CIRCULAR AREA DEVELOPMENT

Recommendations for creating a circularly functioning area

S.C.J. van Bakel | Master Thesis | 25-05-2020

COLOFON

PERSONAL DETAILS

Name:	S.C.J. (Sven) van Bakel
Student number:	4847466
E-mail address:	scjvanbakel@student.tudelft.nl
	svenvanbakel@gmail.com
Phone number:	+31 (0)6 36 49 65 53

REPORT DETAILS

Version:	P5 report
Presentation date:	June 25, 2020

EDUCATION

Institution:	Delft University of Technology
Faculty:	Architecture & the Built Environment
Master:	Architecture, Urbanism & Building Sciences
Master track:	Management in the Built Environment (MBE)
Graduation laboratory:	Sustainable Urban Development and Cities

THESIS SUPERVISORS

1st mentor:	Dr. K.B.J. (Karel) Van den Berghe
2nd mentor:	Dr. A. (Alexander) Wandl
Examiner:	Dr. Ir. M.J. (Machiel) van Dorst

PREFACE

In front of you lies the graduation thesis 'circular area development' that focuses on recommendations for creating a circularly functioning area. The thesis is a result of a year of research and has been written in the context of graduating from the master track Management in the Built Environment at Delft University of Technology.

In the summer of 2017, I graduated for the Bachelor's degree in Built Environment with project management as specialisation, at the Amsterdam University of Applied Sciences. During the bachelor period, I have had an internship at a developing contractor, where I also remained employed for a couple of months after graduating. During the internship period and the employment, I had the opportunity to be involved in the development of various areas and projects. Since then, the complexity of area and project development has caught my interest. In addition, during the graduation period of the bachelor, I conducted a research about 'circular construction'. During the research period I have read a lot of literature about a circular economy and how circular principles can be translated into construction, which inspired me. Since I am interested in both area development and a circular economy, I have decided to combine both worlds in a study of 'circular area development'.

Acknowledgement
Conducting this master thesis was not possible without the help and support of people who were, directly and indirectly, involved in this research. That is why, first of all, I would in particular like to thank my graduation supervisor Karel Van den Berghe for his feedback, expert advice and the time and effort he took to guide me during the research. In addition, I would also like to thank my second supervisor, Alexander Wandl, for his critical comments, expert advice, and providing important information for this study and the guidance. I am grateful to both Karel and Alex for their involvement in this study, as they have had a significant contribution to improving the overall quality of the research.

On this occasion, I would also like to thank all respondents for their time and effort during the interviews and the expert panel, which enabled me to collect necessary information and results. Furthermore, even though my voluntary internship was separate from this research, I would like to thank my internship company Res & Smit for the opportunity to develop myself in the field of project management and development in practice.

Finally, I would like to thank my family, girlfriend and friends for all the support and motivation you have given me during the education and graduation process. Without your support and encouragement, I would never have been able to obtain both the pre-master and the master, this means a lot to me.

I hope you will enjoy reading this thesis!

Sven van Bakel
June, 2020

ABSTRACT

Problem statement – As a result of the increasing world population, use of raw materials and energy, scarcity of the raw materials and the pressure on the environment, a transition to the concept of a circular economy has become more urgent. Since the Dutch government has the ambition to be fully circular in 2050, the concept of a circular economy is more and more linked to area development in the Netherlands. As a result, existing inner-city production areas are, partly because of urbanization, being transformed through a circular design approach into residential and commercial areas. However, due to these transformations, production processes disappear from areas, which in fact makes the areas less circular because the circular functioning in the areas is no longer included. Hence it can be questioned in what extent contemporary circular area developments are actually circular, or whether these circular area developments only consist of a circularly designed area that does not take into account the circular functioning of the area.

Objective – The main objective of this research is to understand how circular functioning can be taken into account in the development of circular areas. Based on the understanding of how the circular functioning of an area is or is not taken into consideration during circular area development, recommendations will be drawn up. The research question that is answered: ''*Which recommendations can contribute to an area development with regard to the circular functioning of an area?''.*

Methods – The research process is divided in three parts. First of all, a literature review has been carried out to collect information in order to gain an understanding and insights about circular area development. Secondly, a case study and several interviews are conducted in order to gain insights of what criteria the recommendations should suffice to with the aim of improving the circular functioning of an area during a circular area development. Thirdly, an expert panel is held to validate draft recommendations to ultimately formulate final conclusions and recommendations.

Results – The results of this research show that circular area development consists of a circularly designed environment and a circularly functioning environment, in which the use of resources and energy is minimized by closing, slowing down and narrowing cycles. In addition, a circular area consists of as much local production and transactions as possible, creating opportunities for the highest possible reuse of products, materials and resources. Further findings claim that area development can significantly change an area's program. As a consequence of an increasing program, material consumption and waste generation increase within an area. It can therefore be argued that, with regard to the circular functioning of an area undergoing an area development, more processing of materials and waste should take place as locally as possible.

Conclusion – Several recommendations have been identified in this study that can be divided into three categories. First, overarching recommendations focus on (1) the specific formulation of guidelines for achieving sustainable and circular objectives and (2) stimulating innovations during area developments. Second, the focus should be on creating both a circularly designed area and a circularly functioning area during area development. This category consists primarily of rethinking the development plans, by analysing the current situation in the area and assessing how the current built environment, infrastructure and established activities can contribute to a circular economy. Subsequently, the following five aspects can be applied: (1) circular criteria for land issues and tenders, (2) design and build according to circular principles, (3) new forms of financial value assessment, (4) introducing flexibility in the existing zoning plan, and (5) stimulating local partnerships to close cycles. The third category, monitor, evaluate and improve, serves to assess whether the sustainable and circular objectives of an area development are achieved and, if possible, to make adjustments to improve the sustainability and circularity of an area. This category consists of the following six components to monitor, analyse and improve: (1) incoming and outgoing flows in an area, (2) existing and future raw materials in an area, (3) energy consumption of an area, (4) climate adaptation of an area, (5) health and well-being of residents in an area, and (6) local economy.

Discussion – COVID-19 broke out during the research process. On the one hand, this created obstacles for the research: respondents were often not available for interviews. Nevertheless, all questions previously drafted in

the protocols have been answered. On the other hand, the coronavirus outbreak has shown that the circular economy principle is more topical than ever, in which port cities in particular should focus more on less volatile manufacturing industries rather than international processes. As a result, countries will be less dependent on international processes and besides, the total number of international transactions will reduce. This given is in line with the principle of a circular economy. Moreover, the focus on less volatile manufacturing industries of port cities will eventually create new job opportunities for local residents. In other words, bringing (re)consumption and (re)production back or closer to port cities not only contributes to the ecological aspect, but also to the local economy.

Keywords – Circular economy, circularity, circular area development, networks, built environment, urban metabolism

MANAGEMENT SAMENVATTING

Probleemstelling – Door de toename van de wereldbevolking, het gebruik van grondstoffen en energie, de grondstoffen schaarste en de druk op het milieu, is de noodzaak van een transitie naar het concept van een circulaire economie steeds meer bekend geworden. Aangezien de Nederlandse overheid de ambitie heeft om in 2050 volledig circulair te zijn, wordt het concept van een circulaire economie steeds meer gekoppeld aan gebiedsontwikkelingen in Nederland. Hierdoor worden bestaande binnenstedelijke productiegebieden, mede door verstedelijking, door een circulaire ontwerpaanpak getransformeerd naar woon- en commerciële gebieden. Door deze transformaties verdwijnen productieprocessen echter uit gebieden, wat de gebieden juist minder circulair maakt omdat het circulair functioneren, zoals (her)productie, niet meer is inbegrepen in de gebieden. Het is dus de vraag of de hedendaagse circulaire gebiedsontwikkelingen daadwerkelijk circulair zijn, of dat deze circulaire gebiedsontwikkelingen enkel bestaan uit een circulair ontworpen gebied waarin geen rekening wordt gehouden met het circulair functioneren van het gebied.

Doelstelling – Het hoofddoel van dit onderzoek is om te begrijpen hoe er rekening gehouden kan worden met het circulair functioneren van gebieden tijdens gebiedsontwikkelingen. Op basis van de inzichten over hoe er rekening kan worden gehouden met het circulair functioneren van een gebied, worden aanbevelingen opgesteld. De onderzoeksvraag die wordt beantwoord in dit onderzoek is: ''*Welke aanbevelingen kunnen bijdragen aan een gebiedsontwikkeling met betrekking tot het circulair functioneren van een gebied?''.*

Methoden – Het onderzoeksproces is verdeeld in drie onderdelen. Allereerst is er een literatuuronderzoek uitgevoerd om informatie te verzamelen om inzichten te krijgen in circulaire gebiedsontwikkeling. Ten tweede is een case studie uitgevoerd en zijn er interviews gehouden om inzicht te krijgen in welke aanbevelingen toegepast kunnen worden om het circulair functioneren van een gebied tijdens een circulaire gebiedsontwikkeling te verbeteren. Ten derde is er een expert panel gehouden om draft aanbevelingen te valideren om uiteindelijk definitieve conclusies en aanbevelingen te formuleren.

Resultaten – De resultaten van dit onderzoek tonen aan dat circulaire gebiedsontwikkeling bestaat uit een circulair ontworpen omgeving en een circulair functionerende omgeving, waarin het gebruik van hulpbronnen en energie wordt geminimaliseerd door het sluiten, vertragen en verkleinen van kringlopen. Daarnaast bestaat een circulair gebied uit zoveel mogelijk lokale productie en transacties, waardoor kansen ontstaan voor een zo hoog mogelijk hergebruik van producten, materialen en middelen. Verdere bevindingen stellen dat door een gebiedsontwikkeling het programma van een gebied aanzienlijk kan veranderen. Als gevolg van een toenemend programma nemen het materiaalverbruik en de afvalproductie in een gebied toe. Vandaar dat er gesteld kan worden dat met betrekking tot het circulair functioneren van een gebied dat een gebiedsontwikkeling ondergaat, meer verwerking van materialen en afval zo lokaal mogelijk dient plaats te vinden.

Conclusie – In dit onderzoek zijn verschillende aanbevelingen geïdentificeerd die in drie categorieën zijn onderverdeeld. Allereerst richten overkoepelende aanbevelingen zich op (1) de specifieke formulering van richtlijnen voor het bereiken van duurzame en circulaire doelstellingen en (2) het stimuleren van innovaties bij gebiedsontwikkelingen. Ten tweede dient de focus te liggen op het creëren van zowel een circulair ontworpen gebied als een circulair functionerend gebied tijdens gebiedsontwikkeling. Deze categorie bestaat voornamelijk uit het heroverwegen van de ontwikkelingsplannen; het analyseren van de huidige situatie in het gebied en het beoordelen hoe de huidige gebouwde omgeving, infrastructuur en gevestigde activiteiten kunnen bijdragen aan een circulaire economie. Vervolgens kunnen de volgende vijf aspecten worden toegepast: (1) circulaire criteria voor gronduitgiften en aanbestedingen, (2) ontwerpen en bouwen volgens circulaire principes, (3) nieuwe vormen van financiële waardebepaling, (4) flexibiliteit introduceren in het bestaande bestemmingsplan, en (5) lokale partnerschappen stimuleren om kringlopen te sluiten. De derde categorie, monitoren, evalueren en verbeteren, dient om te beoordelen of de duurzame en circulaire doelstellingen van een gebiedsontwikkeling worden behaald, en zo mogelijk bij te sturen om de duurzaamheid en circulariteit van een gebied te verbeteren. Deze categorie bestaat uit de volgende zes componenten om te monitoren, analyseren en verbeteren: (1) inkomende en uitgaande stromen in een gebied, (2) bestaande en toekomstige grondstoffen in een gebied, (3)

energieverbruik van een gebied, (4) klimaatadaptatie van een gebied, (5) gezondheid en welzijn van bewoners in een gebied, en (6) lokale economie.

Discussie – Tijdens het onderzoeksproces brak COVID-19 uit, oftewel het coronavirus. Dit had enerzijds belemmeringen voor het onderzoek; respondenten waren vaak niet beschikbaar voor interviews. Desalniettemin zijn alle eerder in de protocollen opgestelde vragen beantwoord. Aan de andere kant heeft de uitbraak van het coronavirus aangetoond dat het principe van de circulaire economie actueler is dan ooit, waarbij met name havensteden zich meer moeten richten op minder instabiele maakindustrieën in plaats van internationale processen. Hierdoor zullen landen minder afhankelijk zijn van internationale processen en bovendien zal het totale aantal internationale transacties afnemen. Dit gegeven sluit aan met het principe van een circulaire economie. Bovendien zal de focus op minder volatiele maakindustrieën van havensteden op den duur nieuwe werkgelegenheid voor de lokale bevolking creëren. Met andere woorden, (her)consumptie en (her)productie terugbrengen naar havensteden draagt niet alleen bij aan het ecologische aspect, maar ook aan de lokale economie.

Sleutelwoorden – Circulaire economie, circulariteit, circulaire gebiedsontwikkeling, netwerken, gebouwde omgeving, stedelijk metabolisme

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CHAPTER 1

INTRODUCTION

1 INTRODUCTION

This chapter contains the introduction for the research. First of all, in the problem statement, the subject of this research is introduced and an associated problem of the subject is explained. Secondly, both the social and scientific relevance of this research are described. Third, the objective of the research is defined and subsequently, the formulated main and sub-questions of this research are introduced. Fifth, the conceptual model of this research is presented. Finally, a description of the research structure is given.

1.1 Problem statement

Due to several facts, the necessity of a transition to a circular economy is increasingly known worldwide (Ness, 2008). A few of these facts are the increasing world population, use of raw materials and energy, scarcity of the raw materials and the pressure on the environment (European Commission, 2018; PBL, 2019; Rijksoverheid, 2016). In 2015, the United Nations has set up seventeen sustainable development goals in collaboration with prominent countries, including the Netherlands, to create a better world by 2030. These goals focus on three different dimensions of sustainable development: social, economic and environmental (IPPF, 2015). In addition to the seventeen goals, the Dutch government has expressed the ambition to be fully circular by 2050. The government-wide program describes how the Netherlands wants to achieve a fully circular economy. Five priority sectors have been identified in the program and one of these sectors is the construction sector (Rijksoverheid, 2016).

Provinces and municipalities can contribute to the achievement of the established sustainable goals by implementing sustainable area developments that, according to World Commission on Environment and Development (1987), meets the needs of the present population without restricting future generations to meet their generation's needs. Worldwide, the principle of a circular economy is more and more seen as one of the crucial strategic goals for sustainable development (Ghisellini, Cialani & Ulgiati, 2016). Since the Dutch government has the ambition to be fully circular in 2050, the concept of a circular economy is increasingly linked to area development in the Netherlands (Platform31, 2018). As a result, more and more existing inner-city production areas are, partly because of urbanization (de Beer, Ekamper & van der Graag, 2017), being transformed through a circular design approach into residential and commercial areas. However, this is in contrast to the principle of a circular economy. Due to these transformations, production processes disappear from urban areas, which in fact makes the areas less circular because the circular functioning in the areas is no longer included (Van den Berghe & Vos, 2019). Moreover, North (2010) claims that the geographical part is important, and therefore, a circular economy should strive for more local activities. By creating industrial symbiosis processes in cities, manufacturing companies can benefit from the urban ecosystem. In this way, materials remain in a closed-loop cycle (SMO, 2016) and (re)manufacturing can be a crucial part of urban value creation (Juraschek et al., 2018).

In the last decades, various researches and experiments have been carried out into the integration of circular principles at a macro- or micro-level, while studies into the realisation of circular principles at a meso-level, also called an area level, is lacking (Pomponi & Moncaster, 2017). Besides, little is known about the creation of urban production processes (Juraschek et al., 2018). Research has also shown that circular objectives in area development create challenges and tensions between regional and local scale levels, especially in economic principles and processes (van Bueren, 2018; Cities of making Brussels, 2018; PBL, 2019). Therefore, sufficient research is needed to gain a better understanding of how the creation of local production networks can add value creation and contribute to the circular functioning of an area in circular area developments.

