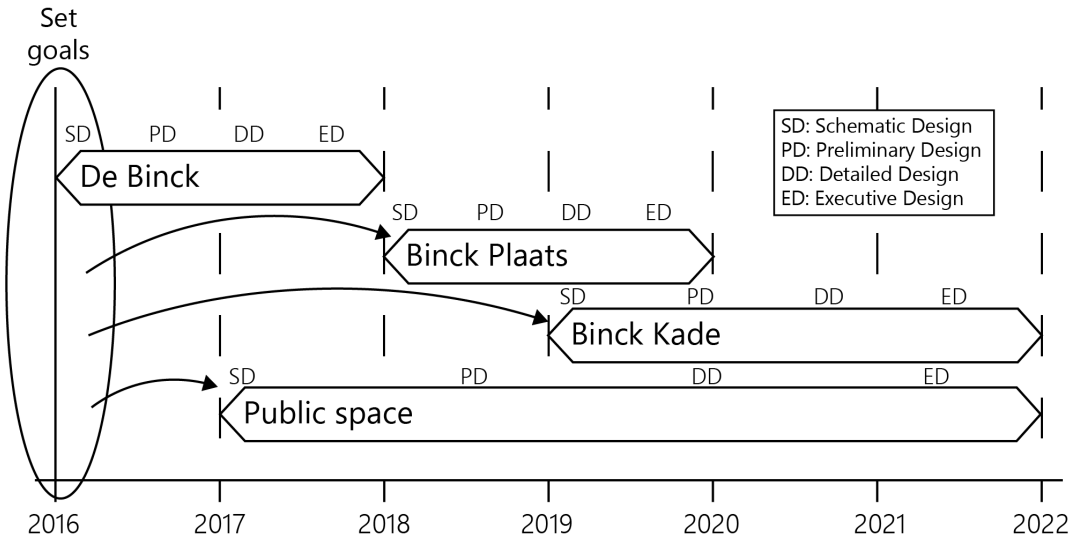
Interviewee 2 also explains that it is very difficult to predict what is possible in the future: "*The difficulty lies in the fact that you don't know exactly what the technology can do beforehand, what the contractor can do precisely. So, you have to keep looking ahead for a long time: what are the solutions you can choose?*" (personal communication, 10 July 2023).

COMMUNICATION

Interviewee 11 points out that during the transition between the preliminary and definite design, he was "*Somewhat less involved*" (personal communication, 17 July 2023). This is the moment at which the civil engineering company refined the preliminary design into a definite design.

Additionally, interviewee 2 points out that due to the long duration of area development projects, people in the process change or disappear. Furthermore, new people can be included later in the process, these: "*no longer know exactly what (ambitions) was agreed upon.*" (Interviewee 2, personal communication, 10 July 2023).

Figure F.1: Timeline development vs. Goals. Drawn by Interviewee 2.



PEOPLE

Furthermore, an often-mentioned barrier are the people that are involved during the processes. Dependence of other parties is big in area development projects. Therefore, the team and parties that are involved influence the outcome heavily.

During the process this became visible in the discussions about the disassembly of the hall, instead of just demolishing it. "*So, regarding Binck Zuid, I would say that the idea of removing that hall and using it in a circular way took quite a bit of time and effort to achieve. Especially due to the other developers, they just didn't understand it, and they thought it was expensive. So, we had to explain that it's actually cheaper than demolishing. And then they said, 'But that's not possible.'*" (Interviewee 2, personal communication, 10 July 2023). What makes this more difficult is that circular measures are often hard to measure, therefore, it is often hard to convince people of its worth. Interviewee 2 says the following about this: "*It is very difficult to prove what circularity yields financially. We know it is a great story and that it works.*" (personal communication, 10 July 2023).

Furthermore, the whole island is developed by multiple developments, each executed by different developers. Meaning one developer cannot make all decisions for the whole island: "*But with the new construction, it's much more challenging. We had less influence on that. We asked the other developers in advance (they did those sub-projects) to consider that in their choices. I wasn't there to make all those considerations.*" (Interviewee 2, personal communication, 10 July 2023).

What makes this even harder, is that circular practices are not standard to implement yet: "*We need to get more accustomed to it, I believe. I think in the past, a lot of work was done purely based on aesthetics.*" (Interviewee 11, personal communication, 2 August 2023). It is both for companies and the future residents a change in standard practices and lifestyle. Interviewee 2 says about this: "*Our industry is not yet set up for that to happen.*" and "*What makes it difficult is that there is a culture, and it is important to understand what culture means: a system of customs and habits for working, that needs to be changed and that takes a very long time.*" (personal communication, 10 July 2023). Here the problem remains that a change in the industry is easier to achieve than a change in the behaviour of future residents.

A last barrier that arises in the process due to collaboration with people is the time it takes to convince people to achieve more sustainable practices. Interviewee 2: "*It requires much more context and much more involvement from all parties to be able to make those choices. That takes a lot of time.*" (personal communication, 10 July 2023). But if everyone in the process wants to understand, and tries its best to achieve sustainable and circular projects this influences the projects positively. Interviewee 2: "*It is also a lot of fun. Look, if everyone understands it, then everyone goes along with it, but it takes time to convince everyone.*" (personal communication, 10 July 2023).

This analysis about the difficulties that people can bring to the process emphasises the importance of strategic partnerships for circular projects. The outcome is very much influenced by the willingness of people to understand and implement circular practices.

Table F.2: Additional research findings people in the process

Interviewee 2 – Developer	Interviewee 11 – landscape designer
"It requires much more context and much more involvement from all parties to be able to make those choices. That takes a lot of time."	"We need to get more accustomed to it, I believe. I think in the past, a lot of work was done purely based on aesthetics."
"What makes it difficult is that there is a culture, and it is important to understand wat culture means: a system of customs and habits for working, that needs to be changed and that takes a very long time."	
"It is very difficult to prove what circularity yields financially. We know it is a great story and that it works."	
"It is also a lot of fun. Look, if everyone understands it, then everyone goes along with it, but it takes time to convince everyone."	

ACCELERATORS

Several themes can be identified in the empirical results, that can act as accelerators for circular interventions. These are explained below.