1.2 Relevance

Societal relevance

The Netherlands is facing a housing shortage, especially in cities in and around the Randstad. The housing shortage is partly caused by the increasing population and the rising number of households (Capital Value, 2018). In order to deal with the housing shortage, many new dwellings will have to be built in the Netherlands the

upcoming decades (ABF Research, 2018). Due to urbanization, most of the new houses will be built in and around cities. By implementing principles of a circular economy in the urban area developments, the developments can contribute to the circular objective of the Netherlands to become more circular by 2050. Hereby the part 'fully circular' is not mentioned because there is still a lot of uncertainty about what the Dutch government sees as fully circular (Delahaye & Balde, 2016). In addition, the integration of a circular economy in the Dutch construction sector can result in new activities to which new jobs are linked (PBL, 2019). However, little is known about what circular urban area development is (Pomponi & Moncaster, 2017) and how current and new activities in areas can contribute to the circular functioning of an area (Juraschek et al., 2018).

Scientific relevance

In recent decades, a lot of research has been done about a circular economy. However, research by Kirchherr et al. (2017) has shown that there is no consensus on the definition of a circular economy. In addition, the construction sector can contribute to accelerate a transition to a circular economy because approximately 40% of the raw materials extracted are worldwide processed in this sector (Jensen & Sommer, 2016). Hence, many articles have been written about the implementation of circularity in the built environment, in particular at a building scale. According to Pomponi & Moncaster (2017), however, the number of publications on the implementation of a circular economy at an urban scale is low. In the Netherlands, more and more existing inner-city production areas are being transformed by a circular design approach (building scale) into residential and commercial areas. As a result, production processes disappear from urban areas, causing that the areas cannot function in a circular way (Van den Berghe & Vos, 2019). Creating local industrial symbiosis networks in areas can contribute to the circular functioning of an area by realising (re)manufacturing in an area. However, little is known about the creation of industrial symbiosis networks in circular area developments (Juraschek et al., 2018). Therefore, this research focuses on filling this gap in literature by investigating how local production networks can contribute to the circular functioning of an area in circular area development.

1.3 Research objective

The main objective of this research is to understand how circular functioning can be taken into account in the development of circular areas. Based on the understanding of how the circular functioning of an area is or is not taken into account during circular area development, recommendations will be drawn up. The recommendations focus on considerations that can be used to improve the circular functioning of an area during circular area developments.

Product:	**Recommendations that can be taken into account to improve the circular functioning of an area during the development of circular areas.**
Aim of product:	Contribute to accelerate a transition to a circular economy, especially within the field of area development.
Use of product:	The recommendations can be used by people (working for public or private parties) who are involved in circular area developments. More specifically, the recommendations can help them make choices with regard to improving the circular functioning of an area while making circular area development plans.

1.4 Research questions

Main research question:

Which recommendations can contribute to an area development with regard to the circular functioning of an area?

In order to answer the main research question, the following sub-questions are formulated:

1. What is the concept of a circular economy?
2. What is the geographical function of a circular economy?
3. What is the network perspective of a circular economy?
4. What is the principle of urban metabolism?
5. How can the principle of urban metabolism combine a geographical area with the network perspective according to the concept of a circular economy?

1.5 Conceptual model

Figure 1 shows the conceptual model of this research. To understand what circular area development entails, first, research is done into the characteristics and principles of a circular economy. Subsequently, the model is divided into (1) a place perspective, which contains the built environment, and (2) an economic perspective, which contains networks. First, to combine the principles of a circular economy with area development, the place perspective investigates the characteristics of a circular area development and what the differences are between the three scales in the built environment with regard to the implementation of circular economy. In the economic perspective, networks of actors and how these actors can collaborate circularly with each other through industrial symbiosis is described. In addition, the networks are combined with a geographical factor, which is in accordance to the principle of a circular economy. Finally, the principle of urban metabolism is introduced, which is an approach to identify the relationship between place and networks.

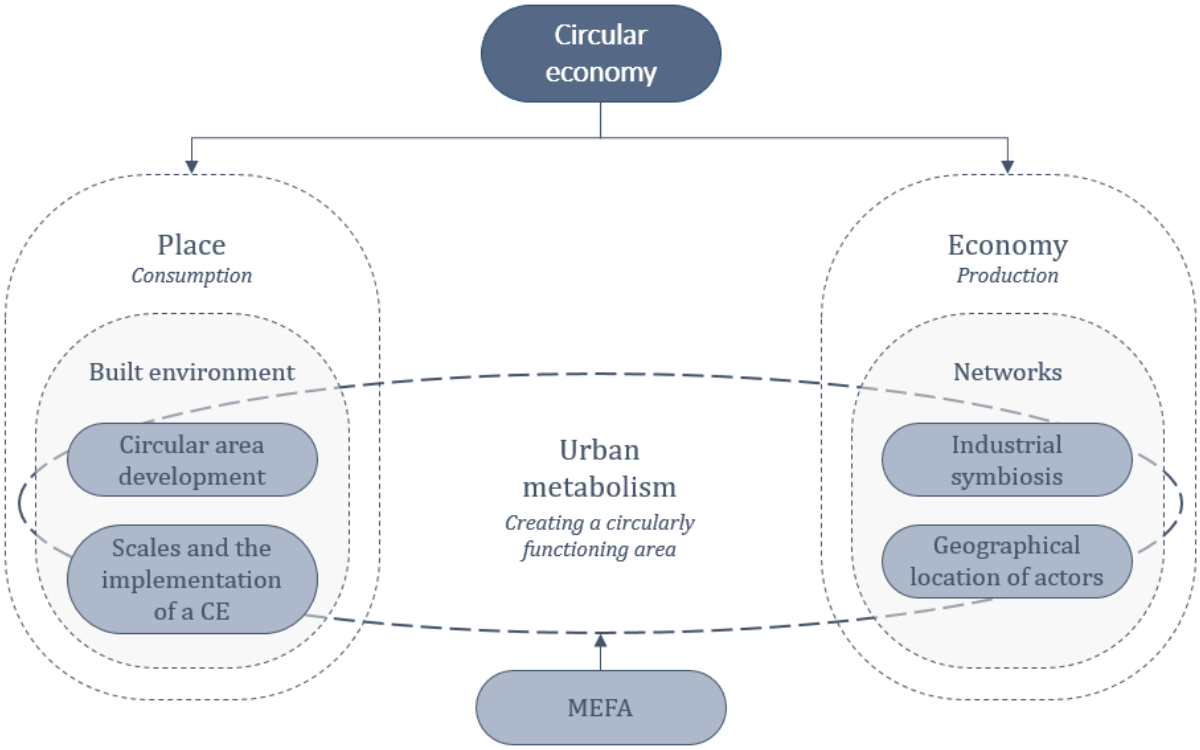


Figure 1 Conceptual model

1.6 Research structure

The structure of this research is illustrated in figure 2 and is divided into four parts and nine chapters. The first part, concepts, includes the introduction (chapter 1) and the methodology of this research (chapter 2). Subsequently, in the theories part, theories on the topics of this study are collected based on a literature study (chapter 3). Subsequently, these theories are linked to practice by conducting a case study and interviews (chapter 4) in the practical part. In the final part, synthesis, the results from both chapters 3 and 4 are combined and confronted with each other in chapter 5. Thereafter, the results are validated based on an expert panel (chapter 6). Based on the validated results, conclusions have been formulated in chapter 7, and in chapter 8, a discussion has been written about both the results and research outcomes. In the end, a reflection regarding the research topic, research process and the applied research methods is written.

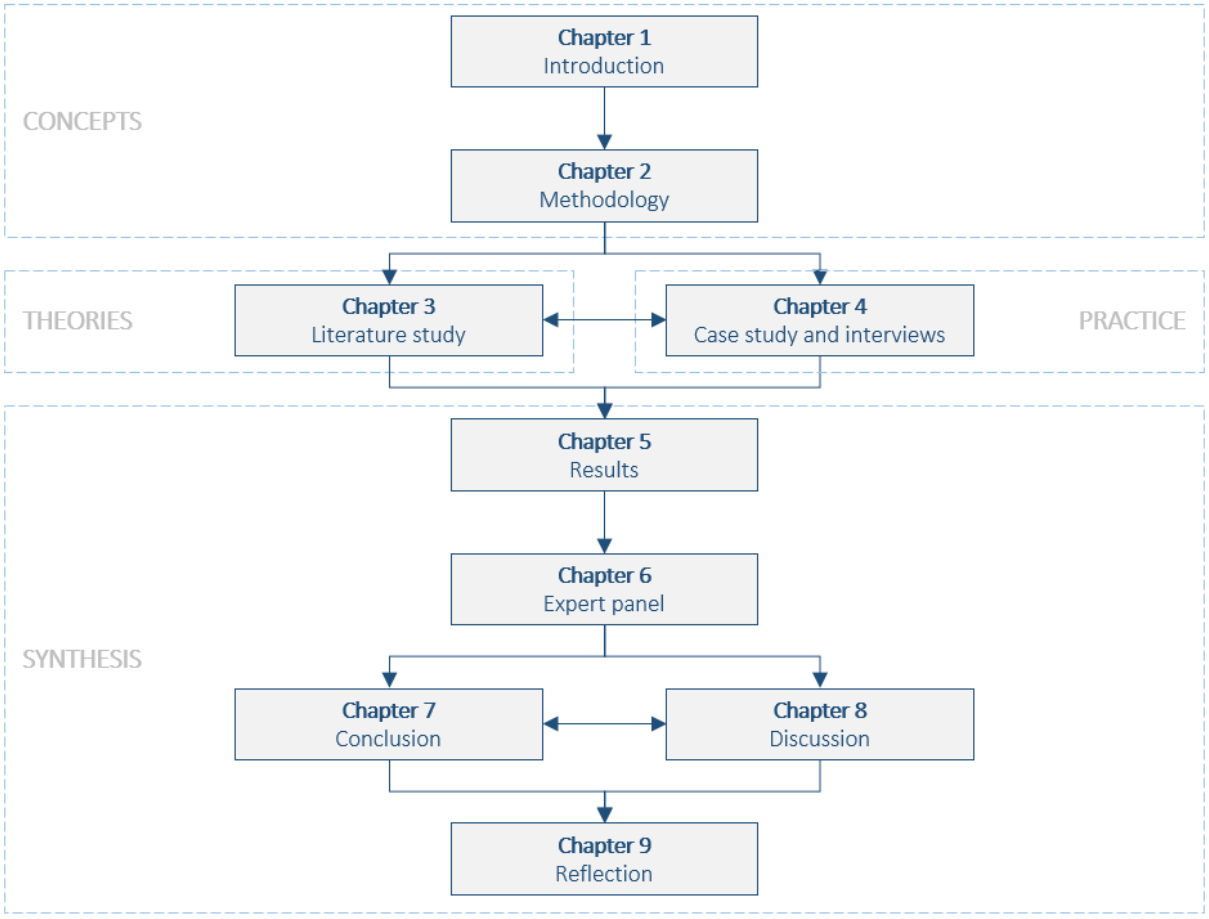


Figure 2 Research structure

CHAPTER 2

METHODOLOGY

2 METHODOLOGY

This chapter describes the applied methods of the research. This research aims to investigate how the circular functioning of an area can be included in Dutch circular area. Since little is known about both circularity in the built environment and industrial symbiosis in area development and there is no consensus on the definition of a circular economy, this research is explorative in nature (Kumar, 2014). Because this research has an explorative approach, new theories are being developed. As a result, a qualitative research approach has been chosen in this study (Bryman, 2012).

2.1 Research method structure

To create an overview and to provide insight into the research method structure of this research, a methodological framework has been designed. The framework includes the conceptual analytical model and the applied research methods and techniques (table 1). The structure of the framework is based on Heurkens (2012), Huijbregts (2017) and Luijt (2019).

Concepts	Conceptual analytical model			
Aim	*Analysis and understanding of the circular economy and the related perspectives economy (production) and place (consumption)*			
Methods	Case study		Theory building	
Aim	*Data collection, analysis and comparison*		*Empirical lessons*	
Techniques	Literature and document review	Semi-structured interviews	Expert panel	Displaying tables and figures
Aim	*Documented information*	*Practical experiences*	*Practical validation*	*Comprehensive overviews*

Table 1 Methodological framework (Own table, based on Heurkens, 2012; Huijbregts, 2017; Luijt, 2019)

The methodological framework is built up with a hierarchy, which consists of three parts. The first part is a conceptual analytical model that serves to collect and study theories. Second, the research methods are determined to collect data, analyse data and make comparisons. Finally, the four research techniques have been determined to support the research methods: (1) literature review, (2) semi-structured interviews, (3) expert panel, and (4) display of the tables and illustrations (Heurkens, 2012; Huijbregts, 2017). In the following sections, the steps of the research process are explained.

2.1.1 Concepts: methodology and theory

The first part of the research process focuses on methodology and theory. Firstly, the research method is determined, and secondly, relevant literature to the main topic is collected.

Objective: Determine the research problem, objective and questions. In addition, theoretical information is collected to gain an understanding and insights about circular area development.
Method: Literature review

2.1.2 Practice: case study and interviews

The second part is focused on practice and consists of a case study and interviews. On the one hand, the case study is aimed at analysing how the relevant case contributes or can contribute to the circular functioning of the area in which it is located. On the other hand, the interviews are held with experts to find out more about the case itself, including context and processes. Subsequently, the findings are analysed and evaluated to determine draft recommendations that can be taken into account for an area to function circularly.

Objective: Gain insight into what recommendations need to take into account to improve the circular functioning of an area during a circular area development.
Method: Case study and interviews

2.1.3 Synthesis: lessons and implications

The final step of the research process focuses on formulating lessons and recommendations for circular area developments. Draft recommendations are described in the second step of the process (section 2.1.2). In this phase, the first conclusions are drawn based on the draft recommendations concerning creating a circularly functioning area development. Finally, the draft recommendations and conclusions are validated by an expert panel in this step.

Objective: Validate draft recommendations and conclusions to ultimately formulate final conclusions and recommendations.
Method: Expert panel

2.2 Research methods

This section describes and provides information about applied research methods. Research methods are used to collect relevant data (Bryman, 2012). In this study, the following research methods have been used: literature research, semi-structured interviews, case study and an expert panel.

2.2.1 Literature review

The purpose of the literature study is to gain a better understanding of the different topics of the research. A 'narrative review' of the literature has, therefore, been applied because it is more appropriate than a systematic review for this research (Bryman, 2012). As a result, useful information has been collected about the topics of this research. According to Bryman (2012), the disadvantage of a 'narrative review' of the literature is that it is less focused and wider in scope in comparison with a systematic review. Each section of the literature study concludes with a final conclusion. Based on the final conclusions, multiple sub-questions can be answered. During the research, the theoretical framework has been supplemented with relevant literature to improve the research process. Furthermore, the gap in literature has been identified on the basis of the literature study by determining both the research problem (section 1.1) and the relevance of the research (section 1.2).

2.2.2 Interviews

Semi-structured interviews with professionals and practitioners from the field are held. The functions of the respondents are shown in table 2. These interviews are conducted to gather additional knowledge about circular area developments and to gain better insights about the case study in particular, which is further explained in section 2.2.3. There has been chosen for semi-structured interviews to create more room for the interviewer to ask further questions in response to what is seen as significant answers. In addition, the series of questions are in general protocols (appendices I, II and III), but the interviewer has the freedom to vary the order of the questions (Bryman, 2012). To prevent uncertainties and misinterpretations, the interviews are held in the Dutch language with Dutch speaking interviewees. Each interview is recorded, a summary with important statements has been made and incorporated in the case study.

	Function	Organisation
Respondent 1	Program manager sustainable area development	Municipality of Amsterdam
Respondent 2	Urban planner & program leader sustainability	Municipality of Amsterdam
Respondent 3	Commercial manager Real Estate	Port of Amsterdam
Respondent 4	Commercial manager Circular & Renewable Industry	Port of Amsterdam

Table 2 Function and organisation of the respondents interviewed

2.2.3 Case study

To gain insights into Dutch practice with regard to the circular functioning of an area, a case study has been conducted. A case study can be described as *"(…) empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident."* (Yin, 2003, p. 13). The contemporary phenomenon investigated in this research is circular area development. The real-life context of the phenomenon of this research takes place in area developments, and especially in inner-city area developments, in the Netherlands.