CIRCULAR INITIATION

Circular initiation of in the process or project is of vital importance. If sustainability is an important factor from the beginning, the chance it will be implemented in its full potential is bigger. This is very much visible in the approach of Binck eiland, where the developer started the process by thinking about how the area can be transformed in the most circular and sustainable way possible. Interviewee 11 confirms this by stating the following; "*If the municipality had said, 'look at what's available and work with that', it would have integrated much more easily into what you're doing, right?*" (personal communication, 2 August 2023).

Table F.3: Additional research findings circular initiation project.

Interviewee 2 – Developer	Interviewee 11 – landscape designer
"The plans started by thinking about how the whole island and buildings on it could be used as sustainable as possible." "We started making plans, and then we immediately thought: well, how can we transform the building in a circular way?" "In the whole project as much as possible circular choices were made, this was included in the request."	"I think that most of it actually came about gradually in the process." "If the municipality had said, 'look at what's available and work with that', it would have integrated much more easily into what you're doing, right? Otherwise, maybe circularity becomes a bit of a side road. You tend to forget it because you're busy with your work, and it becomes an extra thing to deal with." "I see very few projects that prioritize circularity in their requests, so to speak."

STRATEGIC PARTNERSHIPS

Similar to how 'people' and their standard practices and lifestyle can negatively influence the process, working together with the right stakeholders can also positively influence the process. Collaborating with individuals who share the same mindset ensures a smoother process: "*if you all express ambitions together in the beginning and work together on them, because sometimes you have a team that works a bit in isolation. Well, I don't think that's the case with us. The team was just really good, so yeah, that works.*" (Interviewee 11, personal communication, 2 August 2023).

In order to create that same mindset it is important to state common goals, according to interviewee 2 this was challenging: "*The most challenging part is to agree on our common goals together. This takes a lot of explaining and time*" (personal communication, 10 July 2023).

According to the developer in this case, the intrinsic motivation in the organisation or of the collaborating stakeholders is the most important: "*If you ask someone else who has no interest or authority, it won't happen. So, at the beginning, you need to have clear goals and a shared desire to achieve them, along with making agreements about them.*" (Interviewee 2, personal communication, 10 July 2023).

Table F.4: Additional research findings strategic partnerships.

Interviewee 2 – Developer	Interviewee 7 – Civil engineer	Interviewee 11 – landscape designer
"The most challenging part is to agree on our common goals together. This takes a lot of explaining and time." "That's what the contractors do in this case, they can make a good assessment. But they did involve us in considerations like: I can get this here now, can I use it? We would ask: how far does it come from then? It came from Rijswijk, relatively short distances, which is still fine." *about the partnership with the contractor* "Yes, and they can do it very well because they do it a lot, and we're still doing it."	"What went very well? I think everyone has held on to their ideas about what they thought about circularity in area development, or sustainability issues. And that there is also room for it to a certain extent, and that you also advocate for it."	"I believe one thing we may not have mentioned yet is also the team you're in, right? So, the project developer, engineer, architect. That also means a lot. So, if you all express ambitions together in the beginning and work together on them, because sometimes you have a team that works a bit in isolation. Well, I don't think that's the case with us. The team was just really good, so yeah, that works."

PARTICIPATION

The shared rooftop garden adds a social element to the project. The relatively thin soil layer of the rooftop garden acts also as a limiting factor to residents. Therefore, an important factor in this project is the participation of future residents in the design phase of their private and adjacent shared garden. Participation was organised through landscaping advice: "*All the people who have a garden have received landscaping advice. They all had the opportunity to sit down with a landscape architect and receive advice on how to design their garden. This is because the soil layer is relatively thin, and the situation is unique.*" (Interviewee 2, personal communication, 10 July 2023).

The ultimate goal is to normalize that the garden is a communal part of the project, and that the residents around it use and manage it collectively. "*Yes, people must also want to do this together. As more and more people start doing it, it becomes more common, and organizing it becomes easier.*" (Interviewee 2, personal communication, 10 July 2023). During this process, the involvement and communication with residents played a crucial role in ensuring that the communal garden functioned as intended.

"*So far, I have received a lot of positive feedback. I also noticed that initiatives have come from the residents themselves. (...) They are enthusiastic about it themselves. You can tell that if a project is well-designed and you create a nice community, such initiatives naturally emerge.*" (Interviewee 11, personal communication, 2 August 2023).

DECISION-SUPPORT TOOLS

During this process decision-support tools were not used as a means to achieve circularity in the project. However, during the interviews they were discussed. Interviewee 2 states that decision-support tools such as Green certificates "*are helpful in achieving circularity*". However, "*fundamentally, you have to want it yourself*". They also notice that if you don't implement it fundamentally in your projects, "*it won't happen either*" (personal communication, 10 July 2023).

TECHNOLOGY

Technology is also not implemented in this project. However, again the topic was brought up due to another project of interviewee 2. In another project interviewee 2 was using parametric design to determine in the initiation phase what is needed to achieve circularity in the operational phase. "*Yes, the strategy we use for that is to put all the options side by side to see which ones have the most impact.*" (Interviewee 2, personal communication, 10 July 2023).

PROCESS

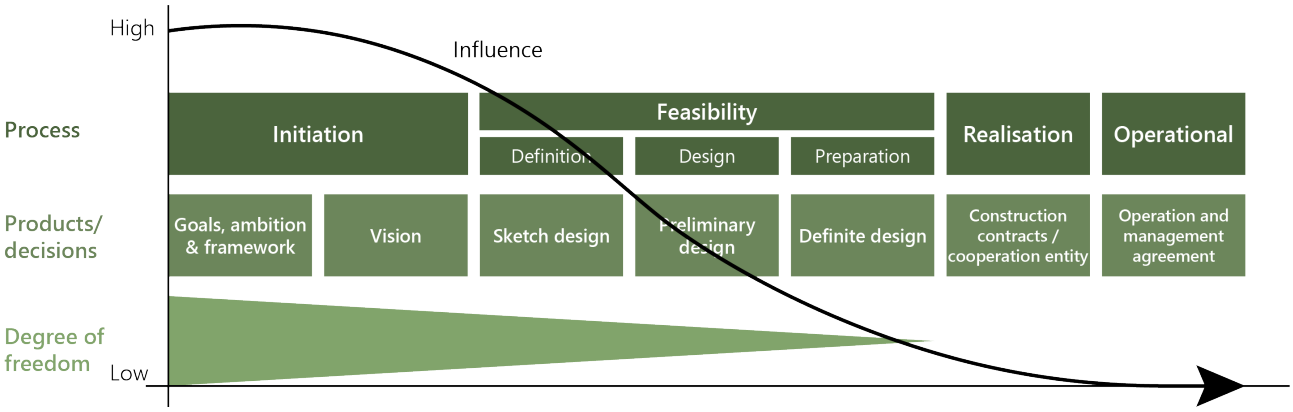
During the interviews questions were asked to identify critical points for circularity measures during the process. An analysis about these questions and participants answers are provided in the following sections. In general, it became clear that discussions about innovative interventions that are paired with circularity strategies often take a long period of time.