Research method of the case study

The research method for the case study is based on a research approach by Yin (2003). The research approach is shown in figure 3 and consists of three steps. First, in the 'definition and planning' step, theories are developed based on a literature study that is used as input for the analysis of the case study. Next, a Dutch case is selected and the data collection protocol has been developed to perform the case study. Secondly, in the 'preparation, collection, analysis' step, the case study is conducted. The case study consists of several sub-areas, and therefore, the findings of each sub-area are documented in an individual paragraph. Subsequently, the individual paragraphs of the sub-areas are combined with each other in other to generate an overview of the case study in total. Thereafter, various analyses have been conducted for the case study. Finally, in the 'analysis and conclusion' part, the different analysis are compared with each other to determine differences and similarities (Bryman, 2012). Subsequently, conclusions can be drawn about how the case study can contribute to the circular functioning of an area and the associated recommendations can be identified.

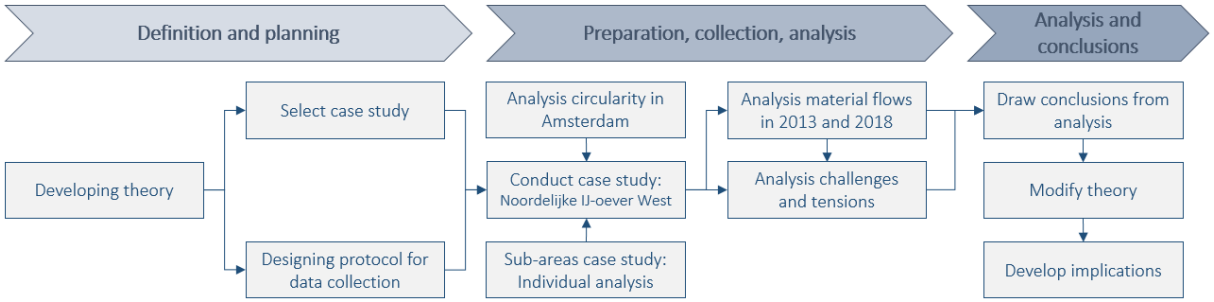


Figure 3 Research method of the case study (Own illustration, adapted from Yin, 2003)

Case study selection

To select a relevant case study for this research, various criteria are established for the selection procedure:

- The case is located in or around a city (the Amsterdam region is preferred) in the Netherlands;
- The municipality in which the case is located has sustainable and/or circular ambitions. The region of Amsterdam is preferred since the municipality of Amsterdam has a circular vision and circular ambitions for the city (Gemeente Amsterdam, 2015);
- Sufficient data is available about the registered waste flows of the case;
- Sufficient data is available about the development plans of the case.

While selecting a suitable case study, it appeared that the majority of possible case studies met the first two criteria (location and sustainable / circular ambitions). However, the criteria about sufficient data were most of the times a bottleneck. In the end, it turned out that sufficient information was available for the area development of Noordelijke IJ-oever West on both the construction and demolition waste and the development plans. In addition, the area is located in Amsterdam and concerns an area transformation from industrial

functions to mixed functions. However, as stated in the research question, due to these transformations, production processes disappear from urban areas, which in fact makes the areas less circular because the circular functioning in the areas is no longer included (Van den Berghe & Vos, 2019). Hence, it has been decided to use Noordelijke IJ-oever West as a case study for this research.

Data collection

Data is observed, collected and analysed during the elaboration of the case study. As mentioned earlier in this section, the case study consists of different sub-areas. In addition, an analysis has been made concerning material flows in 2013 and 2018 (figure 3). In order to subsequently compare the sub-areas or the analysis, it does not have to be similar. However, the same framework must be used for every part to make comparisons feasible (Yin, 2003). Therefore, a data collection model has been designed, consisting of various parts to collect data. More specifically, for each individual analysis of sub-areas and material flows, the same techniques are used to collect data so that findings can be compared with each other (Bryman, 2012).

The main objective of the case study is to gain insight into which recommendations can be made with regard to the circular functioning of an area. In addition, the following objectives have been set:

- Understand the history of the area;
- Provide insights into the policy of the municipality concerned regarding sustainability and circularity;
- Gain insights into the sustainable and circular ambitions of the case;
- Collecting information about the current and future program in both the whole area and the sub-areas;
- Determine how the production and treatment of construction and demolition waste in the case has changed in recent years;
- Mapping the tensions and challenges between different scale levels during the area development of the case;
- Determine how the case can contribute to the circular functioning of the area in which it is located;
- Evaluate the case study to prepare recommendations that can be taken into account to improve the circular functioning, particularly with regard to area development.

In order to achieve the objectives of the case study, a structure for the elaboration of the case study has been made. It should be stated that the literature study is used as a starting point for the analysis of the case study. The structure of the case study report is as follows:

1. Description of the case and its history;
2. Sustainability and circularity in Amsterdam;
3. Sub-areas of Noordelijke IJ oever West and the associated programs;
4. Material flow analysis of Noordelijke IJ-oever West;
5. Challenges and tensions between local and regional scale levels;
6. Conclusion case study and predictions for the future.

2.2.4 Expert panel

An expert panel is held to validate draft recommendations with regard to circular area development. In other words, specialized input as well as opinions are used to carry out an overall evaluation (Department of Sustainability and Environment, 2005). The main purpose of the panel is to put inputs together in order to formulate final recommendations for the future related to the discussed topic (Slocum, 2005). Both the internal and external validity of the formulated draft recommendations are measured and discussed during the expert panel (Yin, 2003). The expert panel mainly focused on how individuals in the group discussed certain draft recommendations (Bryman, 2012). In the expert panel, the emphasis was therefore on the draft recommendations that can be taken into account to improve the circular functioning of an area during a circular area development in Dutch practice. Before experts were invited, the number of experts and their background were considered (Remøy, Koppels, Van Oel & De Jonge, 2007). More specifically, the invited respondents all have experience in area development in combination with sustainability and circularity. However, it is important to mention that the outbreak of COVID-19 during the investigation process made it difficult to approach and invite

experts for the expert panel. Hence, ultimately two experts from the field participated in the expert panel, as stated in table 3.

	Function	Company
Respondent 1	Project developer and contract manager	Res & Smit
Respondent 2	Project developer and project manager	Res & Smit

Table 3 Function and company of the respondents participated in expert panel

2.3 Research process

Both the structure and methods are explained in the previous sections (section 2.1 and section 2.2). In this section, the research process is explained to generate an overview of the process. The research process is shown in figure 4. First, the data collected in the literature review is used to create and gain an understanding and insights of both a circular economy, circular area development, networks, industrial symbiosis, a geographical perspective of networks and urban metabolism. These theories are used for the case study and interviews. By analysing the conducted case study and interviews, draft recommendations could be formulated. Subsequently, the draft recommendations are discussed in an expert panel by experts from practice to validate the draft recommendations. Finally, the results of the expert panel are analysed to formulate final recommendations that can be taken into account to improve the circular functioning of an area during circular area development.

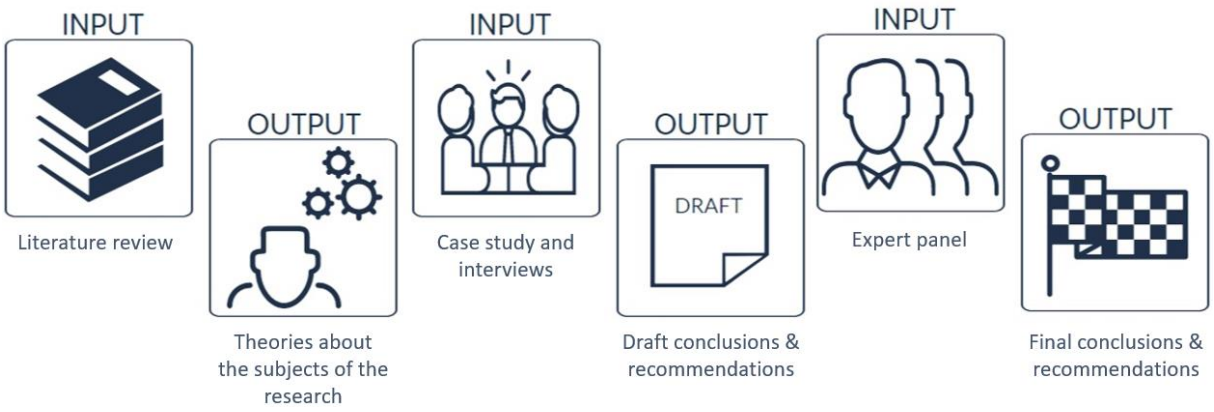


Figure 4 Research process

CHAPTER 3

LITERATURE STUDY

3 LITERATURE STUDY

This chapter contains the theoretical framework of the research. The theoretical framework has been created to generate an overview of existing theories and knowledge related to the research topic. The objective of the literature study is to provide input for the interviews, case-study and ultimately answering the main and sub-questions.

3.1 The concept of a circular economy

This section focuses on answering the first sub-question: *"What is the concept of a circular economy?"*. This section covers aspects such as what a circular economy (CE) is, what the principle of a CE is and what the difference between a CE and circularity is.

3.1.1 Necessity of a circular economy

Since the industrial revolution, two centuries ago, the way of production has slightly changed. In a linear approach, which is still widely used today, the end-user is responsible for the disposal of the product. According to Loppies (2015), this approach is extensively applied because it can provide consumers with affordable products. This linear approach is based on a linear economy. A linear economy is a take-make-waste economy, wherein raw materials are used without restraining (figure 5). The final products are thrown away after use (EMF, 2013; Sauvé, Bernard & Sloan, 2016). In recent decades, there has been an increase of criticism regarding the linear economy since this approach has led to scarcity and waste of raw materials, environmental pollution and climate change (EMF, 2013).

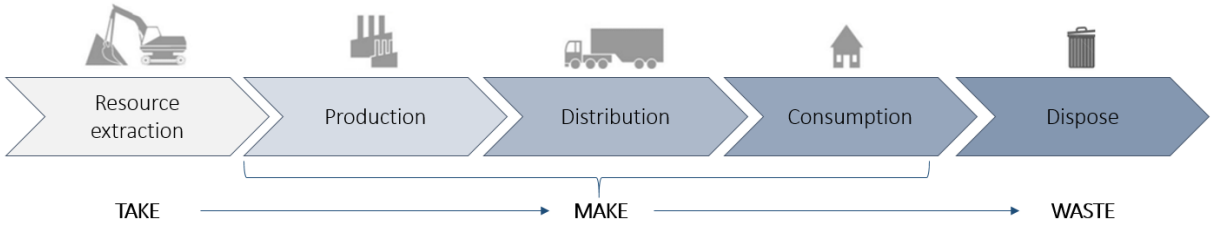


Figure 5 Model of a linear economy (Adapted from Wauteled, 2018)

A linear economy approach does not include life cycles of materials, but can be illustrated as a line with a beginning and end (Sauvé et al., 2016). Thus, the linear principle is wasteful both at the start and end of the material life 'line'. The continuous use of new raw materials at the start, and the pollution caused by the creation of waste at the end of the lifeline. Due to multiple factors, such as increasing world population, the use of raw materials and energy, the scarcity of raw materials and climate changes, the current principle of a linear economy cannot be applied forever. Therefore, a transition to a CE is necessary (EMF, 2013; European Commission, 2018; PBL, 2019; Rijksoverheid, 2016).

3.1.2 Circular economy

In recent years, the concept of a CE has been defined in various ways in literature, resulting in no consensus about the definition (Kirchherr et al., 2017). Therefore, in this study, the definition of a CE described by the Ellen MacArthur Foundation has been chosen as starting point since this definition is the most cited and accepted definition of a CE (Geissdoerfer, Savaget, Bocken & Hultink, 2017; Kirchherr et al., 2017).

> *"A circular economy is an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models." (EMF, 2013, p. 7).*

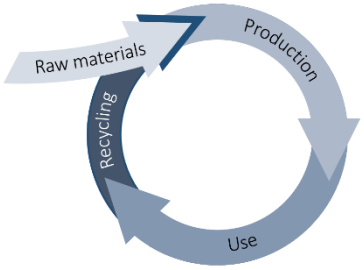


Figure 6 Model of a circular economy (Adapted from Rijksoverheid, 2016)

Various strategies have been defined to move from a linear economy to a circular economy. In literature, the following three strategies are mainly linked to a CE: (1) reducing, (2) reusing and (3) recycling (Kirchherr et al., 2017). In addition to the three strategies, according to Murray, Skene & Haynes (2017) innovation stimulates the development to a CE, linking technical, social and economic aspects. When a product chain is entirely closed, and the materials can be reused continuously, circularity is achieved. However, closing a product chain completely is probably not feasible in practice (Potting et al., 2017). Additionally to the three R's (reducing, reusing and recycling), other R strategies exist and together the strategies form the so-called R-framework (Kirchherr et al., 2017; Potting et al., 2017). Although it is almost impossible to achieve full circularity, the R-framework (figure 7) can be applied to determine which circular strategy offers the most environmental benefits. The R-framework includes a priority order of strategic approaches for waste treatment methods. These strategic approaches are ranked from high to low circularity, and more specifically, the higher on the R-ladder, the fewer resources are needed (PBL, 2019; Potting et al., 2017).

Increasing circularity

Strategies	Description
R0 Refuse	Make product redundant by abandoning its function or by offering the same function with a radically different product
R1 Rethink	Make product use more intensive (e.g. by sharing product)
R2 Reduce	Increase efficiency in product manufacture or use by consuming fewer natural resources and materials
R3 Reuse	Reuse by another consumer of discarded product which is still in good condition and fulfils its original function
R4 Repair	Repair and maintenance of defective product so it can be used with its original function
R5 Refurbish	Restore an old product and bring it up to date
R6 Remanufacture	Use parts of discarded product in a new product with the same function
R7 Repurpose	Use discarded product or its parts in a new product with a different function
R8 Recycle	Process materials to obtain the same (high grade) or lower (low grade) quality
R9 Recover	Incineration of material with energy recovery

Figure 7 R-framework (Adapted from Potting et al., 2017)

In addition to the R-framework, figure 8 shows the three principles of a CE from the perspective of EMF (2015), also known as the butterfly model. The first principle of EMF (2015) is reconsidering the system, whereby basis materials can be replaced. This principle starts with the dematerialization of utility. The required resources are selected for the design process based on the most suitable technologies and processes.

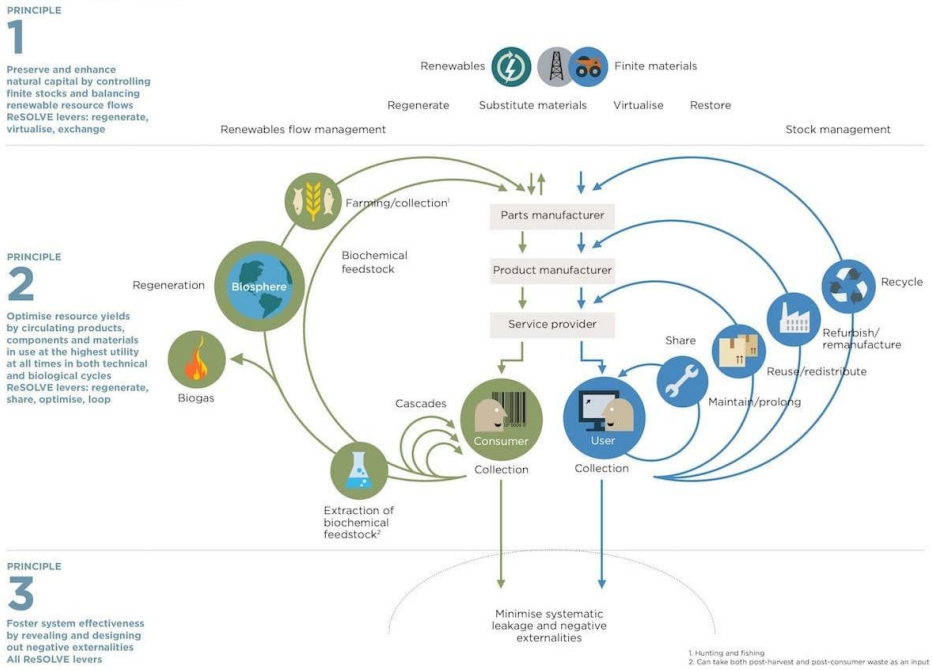


Figure 8 Principles of a circular economy (EMF, 2015)

The second principle distinguishes two different material cycles: (1) the bio-cycle, the left green side of figure 8 and (2) the techno-cycle, the right blue side of figure 8. A distinction has been made between these two separate cycles because organic materials have a different recycling process than technical materials (EMF, 2015; Het Groene Brein, n.d.). On the one hand, the techno-cycle consists of technical materials, such as fossil fuels, plastics and metals, which are limited available. After use, the materials are recovered with the original value from the residual flows. It can be noted that in the butterfly model the principles of reducing, reusing and recycling are illustrated in the technical cycle. On the other hand, the bio-cycle consists of organic materials, such as wood, food and water, which are adopted into the ecosystem through biological processes and then go back into nature. Consumption may take place in the bio-cycle provided that the streams are not contaminated with toxic substances and, moreover, the ecosystems must not be overloaded (EMF, 2015; Het Groene Brein, n.d.). Finally, the third principle of EMF (2015) focuses on limiting negative external effects on the environment. Hereby, the environment consists of systems of food, mobility, shelter, education and health.

3.1.4 Circular economy versus circularity

According to Kirchherr et al. (2017), the main goal of a CE is sustainable development, which can be divided into four different goals. Of these four different goals, economic prosperity is most frequently mentioned as the main goal of a CE in literature, followed by environmental quality, then social equality and finally the future generation (Kirchherr et al., 2017). Because of this, it can be suggested that the main driver for applying a CE approach is making a financially feasible business case which ultimately generates profit. In addition to the principle of a CE, the concept of circularity exists. The concept of circularity is a derivative of a CE and focuses itself on obtaining better environmental quality. To achieve this, materials are reused in a high-quality manner, material cycles are closed and the environmental impact of materials is reduced. In the concept of circularity, only sources are generated from renewable energy (Het Groene Brein, n.d.). In short, the difference between the two is that CE is primarily focused on economic prosperity, while the aim of circularity is to create environmental quality.

According to Ghisellini et al. (2016), principles of a CE can be integrated in three different scales: (1) micro-scale, (2) meso-scale and (3) macro-scale. The micro-scale refers to a building level, while the macro-scale refers to a national or even a global level. Between these two scales is the meso-scale that refers to a neighbourhood or urban area (Ghisellini et al., 2016). Based on the descriptions of the different scales, it can be assumed that a CE is mainly focused on a macro-scale, while circularity focuses primarily on a micro-scale. With regard to a meso-scale, this scale is found in both the principles.

CE	
Main goal:	Economic prosperity
Scale:	Macro & meso

Circularity	
Main goal:	Environmental quality
Scale:	Meso & micro

Table 4 Differences between CE and circularity (Own table)

3.1.5 Conclusion

In a CE, products, materials and resources are kept in the economy for as long as possible, without losing value, whereby system thinking is central (EMF, 2013; European Commission, 2018; Geissdoerfer et al., 2017). Hence, a CE can be seen as the opposite of a linear economy, which has a take-make-waste principle (Sauvé et al., 2016). With regard to a CE, there is no agreement on the concept. However, the majority of literature states that the three R's: reduce, reuse and recycle, are the main principles of a CE (Kirchherr et al., 2017). Other principles and strategies of, for example, EMF (2015) and Potting et al. (2017) are supplementary to the three R's. In addition, the development and transition to a CE is stimulated by innovation. Because of innovation, technical, social and economic components come together (Murray et al., 2017).

Finally, the CE and circularity concepts are closely related, but both have a different focus. The CE is mainly focused on economic prosperity, while circularity focuses on the reusability of materials and the closing of cycles of products and resources. In other words, circularity focuses on achieving higher environmental quality by reducing the environmental impact of a production process.

3.2 Circularity in the built environment

The focus in this section is on answering the second sub-question: *''What is the geographical function of a circular economy?''.* In general, the section aims at places and includes components such as what is area development, what is circularity in an area, and what strategies there are for implementing a CE in an area.

3.2.1 Area development

The development of an area can be described as a complex process in which various tasks are carried out together in a defined area. The tasks in an area development consist of different disciplines that intersect both policy and sectoral boundaries (RLG, 2007). According to Heurkens (2018), many different stakeholders are involved in area development, taking into account both private and public interests. In addition, the development of an area can be divided into two categories: (1) real estate development and (2) spatial plans. On the one hand, real estate development relates to the development of a single building and is generally carried out by private parties. On the other hand, spatial plans are focused on the development of regions and cities and are mainly implemented by public parties. Area development is between these two categories and is, therefore, a combination of both public and private initiatives (Heurkens, 2018).

Different guidelines and frameworks can be used when designing and implementing urban developments. Each guideline or framework has its own approach of dealing with certain decision-making forms and how to deal with stakeholders. In the last decades, various guidelines for environmental assessments with regard to urban planning have been developed, such as the PETUS project and 2000 Environmental Impact Assessment Review (Runhaar, Driessen & Soer, 2009). Runhaar et al. (2009) distinguish between 'substance-oriented tools' that are focused on indicators of spatial development and 'process-oriented tools' that are focused on facilitating dialogues, creating consensus and defining ambitions. Each of these tools has a fixed step-by-step plan, which is illustrated in table 5 (Runhaar et al., 2009).

Step	Description
1. Analysis of the current situation	Investigate the current spatial functions, the state of the area, the relationships and dependencies between the functions and conditions, and furthermore an assessment of the planned development.
2. Determination of the desired area types	Determine the desired functions or qualities.
3. Selection and prioritize	The most important functions or qualities of the area are determined.
4. Formulation of environmental ambition	Formulate the ambitions and goals per prioritized function or quality.
5. Development of action plans	Realise the ambitions and goals by determine implementation plans. E.g. determine which tool can be used for measurements.
6. Monitoring, evaluation and feedback	Observing and evaluating the process to determine whether the ambitions have been achieved and how it can possibly be improved.

Table 5 Stepwise approach of planning tools (Own table, based on Runhaar et al., 2009)

3.2.2 Circular economy in area development

Since the necessity of a CE as an alternative to the current widely used linear economic model is becoming increasingly known worldwide (Ness, 2008), the implementation of a CE is more and more linked to area developments (Platform31, 2018). However, since there is already no consensus on what the definition of a CE is, there is no agreement at all on what circular area development is. According to Geissdoerfer et al. (2017), circularity can be seen as one of the requirements for sustainable development. Sustainable development brings together three developmental aspects, namely: economic, ecological and social (World Economic Forum, 2018). In section 3.1.5 it is concluded that in a CE products, materials and resources are kept in the economy for as long as possible, without losing value, whereby system thinking is central. Geissdoerfer et al. (2017) state that when circularity is implemented on a meso-scale, an area acts as a regenerative system in which the import of products, materials, resources and energy are minimized by closing, slowing down and narrowing cycles.

Figure 9 shows schematically a circular area. EMF (2017) states that a circular city or area is created based on the principles of a CE. Circular areas eliminate waste and are aimed at the reuse of resources. A circular area firstly comprises a built environment that is designed in a modular and flexible manner. Secondly, the energy systems in the area are resilient, renewable, localized, distributed and have a positive impact on the area. Thirdly, the area consists of an infrastructure system that is accessible, affordable and effective. Subsequently, the area has an urban bio-economy, which is related to the bio-cycle of the butterfly model (section 3.1.2). Finally, a circular area contains production systems with local value loops. In other words, more local production and exchanges of values in local economies (EMF, 2017).

In short, a circular area consists of both a circularly built environment and a circularly functioning environment. The principle of a CE is within area development linked to the geographical area of a city because local production is encouraged (EMF, 2017). The geographical boundaries of an area result in, among other things, a reduction in transport and an increased efficiency in the value chain (Green Deal, 2018).

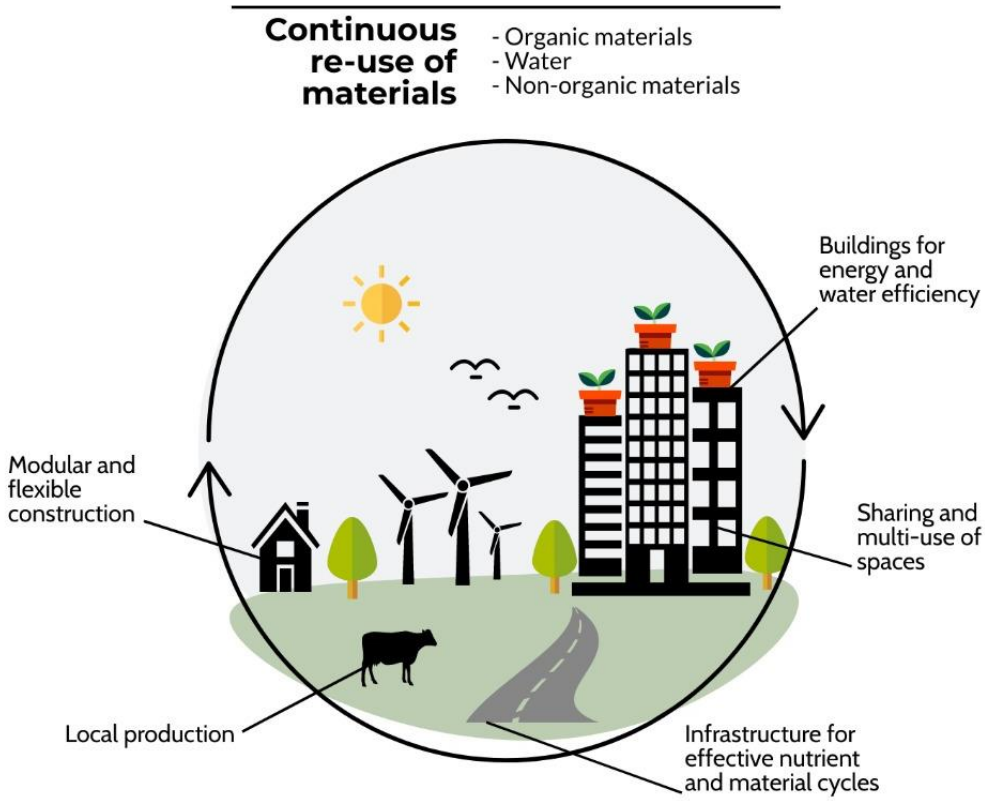


Figure 9 Sketchy visualization of a circular area (Own illustration, based on EMF, 2017)

3.2.3 Implementation of a circular economy in area development

The principle of a CE can be implemented on a micro-, meso- and macro-scale (Geng et al., 2012). The smallest scale, micro-level, refers to firm-level and focuses on ecological design and cleaner production (CP). Meso-scale refers to the inter-firm level and is focused on the development of, for example, Eco-Industrial Parks. Finally, the macro-scale is at a social level, has a recycle-oriented society that focuses on sustainable production and consumption activities (Geng et al., 2012).

The CE often has the image of being 'new' (PBL, 2019). Many discussions, therefore, focus on recent and innovative initiatives (Murray et al., 2017). PBL (2019) states that although recent, innovative initiatives play an important role in the transition, 'newness' or 'innovativeness' is not a condition for circularity. 'Old initiatives' also play a role in a CE. In the Netherlands, there are several circular activities, such as glass recycling or the sale of second-hand cars. More than 70,000 of the activities concern the repair of all kinds of products, such as bicycles, cars, furniture, shoes and computers (figure 10). These are mainly craft companies that have been a common part of the economy for years. In area developments, for example, these activities are often not

recognized as circular, while they do contribute to the principles of a CE. As a result, existing inner-city production areas are being transformed into residential and commercial areas. However, the usual 'old' activities can all be part of a CE. All in all, 'old initiatives' can also contribute to a CE in area development. Hence, when planning an area development, it is important to analyse what is already in the area and if it contributes to a CE, it should be safeguarded or kept close (North, 2010). This is in agreement with a stepwise approach of planning tools, developed by Runhaar et al. (2009).

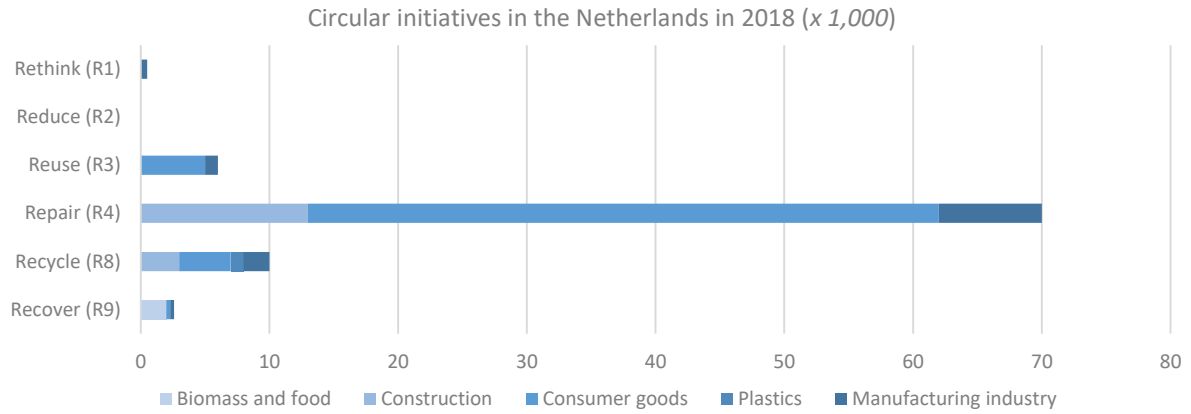


Figure 10 Circular initiatives in the Netherlands in 2018 (Adapted from PBL, 2019)

The implementation of a CE in area development has both economic, social and environmental benefits (EMF, 2019). Researches have shown that the integration of a CE at a meso-scale consists of the implementation and redesign of four systems: (1) industrial system, (2) infrastructure system that provides services, (3) cultural environment and (4) social consumption (Ghisellini et al., 2016; Ness, 2008). The industrial system forms the basis for the other three systems. The industrial system refers to the implementation of synergies and connections of material and energy flows, in other words, industrial symbiosis (IS) districts and networks (Ghisellini et al., 2016). In short, IS can be described as a system approach to sustainable and industrial activities, with the aim of creating energy and material cycles (Lombardi & Laybourn, 2012). Section 3.3.2 explains the principle of IS in more detail.

3.2.4 Conclusion

Firstly, this chapter investigates what area development is. Area development can be described as a complex process involving many stakeholders from both public and private parties, each with their own interests and influence on the process (Winch, 2010). In addition, there are various guidelines and frameworks that can be used to design and implement area development. According to Runhaar et al. (2009), every planning tool has a step-by-step plan. In this research, this step-by-step plan can play an essential part in formulating recommendations for creating a circularly functioning area.

Secondly, circular area development consists of a circularly designed environment and a circularly functioning environment, in which the use of resources and energy is minimized by closing, slowing down and narrowing cycles (EMF, 2017; Geissdoerfer et al., 2017). An important aspect of circular area development is that it is linked to the geographical area of a city, which refers to circularity in value chains, creating opportunities for high-quality reuse of resources and energy (EMF, 2017). This can be achieved through the creation of IS districts and networks.

Finally, 'old initiatives', such as craft companies, which have been established in an area for years are often not recognized as circular, while these companies do contribute to a CE (PBL, 2019). Therefore, during an area development it is important to look at what is already established in the area (Runhaar et al., 2009), how it can contribute to the CE, and if it contributes to the CE it needs to be safeguarded or kept close (North, 2010).

3.3 Networks in a circular economy

This section aims at answering the third sub-question: *"What is the network perspective of a circular economy?".* Firstly, this section covers a description of networks. Subsequently, industrial symbiosis (IS) is explained, since IS can be seen as a suitable approach for the implementation of a CE on a meso-scale. Thirdly, the barriers of IS have been identified and possible solutions have been described. Lastly, the importance of localism of activities is investigated.