There are examples of simple interventions that were discussed for half a year before a final decision was made. "*I mentioned the example of the cobblestones on the street. We really debated about that for six months.*" (Interviewee 2, personal communication, 10 July 2023, p. 2). Some decisions were really made at the last minute: "*Very last-minute, yes, they were busy calculating, while they were already working outside on preparing the site, installing the sewer, and so on. And only then did they decide to break the floor.*" (Interviewee 7, personal communication, 26 July 2023). Indicating that a lot of things are still possible at the very last minute, if everyone is willing to work for it.

INFLUENCE

An overarching theme that was mentioned by interviewee 2 was the influence during the process. Figure F.2 represents a drawing made by interviewee 2 during the conversation. The black line represents the amount of influence during the development process, this is different to the degree of freedom. The degree of freedom is more about the design freedom, while influence is about the influence on the process.

Figure F.2: Influence during the process. Drawn by Interviewee 2.



According to interviewee 2 the idea is that: "*if you have a lot of influence, and you make the right choices and set the right goals, then you can have the most impact at the end of the day.*" (personal communication, 10 July 2023). Interviewee 2 stated that the influence chart might even be more important than the design freedom during the process: "*Because you don't need a lot of freedom when your influence is significant*" (personal communication, 10 July 2023).

INITIATION PHASE

Before the current developers were involved in the process surrounding this project, an area vision was already made by another company. This ambition just mentions that there are several opportunities to make a climate-neutral area (Mannen van schuim, 2016). Interviewee 11 says the following about these ambitions in the process: "*(...) there were also sustainability ambitions. However, especially those sustainability ambitions were very low. There was something about water and something about green, and that was about it. So, we were very much dependent on our own initiatives. Which, of course, makes it interesting.*" (personal communication, 2 August 2023).

Thus, when the project really started in 2016, sustainability and circularity ambitions were not yet established. This means there was a lot of room for interpretation. Interviewee 2 also stated that "*At the beginning, when the influence is greatest, you have to make the right choices. This is where we had all the discussions.*" (personal communication, 10 July 2023). Thus, the circularity ambitions were set here: "*What are our sustainability ambitions? How are we going to do it? What strategy are we going to use to make it circular? And circularity is one thing, sustainability is one thing, but for example, nature inclusivity and green spaces were also topics. You have to start at the beginning because if you don't pursue the same goals, you'll just run into problems there.*" (Interviewee 2, personal communication, 10 July 2023).

Interviewee 11 emphasises the need for ambitions and goals in the early phases of the project. He further elaborates that thinking about the consequences of these ambitions and goals is also necessary: "*Because, I notice in many projects that stating an ambition is very easy, but realizing it is difficult.*" (personal communication, 2 August 2023). This extra step is necessary for successful implementation of circularity measures, as: "*Often in the final phase, things become a bit more expensive, and then it's simply excluded.*" (Interviewee 11, personal communication, 2 August 2023).

Thus, a quantitative or practical translation of the qualitative ambitions and goals is essential in the initiation phases of projects. "*So, in the initiation phase, you already have to say: 'what is our ambition? Are we in agreement, yes or no? And if we agree, what are the implications of this? So, are we going to capture a certain amount per square meter on the roof, and are we moving towards reusing materials, how are we going to approach this with a municipality?*" (Interviewee 11, personal communication, 2 August 2023).

Nonetheless, interviewee 11 mentions that in this process more emphasis could have been given to these ambitions in the initiation phase: "*I think that during the initiation phase, we could have paid more attention to circularity. Indeed, express and translate the ambitions.*" (personal communication, 2 August 2023)

FEASIBILITY PHASE

The feasibility phase is the most important phase, as ambitions and goals are translated into designs in this phase. This is the phase were the important discussions about the practicality of the designs take place. Interviewee 11 indicates that during the schematic design materials and designs are discussed, but the plans should already be documented in this phase: "*Because the longer you wait, the easier it is to push it aside and the easier it just disappears*" (personal communication, 2 August 2023).

In line with this, interviewee 11 indicates that the power of municipal managers should be limited by the actions of the team during the process: "*But at the moment we, at the beginning of the process, together with urban planners, landscape architects, project developers, project managers of the municipality, say, 'these are the ambitions. That means this, this, this, this, and this', and we elaborate on them throughout the project. So, at a very early stage, you also involve the managers to discuss this first because perhaps not everything is possible, but a part is. Then the chance of success is much greater.*" (personal communication, 2 August 2023). Innovative ideas have a greater survival chance as support from both the project leader and municipal manager is increased.

Interviewee 11 says about the project leader from the municipality the following: "*He also has the power, of course, to say, 'yes, but dear manager, we established this at the beginning. We presented it to committees, and whatever else. So, we're just going to do it, period, and you'll have to figure it out.*'" (personal communication, 2 August 2023). This suggest that he could play a more crucial role in decision-making.

Nonetheless, the municipality still has to cooperate to include the municipal manager earlier in the process. Interviewee 7 says about including certain people earlier in the process the following: "*Yes, but when we try that, they don't want to. Because it's still too early. You hear that occasionally: 'yeah, no, I don't have the hours for it,' or 'the project is still unknown,' and whatever else.*" (personal communication, 26 July 2023).

The reverse is also possible; decisions can be made quite late in the process, sometimes even at the final moment. For example, the idea to implement swales in the designs was continuously considered, however as the municipality did not approve, it was excluded from

the designs only in the preliminary design (Interviewee 7, personal communication, 26 July 2023). At this stage, quite late in the process, the team had to come up with another idea to create a circular water system. Similarly, the way in which the old floor of the factory hall was reused was decided upon at the very last minute: "*The idea to completely reuse the floor was, of course, present from the initiation phase, but it was only decided during the execution phase that we couldn't reuse it.*" (Interviewee 7, personal communication, 26 July 2023). On the terrain, preparations for construction and laying down the sewage system was already started.