3.3.1 Networks

A network, illustrated in figure 11, consists of three components that are interdependent: (1) actors, (2) resources and (3) activities. Actors are characterized by the activities they carry out and the resources which they manage. In addition, actors are connected with other actors via resources and activities. The activities of an actor are mainly structured on the basis of customers and suppliers. Activities between actors are described as exchange or transaction activities. Relationships between actors create valuable connections due to the fact that one actor has access to the resources of another actor (Harland, 1996).

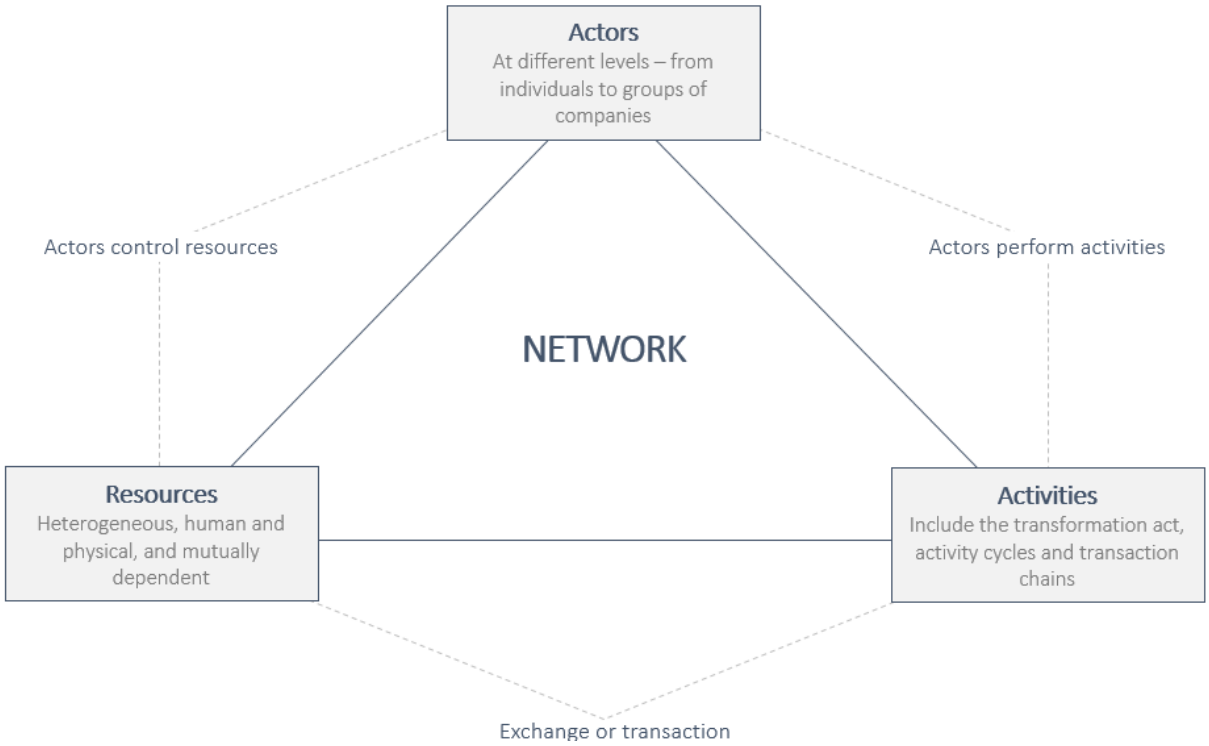


Figure 11 Network model (Adapted from Harland 1996)

Actors can contribute to a transition to a CE through close collaboration and coordination to create closed material cycles. Hereby, established companies must use innovations, create, deliver and capture value through the implementation of principles of a CE (Lahti, Wincent & Parida, 2018).

3.3.2 Industrial symbiosis

In section 3.2.3, industrial symbiosis (IS) is briefly discussed since the industrial system can be seen as the foundation for the implementation of a CE at meso-level and it refers to IS districts and networks (Ghisellini et al., 2016). IS has different definitions, but it is mainly about adding value to by-products and waste (Broere, 2016). Lombardi & Laybourn (2012) describe IS as a system approach of sustainable and industrial activities, with the aim of creating energy and material cycles. Central to this approach is the exchange of energy, water and by-products between traditionally separate organizations (Chertow, 2000). The goal is to create an industrial ecosystem in which energy and material consumption are optimized and waste is minimized. In other words, a system in which the waste from one company forms the input of another company (Broere, 2016), as represented in figure 12. According to van Berkel et al. (2009), the IS principle can be an adequate strategy to make cities more environmentally sustainable.

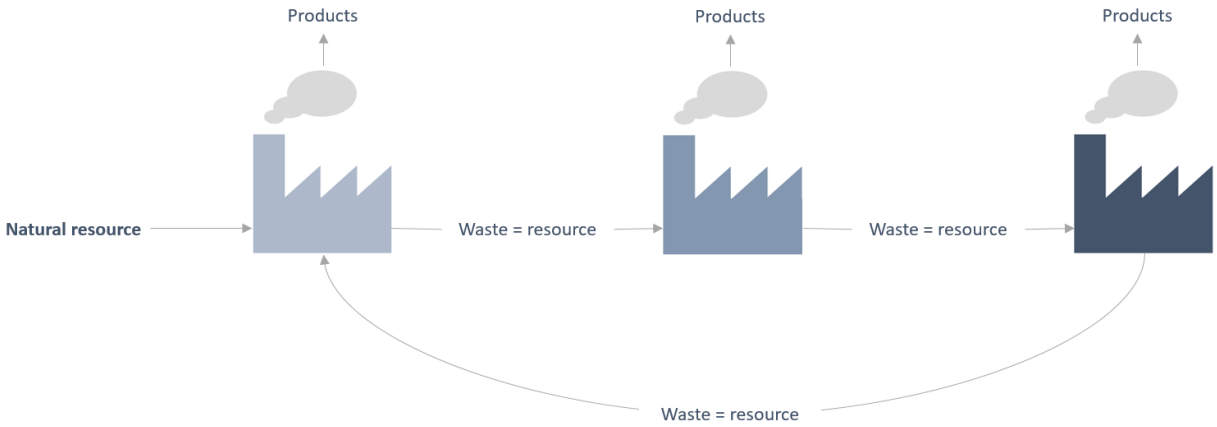


Figure 12 Principle of IS networks (Adapted from European Union, 2018)

In an IS approach, waste and by-products are physically exchanged between organizations that are active in various business sectors (Broere, 2016; European Union, 2018). The purpose of the transactions is to reuse waste and by-products (European Union, 2018). Due to these transactions, economic and ecological benefits arise (Boons et al., 2017). However, these economic and ecological benefits do not only arise from the transactions, but also depend on aspects such as the exchange of knowledge, expertise, capacity and logistics. It is therefore important that organizations involved in the waste and by-product exchange networks devise innovative ways to exchange. In addition, it is crucial that the value of the waste and by-products in the processes is maximized (European Union, 2018), for example by identifying which waste can be directly input for another activity.

3.3.3 Barriers of industrial symbiosis

The creation of IS can be described as a complex process because several stakeholders are involved with different interests (Sun et al., 2017). As a result, it is important to analyse all stakeholders for the creation of IS networks (Van Berkel et al., 2009). According to Fraccascia (2018), there are various barriers to the realisation of IS, namely; technical, informational, and economic barriers.

For technical obstacles, first, a minimal amount of waste is required (Ohnishi et al., 2017). Once the amount of waste is less than the minimum required amount, actors are not prepared to apply IS (Fraccascia, 2018). Secondly, the stability of waste streams is important as the amount of waste can change per period, resulting in possible inefficiencies from an operational perspective. Therefore, constructing an urban waste recycling system is essential. The urban waste recycling system can be applied to collect sufficient waste and then deliver it to the designated actor (Dong et al., 2013).

From the perspective of information barriers, due to lack of data, actors are sometimes not aware of the type, quantity and production rate of waste in a specific area (Dong et al., 2016). To solve this barrier, governments can establish online information platforms in which data is collected about the supply and demand of waste in the relevant area. The data can then be shared with local companies to stimulate IS (Fraccascia, 2018).

For economic barriers, actors generally find investments in IS risky because of the fluctuation of available waste per period, which has an impact on revenues (Van Berkel et al., 2009). In addition, some new products are cheaper to purchase compared to the reuse of waste (Cao et al., 2017). To overcome these obstacles, governments can implement policies and financial incentives to encourage IS. By introducing mandatory recycling targets for waste for cities (Dong et al., 2013), introducing taxes on environmental emissions (Dong et al., 2016) and making financial subsidies available (Dong et al., 2013), governments stimulate actors to set up IS networks (Fraccascia, 2018).

3.3.4 Geographical location of actors

A crucial factor in IS processes is the geographical location of the industrial actors. In other words, the location of the different participating companies in relation to each other (Chertow, 2000). This fact is in agreement with a CE, since North (2010) claims that a CE should strive for more local activities. To organize the exchange of the physical residual flows as efficiently as possible, the network need to consists as much as possible of actors located in the same area (Broere, 2016). Because geographical distances between actors are small, residual flows can be transported more efficiently to another actor, which is following the principle of a CE (Lahti, Wincent & Parida, 2018).

Localism of activities, however, cannot be seen as the end of global networks. More specifically, localism must be focused on production that is done as locally as possible, with the shortest possible distance between the actors. Global trade only serves as an alternative to goods and services that are not produced locally (North, 2010). It is an illusion that there will be no worldwide exchange of products in a CE. Therefore, in a CE, certain regions and areas will specialize in specific activities (Burger et al., 2019), such as the production of Volkswagens in Wolfsburg. In other words, not everything needs to be produced locally since it is better for some products or services, from an environmental point of view, to keep them in another external region (North, 2010). It is, however, important that local specialities give the region the opportunity to develop new CE activities. The new CE activities subsequently can have an impact on increasing employment opportunities in the region and, moreover, contributing to knowledge development in the area (Burger et al., 2019).

With regard to IS, it is important to note that, according to Chertow (2000), IS cannot be created within strict boundaries. It is impossible to optimally reuse all residual flows from an area with IS processes. The area of IS can also be placed in a network with another industrial system in order to transfer residual flows to other areas. Residual flows that cannot be reused within a network can be transferred to other IS areas. This creates three different scales of industrial networks. Firstly, the level of the industrial actor itself (e.g. a company). At this level, the actor makes plans to minimize ecological impact. Secondly, the inter-firm level, this is the level of eco-industrial parks where different companies work together and at this level IS takes place between different actors. Finally, there is the regional/global level (Broere, 2016; Chertow, 2000), in which international trade only happens if the product or service is not available in its own internal region (North, 2010).

3.3.5 Conclusion

First of all, a network consists of three interdependent aspects: (1) actors, (2) resources and (3) activities (Harland, 1996). Actors can contribute to a transition to a CE through close collaboration and coordination to create closed material cycles. IS can be seen as a suitable approach to realise this (Ghisellini et al., 2016). In this approach, the aim is to optimize energy and material consumption and to minimize waste (Chertow, 2000). Due to transactions within IS, economic and ecological benefits arise. However, next to transactions, aspects such as the exchange of knowledge, expertise, capacity and logistics are also important in order to achieve benefits from IS (European Union, 2018).

Secondly, a crucial factor where should be strived for in a CE is that actors who perform activities need to be situated nearby each other, or in other words, as local as possible (North, 2010). This reduces, among other things, the distance of transport. Localism must be aimed at localizing production and the presence of services as locally as possible. International transactions only serve as an alternative if the required products or services are not available in the local region. Moreover, from an environmental point of view, it is also better to keep certain products or services in external areas (North, 2010). As a result, different regions in a CE will more or less specialize in specific activities. However, it is important that local specialities offer the possibility to realize new CE activities in the area. The new activities must thereby contribute first to increasing employment opportunities and, secondly, contribute to knowledge development (Burger et al., 2019).

3.4 Urban metabolism

This section focuses on the fourth sub-question of this research: *'What is the principle of urban metabolism?'.* First, the principle of urban metabolism is explained and thereafter, the benefits are discussed. Secondly, the MEFA tool is investigated, which is often used to analyse urban metabolism in cities.

3.4.1 Urban metabolism

The majority of the world's population will live in cities within a few decades (United Nations, 2015). As a result, the ever-growing cities will increasingly be responsible for global energy and material consumption. Every city consists of flows of goods, services, materials and energy in defined locations. The network of all flows in cities can be described as urban metabolism (UM)(Dijst et al., 2018). The principle of UM contains concepts that are combined from different school of thoughts, such as ecology, industrial ecology, political economy, ecological economy and urban planning (Broto, Allen & Rapoport, 2012; Kennedy, Pincetl & Bunje, 2011). UM can be formulated as: 'the total sum of the technical and socio-economic processes that take place in cities, resulting in growth, production of energy and elimination of waste' (Pincetl, Bunje & Holmes 2012; Kennedy et al., 2011). In other words, the concept of UM focuses on balancing the urban demand for resources and energy in relation to the finite supply of raw materials of the earth (Pincetl et al., 2012).

According to Broto et al. (2012), the UM approach consists of six parts and each part formulates own insights. These parts consist of: (1) the city as an ecosystem, (2) material and energy flows in a city, (3) economic and material connections in a city, (4) economic elements of the relationship between countryside and city, (5) reproduction of urban inequality, and finally (6) attempts to identify the city through new visions of socio-ecological relationships. The added value of the six different parts is that each component can be used to better understand the principle of UM. On the basis of an UM approach, decision-makers involved in sustainable area developments can identify possible solutions to decrease pressure on the environment in the city, while improving the quality of life (Pincetl et al., 2012).

There are several benefits that arise from applying an UM approach in cities. First of all, the advantage of UM is that it can contribute to a transition to a CE, since UM focuses on reducing the current consumption of urban resources by creating closed cycles (Ness & Xing, 2017). Secondly, UM has system boundaries for an analysis. In other words, the boundaries of a defined area (e.g. a city) are quantified. In addition, an UM approach is a suitable analysis for policy choices (e.g. in area development) and technology developments (e.g. in the production process) regarding sustainability goals. Finally, the principle of UM links social aspects (e.g. overweight of the population) with technological aspects (e.g. use of cars in a city)(Kennedy et al., 2011).

3.4.2 Material and energy flow analysis

In general, UM is studied by using a material and energy flow analysis (MEFA) to analyse the flows of energy and materials in a city (Pincetl et al., 2012). Pincetl et al. (2012) have developed a framework for MEFA that consists of human-, social-, policy-, economic- and related systems. By examining all systems in a MEFA, a better understanding of the functioning of the urban material and energy flows is created and, moreover, a better insight of the context of all flows in the city is created (Pincetl et al., 2012).

MEFA can be used to investigate which changes have been caused by social-economic activities in systems. In addition, it is possible to investigate the socio-economic considerations that have stimulated the changes and how the considerations are influenced (Haberl et al., 2004). In this context, the ecosystem consists of metabolism materials and energy exchange. In this ecosystem, materials and energy are absorbed, converted, stored, recycled and possibly put back into nature (Bringezu, Schütz & Moll, 2003). MEFA can be used for three different purposes. First, it can be used to analyse the structure of a specific material flow in an ecosystem. Secondly, a MEFA can serve as research into the importance and relevance of flows and stocks in an ecosystem. Finally, it can also be used to manage flows to achieve sustainable goals (Suh, 2005).

With regard to the different types of flows in a city, Dijst (2013) identified different types of urban processes. These different types of urban processes are depicted in figure 13 and differ in pace of change. For example,

there are slow and very slow processes such as land use and the long life cycle of housing, workplaces and other non-residential buildings. On the other hand, there are extremely and very fast processes, such as the development of ICTs and the daily mobility flows of people and goods. Between the very fast and slow processes are the changes in employment opportunities and household composition (Dijst et al., 2018).