Thus, final decisions are often made either in the preliminary design or definite design. About this interviewee 7 says: "*Regarding certain aspects, decisions need to be made during the preliminary design, such as sewage systems and anything underground. However, details related to above-ground elements, like the final choice of materials, are typically addressed during the definite Design phase.*" (personal communication, 26 July 2023).

BARRIERS, ACCELERATORS, AND PROCESS OF TUINEN VAN GENTA

This paragraph provides the analysis of the empirical findings of the 'Tuinen van Genta' case study, using the findings from the interview and document analysis. The identified barriers and accelerators and the process of the project are described.

BARRIERS

Several barriers can be identified in the process, based on the analysis of the empirical research. These barriers are things or events that are perceived as hindering the implementation of innovative circularity strategies.

MUNICIPALITY

Resistance within the municipality for innovative interventions is also present in this development. For example, the soil protection layer caused some conservative thoughts within the municipality (Interviewee 5, personal communication, 17 July 2023). The practical functioning of the protection layer raises questions, particularly concerning the longevity of knowledge about the pollution, as people in municipalities and local residents change.

Interviewee 8 mentioned discussions about implementing a rainwater sewage system so that the water can flow to the swale; however he thought it would be way more efficient if curbs were lowered. "*But according to the maintenance team, that wasn't possible because they were afraid the grass strips would get damaged by all the delivery vans temporarily parking there. In terms of appearance, it has to be the same everywhere, so uniform curbing and such have to be used everywhere.*" (personal communication, 26 July 2023).

Sometimes these are issues that have to do with the timing of the project: "*And you know what's interesting? We had submitted the Definite Design, and then the municipality suggested, 'Can't we let the rainwater from the houses flow superficially, through the parking lots, into the wadi?'*" (Interviewee 8, personal communication, 26 July 2023).

Furthermore, the municipality project manager indicated that there are numerous elements to incorporate into the plans, yet space for interventions is often limited. For example: "*we have that green compass that demands a certain percentage of green. (...) some political parties have stated that we shouldn't reduce the number of parking spaces. Yet, I still need to achieve a certain percentage of green. Plus, we want to retain as much water as possible. But we have limited space.*" (Interviewee 5, personal communication, 17 July 2023). Therefore, it is sometimes difficult to make an integral choice, because each department wants their own theme to be implemented.

Table F.5: Additional research findings municipal barriers.

Interviewee 1 – Developer	Interviewee 5 – Municipality	Interviewee 8 – Civil engineer
Interviewee 1 about the role of the municipality in different projects: "That project was approached differently. The municipality of Utrecht was already much more focused on circularity at that time than the municipality of Breda."	"I still notice some challenges within the municipality; some people do have resistance to that cap layer." "I find that discussion sometimes challenging because as a municipality, you naturally want some uniformity in the entire public space and you want to stand firm on your requirements because we will, of course, have to maintain it afterward. (…) So sometimes we may be a bit conservative in our requirements or not think as flexibly in that regard" "We do assess, I think, to a greater extent. So we verify better than the administrators themselves, right? They get so many plans to review, they just scan it more"	Interviewee 8 about wadi and water discussion (water flows through rainwater sewage system to wadi): We often have discussions with the municipality and the municipal maintenance team about the practicalities of interventions. "(…) we've had quite good contacts with the administrators from the beginning. That also makes a difference in the feasibility of the phases and the duration of the project." "It depends on where, I think, and which municipality. I notice and see that smaller municipalities dare more than larger ones. (…) That certain things are easier to arrange there, as opposed to the larger municipalities. The connections are shorter." "Although within this project, I do think that the project leader was superb. She ensures that there are connections within the different departments. She dares to fight for certain things to achieve the project's interests, instead of adhering strictly to the demands of the maintainers."

TECHNICAL BARRIERS

The project is characterised by heavily contaminated soil and groundwater on the site (Interviewee 1, personal communication, 7 July 2023; Interviewee 8, personal communication, 26 July 2023). Mineral oil, asbestos, heavy metal and PAK and VOCL contamination had been found on the location (ATKB, 2021). The mineral oil and asbestos contamination is remediated. The contamination with heavy metals and PAK is contained with the new construction or the protective layer, according to the advise of ATKB (2021). It is established that the VOCL contamination does not form a hazard for the new residents, as long as the groundwater is not extracted from the area (Interviewee 8, personal communication, 26 July 2023).

Mainly the heavy metal and PAK contamination provided a technical barrier in the developments. During the design phases, it was always assumed that the whole area was heavily contaminated (Interviewee 8, personal communication, 26 July 2023). Meaning that the protective layer was needed for the whole area. However, when the additional soil investigations were conducted during the preliminary or definite design stages, it became clear that this was not necessary. Conducting these investigations earlier could have resulted in a better alignment with existing buildings. "*We assumed that all the soils there couldn't be removed. While in hindsight, that might not have been the case. Which could have allowed for some remediation and possibly a lower groundlevel.*" (Interviewee 8, personal communication, 26 July 2023)

TIME

When evaluating the projects now, interview participants concluded that some things could have been done better. For example, the plan is still characterised by quite a lot of pavement and the green spaces in the project could have included more water retention, or biodiversity. However, due to the length of the project, some of these things were not included.

Interviewee 5 says about this: "*We are now in 2023, while urban planning was formulated between 2016-2019. Over the past years, we've made significant progress.*" and "*certain aspects were not addressed, and at times, time catches up with you.*" (personal communication, 17 July 2023).

COMMUNICATION

During the process the responsibilities of people in the process change, which also influence the end result. Normally, in the very first phase, when the vision, ambitions and goals are established, everyone works integrally together on the project. Hereafter, everyone goes their separate way to work on their discipline of the project (Interviewee 4, personal communication, 17 July 2023). This is when miscommunication can arise or reduced involvement can occur. Interviewee 4 especially noticed a gap during the preliminary design and the elaboration of the definite design. But this "*(…) varies greatly depending on the project and who I am working with.*" (personal communication, 17 July 2023). During the definite design phase interviewee 4: "*(…) did see the drawings at various points. However, it was a long period during which they were focused on the pavement, making it harder to keep track.*" (personal communication, 17 July 2023).

Furthermore, interviewee 4 indicates the following: "*things can be forgotten simply because you don't automatically interact with each other anymore*" (personal communication, 17 July 2023). Indicating that it is crucial to stay alert on this in the design phases after the project initiation.

Furthermore, interviewee 5 noticed that discussions about the reuse of available materials on the location were often held too late, and not transparent enough. "*While if you had initiated the discussion earlier, you might have had a viable material.*" (Interviewee 5, personal communication, 17 July 2023). There was lack of trust about this topic, interviewee 5 states: "*just be honest and say, 'well, this is the situation. Are there possibilities to reuse this or can we upgrade it?*" (personal communication, 17 July 2023).

Conversations about this reuse of existing concrete as foundations for roads or reuse of sand on the location should be held earlier and more transparent in the process. "*So at least before you start moving the ground, have a discussion about it, before you start demolishing the buildings.*" (Interviewee 5, personal communication, 17 July 2023)

Table F.6: Additional research findings communication barriers.

Interviewee 4 – Landscape designer	Interviewee 5 – Municipality	Interviewee 8 – Civil engineer
"It varies greatly depending on the project and who I am working with. There were personnel changes at the time, which also meant that I was less automatically involved." "In the meantime, I did see the drawings, but it was a long period during which they were working on the pavements. This also made it more challenging to keep track." "That's how it sometimes goes; everyone is doing their own thing. In the initial phase, you are still very much integrated, working on architecture, urban planning, and landscape together. However, at some point, you start going your own way to some extent. You do come together again when you think it's necessary. But things can be forgotten simply because you don't automatically interact with each other anymore"	"While if you had initiated the discussion earlier, you might have had a viable material." "While I think that if you can just have this conversation earlier, more openly with each other, like 'can we potentially upgrade this, so that it does meet the requirements." "Then I think, 'what perspective are we approaching this with?' Do we want to come to a resolution together or not?" "Yeah, just being honest and saying, 'well, this is the situation. Are there possibilities to reuse this or can we upgrade it?" "Then I think, 'you should think about this long before you start making those contracts.'"	About concrete granulate and mixed granulate: "I don't know what, but that was more or less the idea of 'oh, we'll figure it out.' Yeah, we actually didn't. Unfortunately." "Yeah, earlier and more open with each other, and having the courage to discuss this with one another."

PEOPLE

Dependence on other involved parties is great, this shows in the fact that the construction methods of the buildings in this projects are based on the preferences of the constructor. The constructor made the choice for prefabricated concrete structures (Interviewee 1, personal communication, 7 July 2023). That made the reuse of materials more difficult: "*That wasn't possible because our builder wanted to use a prefab concrete construction system*" (Interviewee 1, personal communication, 7 July 2023). Quite traditional, material-inefficient construction techniques were used by the builder. "*This is indeed a lot of concrete and entirely brick on the outside*" (Interviewee 5, personal communication, 17 July 2023). This shows the importance of collaboration with companies that want and try to implement sustainable techniques as well.

Moreover, the interview participants noticed a clear distinction between those who have been involved since the beginning of the designs and the approach of those who haven't. Interviewee 4 noticed a change in approach when the designs were developed into a definite design: "*(...) there were also personnel changes at that time. That has made me somewhat less automatically involved.*" (personal communication, 17 July 2023). Interviewee 4 also states that new people: "*(...) are not aware then that certain things are the way they are for a reason.*" (personal communication, 17 July 2023)

ACCELERATORS

Several of the accelerator themes could be identified in this project or other projects that were discussed. The following paragraphs give a small explanation about the events that occurred that acted as accelerators for circularity interventions.

CIRCULAR INITIATION

An important observation that can be made is that stating ambitions and agreeing upon those is one of the most important actions in the initiation phase. "*The sharper you formulate and establish the goals together in the beginning, the better it is.*" (Interviewee 1, personal communication, 7 July 2023). Interviewee 4 confirms this, as they established: "*ideas and ambitions in a very sketchy manner, but in the end, we really stuck to them. Then you spend months further designing and investigating in detail.*" (personal communication, 17 July 2023).

STRATEGIC PARTNERSHIPS

When asked about the process and if certain ambitions are less possible then hoped, interviewee 1 states that is important to: "*stick to what you want and you have to be firm about it.*" (personal communication, 7 July 2023). This means also that you have to work with companies and individuals that are willing to work for the goals and ambitions. Interviewee 1 states that at the moment that ambitions are at risk of lapsing: "*it's important that you can address each other on the principles and ambitions, and then collectively seek out how it can work. You need to keep challenging and addressing each other in that regard.*" (personal communication, 7 July 2023).

PARTICIPATION

Participation of current and future residents was important during the process. Especially the participation of local residents had positive influence on the process. The site knows a rich history of failed plans, therefore, the local residents might have been sceptical and worried about the development plans. Several evenings and participation activities were organised, to explain and present their ideas, designs and ambitions. Local residents were free to give their opinion and critiques. The principle was that the developer is a guest in the neighbourhood, furthermore, the advisory group, consisting of local residents, may give advice, both when 'requested and not requested' (De Wijde Blik, 2016). Interviewee 8 said about this: "*what he did very well in the beginning was continuously involve the residents.*" (personal communication, 26 July 2023). This might be the reason that during the land use plan procedure little to no questions or objections were made.

Furthermore, the participation of future residents were important during the development plans of the communal garden. "*The residents should also start feeling responsible for 'their' garden. If the residents of the 75 houses say later on 'yes, I actually don't want that garden', then nothing will come of it.*" (Interviewee 1, personal communication, 7 July 2023). A garden committee has been established, who really are involved in the designs. Interviewee 4 about the participation process: "*You hear that these people really get very happy with such a garden; that's why they bought that house, really.*" (personal communication, 17 July 2023)

DECISION-SUPPORT TOOLS

The Tuinen van Genta did not adopt a highly circular approach; however, another project that came up in the discussions did. The 'Wisselspoor' area development located in Utrecht was approached with way more circular ambitions. This was mainly attributed to the approach and position of the Municipality of Utrecht: "*a council member proposing to develop an area with a BREEAM Excellent certification.*" (Interviewee 1, personal communication, 7 July 2023). The Wisselspoor project illustrates that decision-support tools such as the BREEAM excellent certification positively influence the outcome of developments.