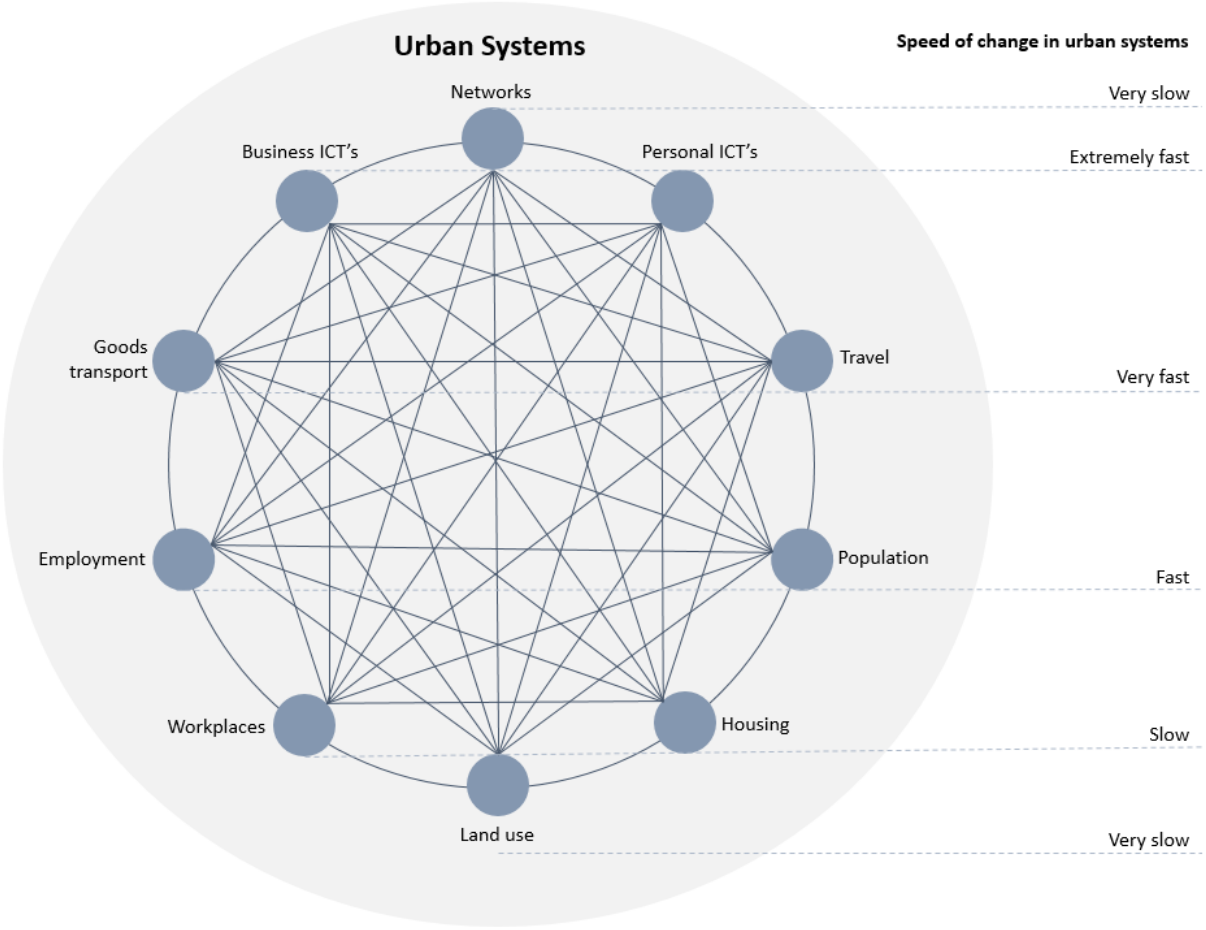


Figure 13 A flow perspective on urban systems (Adapted from Dijst, 2013)

The use of a MEFA has the advantage that it visualises a network structure of a city. Moreover, a MEFA provides the basic data of a network, and this data can be used at a later stage for the optimization of the process (Suh, 2005). In addition, in combination with other tools, such as a life cycle analysis (LCA), a MEFA can investigate the influence of certain materials of energy in a city in order to improve the associated processes, from an environmental point of view.

3.4.3 Conclusion

UM analyses all flows of socio-economic processes that enter and leave an area or city. UM focuses on reducing the current consumption of urban resources by realizing closed cycles, which is in accordance with the principle of a CE (Ness & Xing, 2017). However, to create closed cycles, the different flows in a city must be known. MEFA can be used to visualize the flows within a city. In addition to the advantage that an MEFA visualises the flows and networks in a city, the data of flows and networks can be used to optimize the processes (Suh, 2005). Process optimization can then contribute to closing cycles. In addition, a MEFA can be used to investigate the influence of a certain material or energy in a city, so that interdependent processes can be improved with regard to closing cycles.

CHAPTER 4

CASE STUDY AND INTERVIEWS

4 CASE STUDY AND INTERVIEWS

In this chapter a case study is conducted to gather empirical evidence about circular area development in practice. First, the case study is introduced, and thereafter, the vision of the municipality concerned with regard to sustainability and circularity is described. Thirdly, the various sub-areas of the case study are discussed. Fourth, an activity based spatial material flow analysis (AS-MFA) from 2013 and 2018 of the case study is analysed. Subsequently, the analyses of the case study and interviews clarified the challenges and tensions that arise from circular area developments at different scales. Finally, a conclusion from the case study is formulated, and furthermore, predictions have been determined for the circular functioning of the area in the future.

4.1 Noordelijke IJ-oever West, Amsterdam

In this section, first of all, the area of the case study is introduced. Moreover, the development plan for the area are described. Subsequently, the history and origin of the Noordelijke IJ-oever is shortly outlined.

4.1.1 Area development Noordelijke IJ-oever West

The bank of Amsterdam-North that stretches between the Noordhollands Kanaal and Zaanstad is called Noordelijke IJ-oever West. Figure 14 shows the location of the area on a large scale, while figure 15 illustrates the location of the plan area in Amsterdam-North. Noordelijke IJ-oever West has a total surface area of 405 hectares, of which 250 hectares of land and 155 hectares of water (AlleCijfers.nl, n.d.).

Figure 14 Location of Amsterdam

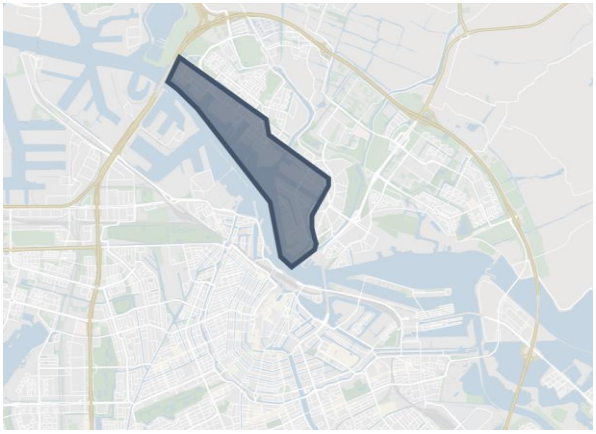


Figure 15 Location of Noordelijke IJ-oever in Amsterdam-North

The municipality of Amsterdam is working with developers and corporations on a metamorphosis of Noordelijke IJ-oever. In the coming years, old factory halls and workplaces will make way for mixed urban districts (NUL20, 2017). In 2003 the plans for the transformation of an industrial area into mixed city districts were already described in a master plan (BVR, 2003). However, due to the economic crisis from 2008 until 2014, the area development has not started completely. Since the end of the economic crisis in 2014, both the European and the Dutch economy have continued to grow (Rijksoverheid, 2019). In addition, Amsterdam is struggling with a considerable housing shortage (Capital Value, 2019). Due to the housing shortage and the current economic situation, the area development of Noordelijke IJ-oever has resumed. As a result, several dwellings have already been realized in recent years. This is confirmed by data from AlleCijfers.nl (n.d.): the number of inhabitants in Noordelijke IJ-oever West increased by 2,821 inhabitants from 1,234 in 2013 to 4,055 in 2019. This is an increase of 228% in six years.

4.1.2 History and origin Noordelijke IJ-oever West

Around 1800 the area was still water, part of the IJ. The shallow water and the land outside the dykes were then drained, making the IJ a lot smaller. This new land was meant for agriculture. However, due to the pressure of the city, the new created land soon took on a different function. Industrial sites were built, canals were dug and shipbuilding grew within the area. The tuindorpen were located behind the Noordelijke IJ-oever, where most of the workers lived (BVR, 2003).

Figure 16 Noordelijke IJ-oever West around 1970 (Gemeente Amsterdam, n.d.)

The close relationship between North and IJ came to an end when shipbuilding largely disappeared in the 1970s and 1980s, and ports and industry were increasingly shifted to the west due to scaling up (BVR, 2003; Gemeente Amsterdam, 2019a). Slowly new companies have arrived, on vacant plots of land and between companies that have remained. In some cases, these companies are still dependent on the water for transport. Because these 'new' companies are usually much less harmful to the environment and require less space than the old industry, housing construction in parts of Noordelijke IJ-oever can now be considered for the first time (BVR, 2003).

Figure 17 Shipbuilding NDSM (NDSM, 2019)

Figure 18 Shipbuilding NDSM (GAN, n.d.)

Figure 19 Noordelijke IJ-oever West around 1970 (Huissen, 2015)

4.2 Sustainability and circularity in Amsterdam

This section is divided into three parts. The first part consists of an analysis of the vision of the municipality of Amsterdam for sustainability and circularity. In the second and third part of this section, the area development strategies of both Buiksloterham and Haven-Stad are investigated and described. The main focus is on how the municipality of Amsterdam wants to implement sustainability and circularity in both areas. Hereby, it is important to note that, during this research, insufficient information is available about the area development of the other sub-areas located in Noordelijke IJ-oever West. Therefore, only the strategies of Buiksloterham and Haven-Stad have been investigated.

4.2.1 Vision of the municipality of Amsterdam with regard to sustainability and circularity

Amsterdam Circulair

In its sustainability agenda from 2014, the municipality of Amsterdam has fully focused on the circular economy as a pillar of sustainability policy. Following the sustainability agenda, the City of Amsterdam, in collaboration with Circle Economy, TNO and Fabric, has published a vision and roadmap for the city and region to create a circular Amsterdam (Gemeente Amsterdam, Circle Economy, TNO & Fabric, 2015). In this report, seven aspects have been formulated that the municipality of Amsterdam is focusing on for creating a circular economy within the city. Firstly, there is no waste in a circular economy, so that all materials in and around Amsterdam end up in an infinite technical or biological cycle. Secondly, all energy comes from renewable sources. Thirdly, raw materials are used to generate value. The fourth principle is implementing modular and flexible designs. This allows products and production chains to increase the adaptability of systems. Fifth, there will be a transition from ownership of goods to services. This requires new business models for production, distribution and consumption. Sixthly, the municipality of Amsterdam will change the logistics system, in which are more region-oriented service and returns logistics. Finally, human activities contribute to ecosystems and ecosystem services and the reconstruction of natural capital (Gemeente Amsterdam et al., 2015).

Circulair innovatieprogramma 2016-2018

In addition to the report 'Amsterdam Circular', the Circular Innovation Program 2016-2018 has been published to provide insight into the most important innovations and developments in the field of circularity and the way in which Amsterdam anticipates to this. The circular innovation program is the joint deployment of knowledge institutions, companies and the municipality of Amsterdam that reinforces and accelerates innovation, research and circular activity. To achieve this, the innovation program states that innovations in the city should be encouraged, such as circular living labs to test innovations in the physical city (Gemeente Amsterdam, 2016a).

Programma Duurzame Gebiedsontwikkeling

The report 'Programma Duurzame Gebiedsontwikkeling' has been in existence since 2018 and, through all projects, managements and domains in Amsterdam, contributes to the spatial development of a future-proof city. In this program, area development is described as the (re)development of a location into a new area in which all kinds of functions such as living, working, retail, infrastructure, social facilities, green areas and recreation come together (Gemeente Amsterdam, 2019b). In this report, a total of six principles of sustainable area development have been drawn up by the municipality of Amsterdam. Firstly, sustainable area development must contribute to cleaner air, soil and water. Secondly, sustainable area development makes the city greener, quieter and more energy-efficient. The third principle is that Amsterdam uses the limited land in the city as optimally as possible. Fourthly, as many raw materials and materials as possible are reused in new construction projects. Fifthly, sustainable area development uses renewable energy sources as much as possible for the electricity and heat supply. Finally, climate change is taken into account during sustainable area development (Gemeente Amsterdam, 2019b).

In addition, Programma Duurzame Gebiedsontwikkeling contains six different themes that should be focused on during area developments. The six previously mentioned principles for sustainable area development are reflected in the themes. The six different themes are shown and explained in table 6.

1. Sustainable energy and a city without natural gas	2. Cleaner air through emission-free mobility
Amsterdam has the ambition to be free of natural gas by 2040. Natural gas is responsible for an important part of CO2 emissions, and therefore, for global warming. The goal is to have 55 percent less CO2 emissions by 2030 and 90 percent less by 2050. That is why natural gas-free construction is being carried out in the area development and solely focused on sustainable energy. 	Traffic in the city is one of the major air polluters. That is why there are environmental zones to keep out most of the polluting traffic. Amsterdam encourages electric transport, among other things, by creating a network of electric charging points. The municipality also encourages car sharing. In the area development, the city wants to give priority to cyclists and pedestrians. 
3. Climate adaptation	**4. Building green and nature-inclusive**
The climate is changing. The summers are getting hotter and drier and there are more and more extreme rain showers. By designing and building climate-proof public spaces and homes, Amsterdam is preparing itself for climate change. Examples are infiltration strips, more green, blue-green roofs for water storage and the installation of strategic differences in height for effective water drainage. 	It is important that the greenery in the city grows with the city. That is why the urban nature receives special attention in all plans for housing. It enables the municipality to improve and expand existing green spaces. 
5. Circular construction	**6. Waste and raw materials**
Amsterdam wants to be fully circular by 2050: all raw materials and materials will then be reused. For area development, this means that only recycled and reusable materials are used, that construction is flexible and removable and that strict environmental performance values apply, which means that Amsterdam sets a high standard for the sustainability of buildings. 	Amsterdam wants the creation of waste to be prevented as much as possible. If that is not possible, the raw materials from the waste are reused. That is why the municipality is investing in waste separation and installations to extract raw materials from the waste. So that Amsterdam will be a circular city in 2050. For area development, this means, among other things, that sufficient space is reserved for separate waste collection when designing public space in new or renewed areas. 

Table 6 Six themes of sustainable area development in Amsterdam (Own table, based on Gemeente Amsterdam, 2019b)

4.2.2 Buiksloterham: analysis of area development strategy concerning sustainability and circularity

Vision on sustainability and circularity

Buiksloterham is part of the redevelopment of Noordelijke IJ-oever and the concept of the area development is shown in figure 20. The neighbourhood will be an example for circularity and sustainability (Gemeente Amsterdam, 2019a). In the report 'Circular Buiksloterham', a vision has been formulated to turn Buiksloterham into a circular area. The vision describes that Buiksloterham will become a neighbourhood where people are constantly experimenting and innovating. The culture will be socially diverse and will have a high degree of involvement from residents and entrepreneurs. A local and resilient economy will emerge where services and goods will be exchanged with money, time and local exchange systems. In addition, all energy will come from renewable sources. All products and materials will be recovered for reuse, repair and further recycling. The area will have a large biodiversity and has attractive streets and buildings (Gladek, van Odijk, Theuws & Herder, 2015).

Figure 20 Area development Buiksloterham (Gemeente Amsterdam, n.d.)

The following starting points form the ambition that is being pursued during the Buiksloterham area development (Gladek et al., 2015):

- The area is self-sufficient in energy and based on renewable energy;
- The area is a 'zero waste' neighbourhood with as much closed material flows as possible;
- The area is rain proof and extracts nutrients from waste water;
- Ecosystems in the area are being regenerated;
- Infrastructure in the area is used maximally in function and the local zero emission mobility causes no harmful emissions;
- The area is a diverse, liveable and inclusive residential area;
- The area contributes to the local economy and promotes entrepreneurship;
- The area involves residents and companies in local investments and value development;
- The area is a healthy, safe and attractive environment with space recreation and relaxation.