The municipality eventually agreed to the BREEAM excellent score in the land use plan procedure "*So, in terms of conditions, the municipality has provided more frameworks.*" (Interviewee 1, personal communication, 7 July 2023). This agreement provides leverage for the project, to actually implement innovative ideas. Based on the BREEAM excellent score, analysis were conducted on the influential factors in projects: "*Well, that included circularity, for example, but also heat stress and rainwater infiltration*" (Interviewee 1, personal communication, 7 July 2023).

CIRCULARITY POLICIES

As of 2020, all new development plans could only receive a permit if the buildings are delivered without a gas connection. This became the driving force behind sustainable energy and heating systems for many new projects. Additionally, it led to higher energy efficiency in buildings. This may also have been the drive for this particular project, given the high likelihood of receiving a permit after 2020.

REFERENCE PROJECTS

The approval of this development is, in part, attributed to the reference projects that the development team has demonstrated to the municipality in real life. The development team took members of the municipality on a bicycle tour through Haarlem to demonstrate how elements of the design worked in real life in other projects. "*Then we said, 'we will go for a bike ride around Haarlem' with the policymakers, project leaders from the municipality, and also with the administrators, I think.*" (Interviewee 8, personal communication, 26 July 2023).

The goal was to create support within the municipality and with the municipal managers, so that the plans would be accepted. That worked: "*We showed them how it works. The municipality was enthusiastic about it, (...) how it works, and so on. It was great.*" (Interviewee 8, personal communication, 26 July 2023). The reference projects were the base for the approval of the plans, although there were still some concerns.

PROCESS

During the interviews questions were asked to identify critical points for circularity measures during the process. An analysis about these questions and participants answers are provided in the following sections.

During the interviews it became clear that there are some crucial moments during the design phases, at which certain ideas etc. should already be clear. One of these things is, for example, the use of crushed old concrete. As soon as you acquire a certain location you should think about what you want or are going to do with the available materials on site. "*As soon as you start any work, essentially as soon as you remove soil or sand, you have to start thinking about 'what am I going to do with it?*" (Interviewee 5, personal communication, 17 July 2023).

INITIATION PHASE

Often in the initial phase a structural design is created "*(...) a layout plan with the spatial program upon which land and property development are based, and financial feasibility is assessed.*" (Interviewee 1, personal communication, 7 July 2023). During this stage, circularity ambitions should be clearly defined, considering that inclusion is often determined by budget constraints. This means that some sort of idea has to be formed about all themes during the initiation phase of the development process.

Furthermore, interviewee 1 emphasizes the need to decide upon structuring decisions soon in the process. For example: "*some choices are very structuring in nature. I mean, greenery versus parking. Yes, that's a real choice you have to make in advance.*" or "*also the choice, for example, to keep a historic building or not, that can only be made at the beginning.*" (personal communication, 7 July 2023). For each project these decisions differ, as the reuse of buildings and providing parking facilities under buildings is something that is not possible or desirable for each project.

Within this plan the goals and ambitions were conceived simultaneously to the first designs, this might have resulted in low sustainability or circularity goals. Interviewee 8 states that: "*except for the soil, because that was naturally budget-driven. There were certain thoughts about the layout from the landscape architect, but nothing about sustainability and such, as far as I know.*" (personal communication, 26 July 2023). Themes such as water and environmental networks could have been exploited further, when compared to the standard right now (Interviewee 5, personal communication, 17 July 2023).

FEASIBILITY PHASE

There are certain choices and topics that can be decided upon later on in the process. However, there are not many: "*Regarding the choices we discussed earlier, there aren't many that you can make very late in your plan.*" (Interviewee 1, personal communication, 7 July 2023). The decision that can be made later on in the process also have to be clear in the preliminary or at the latest in the definite design: "*But then you are talking about decisions during a preliminary or definite design, and then it needs to be clear, or else it won't be easily incorporated*" (Interviewee 1, personal communication, 7 July 2023).

Interviewee 1 explained that considering the waste streams, but also the reuse of the concrete on the location can be done later in the process. "*That doesn't have to be done at the beginning. You can also do that later on.*" (personal communication, 7 July 2023).

However, the risk lies in the potential oversight of the topic, which may result in addressing it too late. According to interviewee 5, this might have been the case in this project, as the reuse of existing concrete was discussed with the municipality quite late in the process (personal communication, 17 July 2023). While during the first sketch designs certain heights etc. are already known, therefore this should also be the moment the discussion about the topic is opened. "*So there are already thoughts about it, so have the discussion about it as well*" (Interviewee 5, personal communication, 17 July 2023).

During the first sketch designs certain heights etc. are already known, therefore this should also be the moment the discussion about the topic is opened. "*So there are already thoughts about it, so have the discussion about it as well*" (Interviewee 5, personal communication, 17 July 2023). Interviewee 1 also acknowledged that they could have addressed this topic sooner, but that this is also something that they have learned from: "*Now we are already, in the first stage of the next phase in 'Wisselspoor', working with a party that is mapping the soil streams*" (personal communication, 7 July 2023).

Table F.7: Additional research findings process

Interviewee 1 – Developer	Interviewee 4 – Landscape designer	Interviewee 5 – Municipality	Interviewee 8 – Civil engineer
"If you have found a good plan concept, then you should especially embrace it and stick to it" "Actually, the most important decisions are made right at the beginning of the project. It's crucial to define your plan concept and ambitions clearly during that phase" "You capture the ambitions early on, and the precise elaboration can come later. When you have the ambitions and references clear early on, you can refer back to them throughout the entire design phase"	"These are, of course, the main outlines. Initially, you have ideas and ambitions in a very sketchy manner, but ultimately, we stuck to them. Then you continue to design and investigate in detail for months, so a lot of time goes into that" "That was indeed interesting because you often see many projects where endless reports with requirements and wishes are created first. We didn't do that here. We actually just came up with the main setup together, and in hindsight, I find that a very enjoyable way of working. Usually, you have the municipality writing down goals first." "I do think that overall, this plan has been a very strong concept from the beginning to the end (…) I think it certainly helps. Yes, and I am also pleased. There are always cost-cutting operations, but it has held its ground. It definitely has to do with having a clear idea and collectively understanding what it has been from the start; then you're not just going to give that up easily."	"For me, this was now development two. I thought, 'okay, this groundwork should be discussed earlier by the environmental and engineering departments of the municipality. The conversation just needs to be opened earlier with the developers to ultimately make it better for everyone. We also want to contribute our ideas." "It also seems like, yes, that groundwork is then introduced later, while it is one of the fundamental things, of course." "So yeah, I think the biggest advice is that we should just open up the discussion earlier." "So in any case, before you move any soil, have a discussion about it before demolishing the buildings."	Ambition for energy neutral buildings mainly came from the legislations, that buildings built after 2020, could not be connected with gas. "Nowadays, what you almost always see is that you have a Conceptual Design (SO), urban plan, and then we develop it towards the Preliminary Design (VO). And actually, when the preliminary design is often not even 100% approved, or is about to be approved, the developer often says, okay, we're going to start preparing the site for construction.".