Implementation of sustainable and circular principles in Buiksloterham

The report 'Investeringsnota Buiksloterham 2019' describes how circularity will be realized in the area for various components. These components consist of (1) raw materials and materials, (2) waste collection, (3) energy, and (4) water (Gemeente Amsterdam, 2019a). For the raw materials and materials component, the main focus is on maximizing the reuse of raw materials and materials, with the least possible loss of value. This is done, for example, by introducing circular construction. More specific, flexible and adaptable buildings reduce the use of

resources and is therefore a starting point in Buiksloterham (Gemeente Amsterdam, 2019a; Gladek, van Odijk, Theuws & Herder, 2015). In addition, fifty percent of the materials for the construction of buildings must be recycled, and thirty percent must be renewable. Moreover, the design and layout of the public space are based on circular materials, such as parks, playgrounds, school yards, bridges and 30 km streets with recycled baked paving stones. The aim is to use eighty percent recycled or renewable materials. To encourage circular construction, circular tenders will also be held in Buiksloterham. This means that the subject of raw materials and materials is included as an important criterion in the tenders and the agreements with developers and construction companies (Gemeente Amsterdam, 2019a).

With regard to waste collection, the aim is to collect as much as possible separately from household and industrial waste in at least six fractions: glass, paper, textile, plastic, vegetable-fruit-food waste, and residual waste (Gemeente Amsterdam, 2019a; Gladek et al., 2015). This will be done by placing underground waste containers for the different fractions at various locations in the public space of the area (Gemeente Amsterdam, 2019a).

The third part is energy use, whereby different attempts will be made to minimize energy use. First, Buiksloterham will be natural gas-free with energy-neutral or even energy-supplying buildings (Gemeente Amsterdam, 2019a; Gladek, van Odijk, Theuws & Herder, 2015). The buildings must optimally benefit from local renewable energy sources such as the sun, soil or surface water. In addition, the existing buildings in Buiksloterham must eventually switch to sustainable sources. Secondly, a smart grid will be realized. A smart grid is an electricity system that uses information, two-way traffic, communication technologies and computer intelligence to optimize energy generation, distribution and use. Thirdly, an energy-neutral public space will be created in Buiksloterham. Buiksloterham wants to generate sustainable energy use for street lighting, pumps and pumping stations. In addition, there will be a scan for locations to generate sustainable energy. Possible locations are roofs of existing buildings and above parking spaces (Gemeente Amsterdam, 2019a).

The final component focuses on the handling and use of water in the area. Enough greenery will be realized on both the plots and in the public space. In addition, water will be used smartly so that reuse is possible (Gemeente Amsterdam, 2019a; Gladek et al., 2015).

4.2.3 Haven-Stad: analysis of area development strategy concerning sustainability

Haven-Stad comprises the transformation of the western harbour areas within the A10 ring road and on both sides of the IJ, into a highly urban-working area. This concerns different areas that are directly and not directly linked to the water. The reason that Haven-Stad's area development strategy is analysed in this study is because the Cornelis Douwes area, which is part of Noordelijke IJ-oever, has been included in Haven-stad's area development. Haven-Stad has a total area of approximately 650 hectares (excluding water), is almost equal in size to the Centrum district (around 800 hectares) and is illustrated in figure 21.

Figure 21 Sketchy representation of Haven-Stad in 2040 (Gemeente Amsterdam, 2017)

Vision on sustainability

In the development strategy of Haven-Stad is stated that the sustainability objective is ambitious: Haven-Stad will be the sustainable city of tomorrow. Five objectives have been formulated to achieve this ambition (Gemeente Amsterdam, 2017):

1. Sustainable energy: 75% CO2 reduction compared to 2016, and between 85%-100% in 2050;
2. Emission-free mobility in 2029;
3. Water-resistant neighbourhoods: improvement of water storage in the area;
4. Raw materials: 50% re-use in public spaces and buildings in 2029, and 100% in 2050;
5. Raw materials: 65% separation of household waste, and 100% in 2050.

Implementation of sustainability in Haven-Stad

Based on the five objectives formulated, Gemeente Amsterdam (2017) has defined an approach for each theme. The first theme is sustainable energy. Sustainable energy, energy-neutral construction and natural gas-free developments are important parts of the sustainable development of Haven-Stad. By realizing energy-efficient buildings and making the heat and cold supply sustainable, major steps are being taken to reduce CO2 emissions. In addition, there is a focus on additional sustainable electricity generation in Haven-Stad (Gemeente Amsterdam, 2017).

Theme number two, emission-free mobility, focuses on the use of public transport and bicycles in order to reduce the use of cars within the area. As a result, Haven-Stad is trying to prevent the adverse effects on air quality in and around the plan area. The ambition is emission-free mobility: Haven-Stad becomes part of the environmental zone. This means that old and polluting vehicles are not allowed in the area and are not eligible for a parking permit (Gemeente Amsterdam, 2017).

Thirdly, Haven-Stad will become water-resistant. That means a combination of ensuring the right groundwater level, to be able to build and grow trees, and to take measures for a rain-proof city. Showers are getting heavier and rainwater has to be collected mainly in the subareas. By temporarily storing rainwater in the area or discharging it into the surface water, the sewer system has enough time to drain the water (Gemeente Amsterdam, 2017).

The fourth theme is circular construction to use raw materials efficiently. Flexible and adaptable building are introduced to achieve the re-use of raw materials. In addition, the public space is also designed and arranged according to circular principles so that the reuse of raw materials becomes possible (Gemeente Amsterdam, 2017).

Finally, the fifth theme focuses on the transition from waste to raw material. This is aimed at reusing waste as much as possible. The objective is 65% separation of (household) waste in 2020 and 100% in 2050. Furthermore, the following principle applies to Haven-Stad: ‘no waste on the street’. For household waste, the municipality wants to promote source separation, with good facilities for recyclable raw materials. Due to the high building density, the waste containers would dominate the streets. That is why temporary storage of waste is being moved from public space to buildings (Gemeente Amsterdam, 2017).

4.3 Sub-areas of Noordelijke IJ-oever and the associated programs

This section provides a global overview of the programs in the sub-areas of Noordelijke IJ-over West in 2013, 2018 and the expected future. As shown in figure 22, Noordelijke IJ-oever West can be divided into the following four different neighbourhoods; (1) Cornelis Douwes, (2) NDSM-werf, (3) Buiksloterham, and (4) Overhoeks. In the first instance, all sub-areas are analysed individually. Subsequently, all data is collected together to provide insight into the changes in the entire area. The information and data collected serves as input for the in-case analysis in section 4.5 and the conclusions in section 4.6. This involves, among other things, investigating the consequences of the changes in the program with regard to the circular functioning of the area.

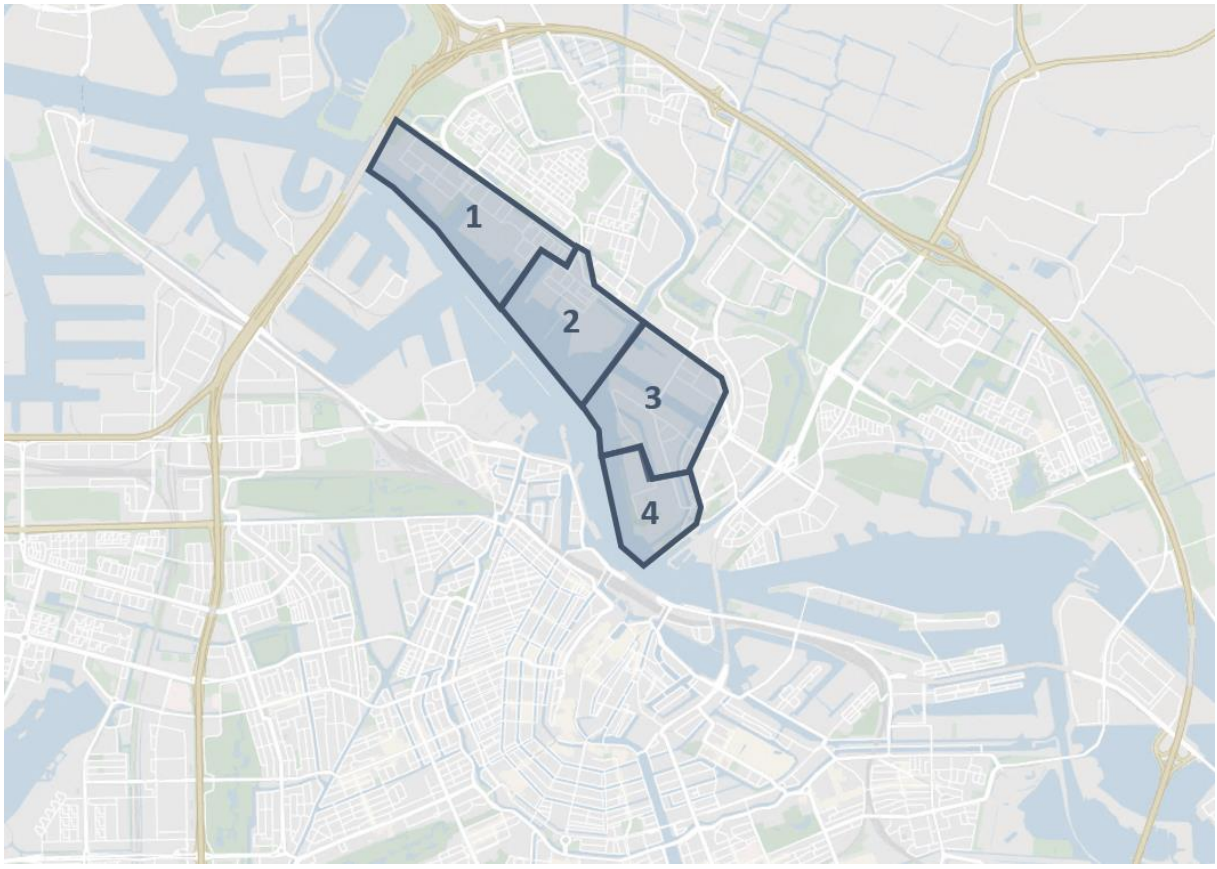


Figure 22 The four different neighbourhoods in the Noordelijke IJ-oever West

4.3.1 Cornelis Douwes

On Cornelis Douwes, housing development up to 2029 is not possible, as determined in the Houthavens/NDSM Covenant (Gemeente Amsterdam, 2017; NUL20, 2017). The existing Mebin concrete plant limits the possibilities to realize housing on the western part of the site of Cornelis Douwes. In addition, the possibility of housing depends on the future of the company Damen. The Damen Shipdock company has environmental category 5. The environmental category is a classification of the load that a (business) activity can have on the environment, with category 1 being the lowest and category 6 being the highest. The shipyard of Damen Shipdock forms a cultural-historical heritage and plays an important role in the development of Cornelis Douwes into an urban living and working area. Two development scenarios have been determined for the area (Gemeente Amsterdam, 2017):

- A mix of living and water-related activities. Damen Shipdock is relocated in its entirety. The municipality and the port authority are investigating the possibility of a suitable location within Westpoort.
- A compact yard. By taking source measures at Damen Shipdock, the environmental contour is reduced so that business can continue to take place alongside housing. Perhaps a part of the yard can become a public experience centre, so that the yard becomes more part of the environment.

	2013	2018	Future
Population	0	0	
Number of dwellings	0	0	16,500
Number of jobs	3,947	3,099	11,000
Companies (trade, industry, construction, repair, etc.)	*2,707*	*1,850*	
Horeca	*0*	*0*	
Office	*926*	*885*	
Services (police, education, healthcare, etc.)	*314*	*364*	
Number of branches	233	273	
Companies (trade, industry, construction, repair, etc.)	*50*	*64*	
Horeca	*2*	*2*	
Offices	*80*	*94*	
Stores	*6*	*7*	
Minerals	*0*	*4*	
Other	*95*	*102*	
GFA in m^2		279,839	1,650,000
Number of schools		0	11
Number of care centres		0	12
Site for organized sports in m^2		0	82,500

Table 7 Overview of the program of Cornelis Douwes in 2013, 2018 and the future (Own table, based on Gemeente Amsterdam, 2017; Gemeente Amsterdam, 2020a)

4.3.2 NDSM-werf

Because of its location along het IJ and the short distance to the city centre, the NDSM site has the potential to be transformed into a highly mixed area for living, working and facilities. Business remains an important activity within the NDSM area. Due to the fact that sensitive functions are permitted in the plan area (e.g. residential building), heavy companies are not allowed to establish a business in future in order to prevent potential environmental nuisance. The starting point for the transformation is that existing companies must be able to continue to conduct their business without hindrance, as a result of which housing construction is not permitted in places where this would limit the required environmental space of companies (Gemeente Amsterdam, 2012).

	2013	2018	Future
Population	413	1,174	
Number of dwellings	385	765	4,000
Number of jobs	2,403	2,989	
Companies (trade, industry, construction, repair, etc.)	*1,008*	*689*	
Horeca	*104*	*347*	
Offices	*1,099*	*1,695*	
Services (police, education, healthcare, etc.)	*192*	*258*	
Number of branches	245	351	
Companies (trade, industry, construction, repair, etc.)	*31*	*26*	
Horeca	*11*	*15*	
Office	*106*	*172*	
Stores	*4*	*8*	
Minerals	*1*	*3*	
Other	*92*	*127*	
Office space in m^2		79,450	112,515
Site for organized sports in m^2		0	4,900

Table 8 Overview of the program of NDSM-werf in 2013, 2018 and the future (Own table, based on Gemeente Amsterdam, 2012; Gemeente Amsterdam, 2020; AlleCijfers.nl, n.d.)

4.3.3 Buiksloterham

Buiksloterham is classified as a future productive neighbourhood. Productive neighbourhoods are mixed residential-working areas where businesses and housing are integrated into a mixed and vibrant urban environment. Productive neighbourhoods are intended to preserve productive activity for the city and to prevent spatial sorting of business space by rental price level (productive companies are often dependent on a relatively low rental price). The business premises are used for production, repair and for the storage and transhipment of goods and has many manifestations such as crafts, recycling, knowledge-intensive industry, logistics, garage and installation companies. Hybrid forms are also possible, with combinations of business space and office. In Buiksloterham, the general principle is that at least 20% of the program is reserved for activity and a maximum of 70% is reserved for housing (Gemeente Amsterdam, 2019a).

In the zoning plan of Buiksloterham is very limited space for new retail: a maximum of 500 m2 throughout Buiksloterham. However, because additional homes are being realized in the area, it has been decided to reserve an extension space of 4,000 m2 GFA for retail in the Klaprozenbuurt (Gemeente Amsterdam, 2019a).

	2013	**2018**	**Future**
Population	24	182	
Number of dwellings	7	52	8,575
Number of jobs	1,649	1,919	8,000
Companies (trade, industry, construction, repair, etc.)	*926*	*814*	
Horeca	*0*	*27*	
Offices	*523*	*918*	
Services (police, education, healthcare, etc.)	*200*	*160*	
Number of branches	277	371	
Companies (trade, industry, construction, repair, etc.)	*29*	*30*	
Horeca	*2*	*5*	
Office	*144*	*192*	
Stores	*3*	*12*	
Minerals	*5*	*4*	
Other	*94*	*128*	

Table 9 Overview of the program of Buiksloterham in 2013, 2018 and the future (Own table, based on Gemeente Amsterdam, 2019a; Gemeente Amsterdam, 2020a)

4.3.4 Overhoeks

Overhoeks will be a new city district on the former Shell Research site opposite Amsterdam Central Station. The future program consists of 70% homes and 30% other functions. The category 'other functions' can be subdivided into approximately 33,000 m² GFA of office and business space and approximately 100,000 m² GFA provisions. In addition to the living and working functions, the area will also be provided with entertainment and cultural facilities (Gemeente Amsterdam, 2016b).

The public places along het IJ and the park will mainly be used for facilities in the field of hospitality and culture. Together, these functions can offer good opportunities to attract other facilities. Cafes and restaurants should preferably be able to benefit from the view over het IJ. In addition, the arrival of cultural institutions with an (inter)national reputation, such as the EYE, contributes to the reputation and popularity of the location. Visitors to these cultural institutions increase the liveliness and provide more customers for the hospitality industry and other functions (Gemeente Amsterdam, 2016b).