BARRIERS, ACCELERATORS, AND PROCESS OF ERASMUSVELD MIDDEN

This paragraph contains an examination of the practical results from the Erasmusveld midden case study. Findings from the interviews and document analysis are used. The identified barriers and accelerators and the process of the project are described.

BARRIERS

During the process several events or things occurred that held back circularity interventions, these were perceived as barriers by the interview participants. These are described in the following sections.

MUNICIPALITY

Within the Erasmusveld midden development, the municipality was a big limiting factor for innovative ideas. Although a lot of measures were still implemented in the plans, according to the interviewees this took quite a lot of effort to convince them. For example, interviewee 6 stated that "*We've probably visited the municipal managers about six times because they have opinions about what we're drawing*" (personal communication, 19 July 2023). Furthermore, interviewee 8 stated that; "*with that swale in Erasmusveld; we were 2.5 years into it before we finally got permission*" (personal communication, 26 July 2023).

There is a noticeable gap, particularly between the higher and lower layers within the hierarchical system of the municipality of The Hague. Interview participants state that often innovative ambitions regarding topics such as circularity and sustainability are agreed upon with alderman, program directors and policy-makers (Interviewee 3, personal communication, 12 July 2023; Interviewee 10, personal communication, 31 July 2023). "*We often see that they think innovatively and*

that's great." (Interviewee 3, personal communication, 12 July 2023). However, as soon as the designs get more and more concrete and the municipal managers get involved, innovative ideas are rejected. "*The maintenance department assesses it, forms opinions, and they say no.*" (Interviewee 3, personal communication, 12 July 2023).

The maintenance departments within all municipalities are perceived as very conservative: "*They are not the most innovative individuals.*" (Interviewee 3, personal communication, 12 July 2023) and "*Municipal managers, especially in large municipalities, tend to be quite conservative.*" (Interviewee 10, personal communication, 31 July 2023). They tend to favour the application of standard materials and components, as they are more familiar with those. They know what it costs and all of its characteristics: "*They prefer standard elements because they are easier to maintain. (...) We know exactly what it costs. For anything new, we don't know the exact costs. So, well, let's not do it.*" (Interviewee 10, personal communication, 31 July 2023).

As municipal managers become involved in the process, the extent of their influence becomes apparent. Interviewee 3 states: "*Those sectors have too much power. It's better to just stay within the lines; then we would have been done already.*" (personal communication, 12 July 2023).

Another barrier within the municipality during the process was the sectoral system within the maintenance department. There are many different departments for the different disciplines, such as greenery and sewage systems. Each of these departments individually evaluates the design on their own criteria, scale and priorities, and "*they all want it to be an eight.*" (Interviewee 3, personal communication, 12 July 2023). Furthermore, innovative measures often deviate from the municipal standard. Then the question arises which department should maintain it? Both interviewee 3 and 6 point out that this results in extensive discussions about the implementation of swales in the plans. In this particular case, the department for green facilities insisted that the swale should be maintained by the sewage department, while the latter department insisted the opposite .(Interviewee 3, personal communication, 12 July 2023; Interviewee 6, personal communication, 19 July 2023).

Furthermore, interviewee 3 and 6 indicated that the municipal managers get involved late in the process, which negatively effects the implementation of circularity strategies. When the plans develop from a preliminary design to the definite design, the maintenance department gets involved. Interviewee 6 states: "*And then you indeed perhaps encounter the tension between what you would like and what is allowed.*" (personal communication, 19 July 2023).

According to interviewee 6 other municipalities of course also evaluate the designs on the same or similar themes and criteria, however they "*approach it in a coherent manner*" (personal communication, 19 July 2023). Interviewee 3 points out that sectoral characteristics are quite common in large municipalities, consequently, these pose challenges when it comes to innovative designs. Similarly, interviewee 10 concludes that smaller municipalities are easier to work with.

TECHNICAL BARRIERS

Interviewee 3 indicates that the reuse of materials is more difficult because warranties are not provided on reused materials. Meaning that "*so we cannot deliver homes to buyers under warranty*" (Interviewee 3, personal communication, 12 July 2023). This is quite a big technical barrier, as it provides too much risk for developers to built and design with reused materials.

TIME

The duration of area development projects is also seen as a barrier for the implementation of circular principles. Ambitions within a municipality can change, but also changes in the economy and housing market influence the feasibility and design of developments. Furthermore, technologies and possibilities regarding innovations change over the years. Plans are made about ten years prior to the actual delivery of houses and areas. All of these things influence the integration of circularity aspects.

Interviewee 3 indicates that it is important to "*create plans that are very flexible to accommodate various possibilities. (...) basically, everything should fit in.*" (personal communication, 12 July 2023). Therefore, it is important to create robust structures that reserve space for important themes such as mobility, sustainability, water, green etc.

COMMUNICATION

Interviewee 3 pointed out that "*Erasmusveld midden was supposed to become the most sustainable neighbourhood in Europe.*" (personal communication, 12 July 2023). However, that ambition has faded away during the process. This partly has to do with the communication with the municipality and the all of the different departments demanding something.

Furthermore, interviewee 10 mentioned several cases of miscommunication within the development team. For example, the drainage of rainwater in the area. "*But what did they do ultimately? They didn't look at the plan I had prepared, and they made all the roofs face the front.*" (Interviewee 10, personal communication, 31 July 2023). Eventually, this resulted in extra costs, that could have been prevented. Interviewee 10 stated: "*communicate with each other beforehand. What's the overall principle? So that you can work together*" (personal communication, 31 July 2023).

Table F.8: Additional research findings municipal barrier

Interviewee 3 – Developer	Interviewee 6 – Civil engineer	Interviewee 10 – Civil engineer
"We always transfer ownership and maintenance of the public area to the municipality. The municipality has it managed by the maintenance department. They are not the most innovative individuals. (…) They say: 'Hey, it's great that you come up with this principle or that idea, but this is my standard. I have this in stock at the yard. So, I want this to be applied." "The green department says: 'Yes, the swale is part of the drainage system, not my responsibility.' And the drainage department says: 'No, it's not drainage, it's green.' Well, we don't care, can the municipality approve it anyway?" "Then you see the power of such a maintenance department. A bit blunt to say, but I've heard statements where they say: 'Hey, that contract you've signed, nice, but those ambitions were agreed with the alderman, not with me.' Literally: 'I have nothing to do with it; I have to manage it." "(…) especially in large municipalities, they are quite sectoral organised. (…) Well, all these departments assess your plan against their yardstick, and they all want it to be an eight. But that's not feasible; you can't give all components a score of eight." "So you see: ambition is one thing, but along the way, you have to tick all those boxes, and that's not possible."	"We've probably visited the municipal managers about six times because they have opinions about what we're drawing; the roads are too small, for instance." "Other municipalities, of course, have their control rounds, but they approach it in a coherent manner." "The municipal system has a 'public space manual', and the chapter on swales isn't in there yet. They say, 'No, I'm not going to manage it.' But they also have various different services. So, they have a service dealing with greenery, which gets a budget for maintenance. A service deals with water drainage and the sewer system, which gets a budget. This is something where: there's greenery on top, and there's a sewer below, so who's going to manage that?"	"What's different that the municipality approved it? Interviewee: The municipality of Westland is smaller than The Hague." "Furthermore, they are also concerned about maintenance. They prefer standard elements because they are easier to maintain. (…) Ultimately, it comes down to money, and everything we are applying now is known. We know exactly what it costs. For anything new, we don't know the exact costs. So, well, let's not do it. (…) That is very conservative. Municipal managers, especially in large municipalities, tend to be quite conservative." "So, you know, the municipality's board, the alderman, and the policy-makers, they want everything, but that's where it stops. The rest don't have to go along with all the innovation." "They (smaller municipalities) are often more progressive and willing to take more risks"

ACCELERATORS

The interviewees also pointed out tools and events that had a positive effect on the circular design of the area. These are elaborated in the following section.

CIRCULAR INITIATION

The implementation of circularity interventions starts with establishing ambitions on the circularity themes that should be included in the designs. Interviewee 6 states: "*basically, it starts with those high ambitions that have been set, and once they are there, the plan continues and might be tweaked a bit.*" (personal communication, 19 July 2023). Thus, setting high ambitions on the important themes really ensures that these are developed throughout the plans.

Interviewee 3 points out that in the vision, ambitions are established, which are then integrated into the project. During the masterplan phase, these ambitions are further developed and refined. Subsequently, in the urban plan, crucial decisions are made. This also indicates that it starts by setting high ambitions.

STRATEGIC PARTNERSHIPS

Interviewee 3 indicates that the solution for dealing with hierarchical and sectoral municipalities such as The Hague is to establish a strategic partnership with the municipal project leader.

First, the entire development team should reach consensus on the innovative and progressive ambitions. Subsequently, he states: "*If we really want this, there's one condition: that a project manager is appointed from the municipality who also has the authority and thus the mandate to override the various departments to make the integral assessment*" (Interviewee 3, personal communication, 12 July 2023). This way a strategic partnership is established with the municipality. "*Someone from the municipality with whom you jointly drive the project, with the authority and funds that are needed*", otherwise the municipal project leader only functions as the "*messenger between you as a developer and those maintenance departments*" (Interviewee 3, personal communication, 12 July 2023).

Moreover, interviewee 6 explains that the early involvement of the maintenance department also positively effects the projects. "*So what we have done well here or are doing well is involving them very early. It does take a lot of energy at the front end, but if you then have all those check boxes, I assume that in a year or two, we can hand it over at once*" (Interviewee 6, personal communication, 19 July 2023).

REFERENCE PROJECTS

During the interview, interviewee 10 explained about the use of references in another project to get the approval for innovative and sustainable interventions. "*At the start of the project, we went cycling with municipal officials through Delft, passing by all the climate-adaptive and sustainable measures, because that way you can show what is possible. And that helped a lot for the Liermolen project*" (Interviewee 10, personal communication, 31 July 2023).

It seemed to be an effective way to show the practicalities of innovative measures, taking away doubts about this. However, for municipalities such as The Hague, this is a lot more difficult. Mainly, due to the size of the municipality.

PROCESS

During the interviews questions were asked to identify critical points for circularity measures during the process. An analysis about these questions and participants answers are provided in the following sections. In general, it became clear that, when it is the ambition to create a circular project, ambitions about corresponding subjects should be stated in the very first phase.

INITIATION PHASE

When setting the ambitions at the start of the process, it is crucial to specify them as precisely as possible early in the process, without constraining the urban structure's flexibility. Considering the lengthy durations paired with area development projects, ambitions should be adaptable to the dynamic needs of the market and society (Interviewee 3, personal communication, 12 July 2023). Thus the creation of that urban plan is an important phase: "*mainly outlines that robust public space. And ideally, you want to be flexible in the design within that.*" (Interviewee 3, personal communication, 12 July 2023). Thus, ambitions regarding for example greenery are established at the beginning and in the urban plan: "*you establish that at the core. And for each sub-plan, you further elaborate on that in an actual green plan.*" (Interviewee 3, personal communication, 12 July 2023).

FEASIBILITY PHASE

During the actual design phases the moment the maintenance departments of the municipality are involved is crucial. The sooner they are involved, the better. As of the preliminary design or the definite design they often get more involved, interviewee 6 points out that this is the moment plans, ambitions and their practicalities might get refined or stripped down, as tensions with the municipality increase.

Once the interventions and measures are in the construction specifications, they are final: "*But once it's in the specifications, then it just proceeds. So, actually, between preliminary design and definite design, that's where the stripping down happens, causing certain things not to be achieved.*" (Interviewee 6, personal communication, 19 July 2023).

Similarly, interviewee 3 indicates that the time between the preliminary and definite design is crucial, as the maintenance department gets involved at this stage: "*Then we say: 'Well, we're going to use these materials, this type of green, this is how we're actually going to design the public space.' The maintenance department assesses it, forms opinions, and they say no.*" (personal communication, 12 July 2023).