	2013	2018	Future
Population	606	1,361	
Number of dwellings	356	696	2,800
Number of jobs	1,260	1,883	2,000
Companies (trade, industry, construction, repair, etc.)	*29*	*40*	
Horeca	*0*	*233*	
Offices	*1,104*	*1,298*	
Services (police, education, healthcare, etc.)	*127*	*312*	
Number of branches	62	263	
Companies (trade, industry, construction, repair, etc.)	*1*	*2*	
Horeca	*1*	*8*	
Office	*39*	*166*	
Stores	*1*	*2*	
Minerals	*1*	*5*	
Other	*19*	*80*	

Table 10 Overview of the program of Overhoeks in 2013, 2018 and the future (Own table, based on Gemeente Amsterdam, 2016b; Gemeente Amsterdam, 2020a)

4.3.5 Sub-areas added together: Noordelijke IJ-oever West

In this section, all tables from the analysed subareas are combined with each other. Table 11 shows the combined data for both 2013, 2018 and the future (if known). From the table, it can be concluded that all parts, with the exception of the number of jobs for companies specialized in trade, industry, construction, maintenance and repair, have risen between 2013 and 2018. Partly due to the transformation from the industrial area into a mixed-area, several of these types of companies disappear from the area. As a result, these types of companies have less work to offer in Noordelijke IJ-oever West. However, the counter-argument can be given that the number of such companies increased between 2013 and 2018, but between these years mainly large companies disappeared and small companies returned to the area. For example, in Buiksloterham larger companies with a high environmental category have disappeared between these dates (Gemeente Amsterdam, 2019a).

In addition, the number of square meters of these types of companies will decrease in future. A good example of this is described in section 4.3.1, wherein two options for Damen Shipdock are described; (1) Damen Shipdock will be relocated in another area, or (2) the environmental contour is reduced and part of the site will be used as a public experience centre.

	2013	2018	Difference '13-'18	Future
Population	1,043	2,717	+ 160%	
Number of dwellings	748	1,513	+ 102%	31,875
Number of jobs	9,259	9,890	+ 7%	21,000 +
Companies (trade, industry, construction, repair, etc.)	*4,670*	*3,393*	*- 27%*	
Horeca	*104*	*607*	*+ 483%*	
Offices	*3,652*	*4,796*	*+ 31%*	
Services (police, education, healthcare, etc.)	*833*	*1,094*	*+ 31%*	
Number of branches	817	1,258	+ 54%	
Companies (trade, industry, construction, repair, etc.)	*111*	*122*	*+ 10%*	
Horeca	*16*	*30*	*+ 88%*	
Office	*369*	*624*	*+ 69%*	
Stores	*14*	*29*	*+ 107%*	
Minerals	*7*	*16*	*+ 129%*	
Other	*300*	*437*	*+ 46%*	

Table 11 Overview of the program of Noordelijke IJ-oever West in 2013, 2018 and the future (Own table, based on data from table 7, 8, 9 and 10)

4.4 Material flow analysis of Noordelijke IJ-oever West

In this section, activity based spatial material flow analysis (AS-MFA) of construction and demolition waste from Noordelijke IJ-oever West for the years 2013 and 2018 are analysed. Firstly, the AS-MFA of construction and demolition waste is introduced. Subsequently, the AS-MFAs of CDW from 2013 and 2018 are analysed in order to gain insight into the context of the flows in the area. Finally, the analyses of the AS-MFAs from 2013 and 2018 are compared with each other to show how the production and treatment of construction and demolition waste in the area are developed and what the consequences are for Noordelijke IJ-oever West.

4.4.1 Introduction AS-MFA of construction and demolition waste

REPAiR has conducted several AS-MFAs in the field of waste and resource management in different countries and territories. The AS-MFAs make it possible to identify both local and regional challenges. Eco-innovative solutions can then be devised for these challenges (REPAiR, 2016), since the data from an AS-MFA can be used to improve processes (Suh, 2005). One of the AS-MFAs that has been carried out focuses on construction and demolition waste (CDW), which was, among other regions, carried out in the Amsterdam Metropolitan Region, with a special focus on the port areas. REPAiR uses the following definition of CDW: *''Any substance or object, arising out of construction and demolition work, which the owner of the substance discards, intends or required to discard''* (REPAiR, 2017, p. 36).

Since the case study of this study is localized in Amsterdam, an AS-MFA is available from CDW in Amsterdam and on top of that CDW is one of the key waste fractions in Amsterdam (REPAiR, 2016), in this study it is decided to apply AS-MFAs of CDW in a part of the port area of Amsterdam. This part of the port area has already been previously introduced in this chapter, namely Noordelijke IJ-oever West. The AS-MFAs used for this study comprise two parts; (1) production of waste (input), and (2) treatment of waste (output). Appendix IV of this research contains the data from the AS-MFAs concerning the input and output of CDW. The data of both input and output includes the following aspects; origin, origin code, destination code and amount of waste in tons per year.

4.4.2 Noordelijke IJ-oever West: AS-MFA of CDW in 2013

Production of construction and demolition waste in 2013

In 2013, a total of 75,586,882 tons of CDW came from 42 different actors. No less than 57.9% of the CDW that entered the area has been sorted and separated, 19.5% of the waste has been broken/decomposed and 13.1% of the waste (mainly soil) has been cleaned. In addition, 5.6% of the CDW has been stored to eventually be transported to other areas. Figure 23 represents the origin of the CDW on a regional scale, while figure 24 illustrates the origin of the CDW on a local scale. Figure 23 shows that the majority of CDW originates from the Amersfoort area. In comparison to other areas, a relatively large amount of CDW also comes from the areas around Haarlem, Utrecht, Leiden and Middenmeer. On a smaller scale (figure 24) it can be noted that the majority of CDW is transported to the subarea Cornelis Douwes in 2013. Moreover, it can be observed that most of the actors, which receive the CDW, are located along the water.

Figure 23 Flow map of the production of CDW on a regional scale in 2013 (Sileryte et al., 2020)

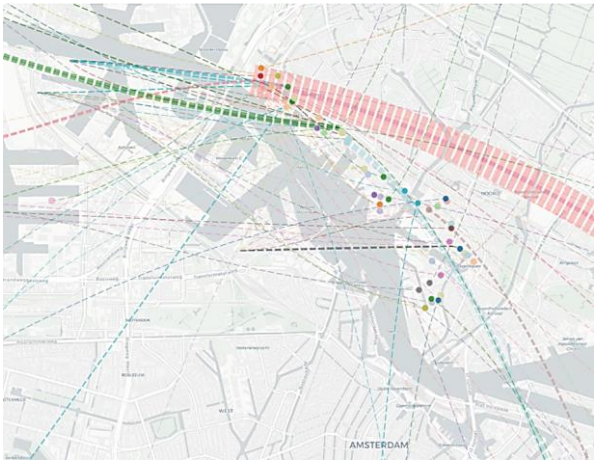


Figure 24 Flow map of the production of CDW on a local scale in 2013 (Sileryte et al., 2020)

Treatment of construction and demolition waste in 2013

In addition to importing CDW, CDW has also left the area. In 2013, a total of 8,074,870 tonnes of CDW left Noordelijke IJ-oever West. The waste has been moved to ten different actors, whereby the actors mainly performed the activities of sorting and separating the CDW (94.7% of total output). The treatment of the CDW in Noordelijke IJ-oever West is shown on a regional scale in figure 25, which shows that most of the CDW is transported to the Amersfoort area. On a local scale, figure 26, it can be seen that small parts of the CDW are being relocated to other areas within Noordelijke IJ-oever; NDSM-werf, Buiksloterham and Hamerkwartier.

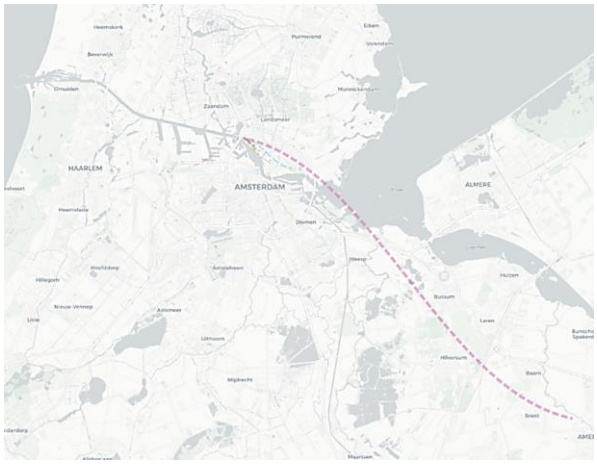


Figure 25 Flow map of the treatment of CDW on a regional scale in 2013 (Sileryte et al., 2020)

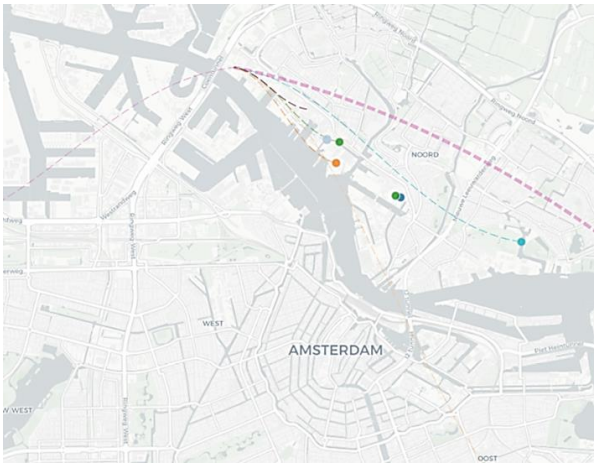


Figure 26 Flow map of the treatment of CDW on a local scale in 2013 (Sileryte et al., 2020)

4.4.3 Noordelijke IJ-oever West: AS-MFA of CDW in 2018

Production of construction and demolition waste in 2018

In 2018, a total of 131,859,311 tons of CDW arrived in Noordelijke IJ-oever West. The CDW came from 52 different actors. The majority of the CDW that entered the area has been sorted and separated (36.11%), or has been stored to eventually be transported to other areas (33.4%). In addition, 19.3% of the CDW has been broken and taken apart, while 9.4% of the CDW consisted of cleaning soil. Figure 27 depicts the origin of the CDW on a regional scale, whereas figure 28 is an illustration of the origin of the CDW on a local scale. Figure 27 shows that the majority of the CDW comes from the environments around Haarlem and Utrecht. With regard to figure 28, it can be seen that on a local scale the CDW enters every sub-area of Noordelijke IJ-oever West. Moreover, almost every actor who receives the CDW is located along water.

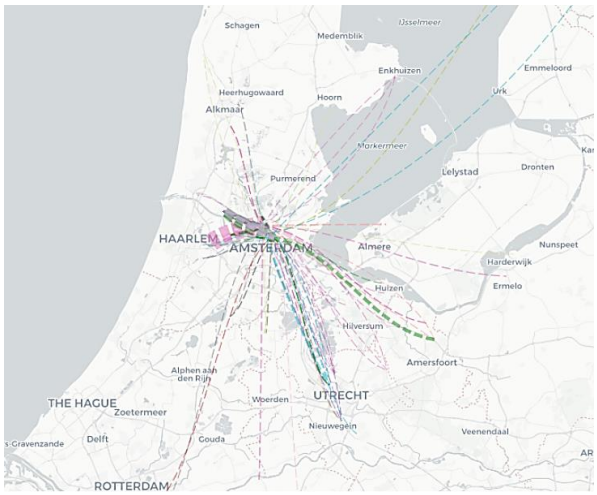


Figure 27 Flow map of the production of CDW on a regional scale in 2018 (Sileryte et al., 2020)

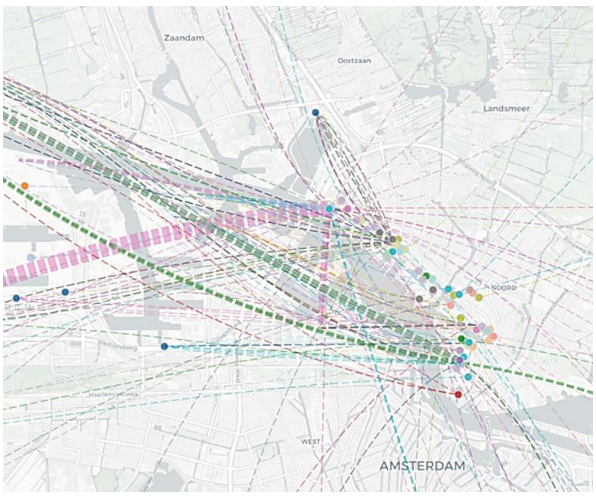


Figure 28 Flow map of the production of CDW on a local scale in 2018 (Sileryte et al., 2020)

Treatment of construction and demolition waste in 2018

In 2018, in addition to the import of CDW, there has also been export of CDW from Noordelijke IJ-oever West to other areas. A total of 34,430,130 tonnes of CDW has been exported to other areas, of which 99.9% of the exported CDW has been sorted and separated at other locations. Figure 29 illustrates where the CDW has been transported too and it can be noted that the CDW that has transported from the area is still within the Amsterdam region. More specifically, CDW has been transferred to both the other side of Noordelijke IJ-oever, Diemen, and most noticeable, there has been waste treatment within the area. Hereby, CDW has been transferred from Cornelis Douwes to NDSM-werf.

Figure 29 Flow map of the treatment of CDW on a local scale in 2018 (Sileryte et al., 2020)

4.4.4 Noordelijke IJ-oever West: comparison between 2013 and 2018

Production of construction and demolition waste

Figure 30 shows the differences between 2013 and 2018 concerning the production of CDW. The CDW that entered Noordelijke IJ-oever West increased by almost 75% in total from 2013 to 2018. The increase in the program of the area between 2013 and 2018, in which an increase of 160% in the number of inhabitants, 765 homes and 441 businesses took place, is partly responsible for the rise in CDW. In both years, the majority of the CDW is sorted and separated within the area. However, in 2013, 4,206,039 tons of CDW has been stored and then transported to another area, while in 2018 the same happened with 43,989,364 tons of CDW: an increase of 946%. This shows that Noordelijke IJ-oever West is increasingly being used for storing waste, and then transporting it to other areas. In other words, a logistics centre has been created in the area to transport the CDW by water or road to other locations, which is in accordance with the zoning plan for Cornelis Douwes (Gemeente Amsterdam, 2013).

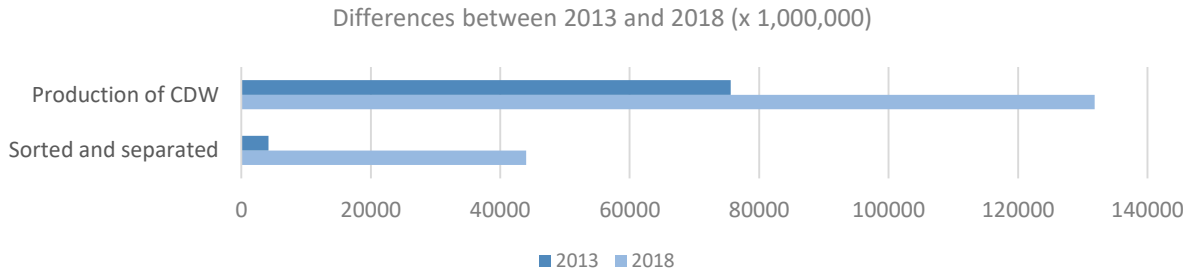


Figure 30 Differences between 2013 and 2018 regarding the production of CDW (Based on data Sileryte et al., 2020)

The comparison of the maps shows that the origin of the CDW extends beyond the Amsterdam region in both 2013 and 2018. More specifically, certain streams of CDW originate from Utrecht, Rotterdam, The Hague or even the Province of Friesland. The scale of CDW flows is therefore not local, but regional. As a result, the transport of CDW results in considerable CO2 emissions due to the relatively long distances. In 2018, the majority of the CDW came from Haarlem, which is closer to the majority of the CDW that came from Amersfoort in 2013. It should be noted that there was also a lot of CDW from the Utrecht region in 2018. In short, the transport distances for the majority of the CDW have reduced in 2018 compared to 2013. However, because the total number of CDW in tons increased by almost 75% between 2013 and 2018, the total transport distances for CDW in 2018 are higher than in 2013, which means a higher CO2 emission.

Treatment of construction and demolition waste

With regard to CDW exports, a total of 326% more CDW left Noordelijke IJ-oever West in 2018 compared to 2013 (figure 31). In both years, the majority of CDW is transported to actors who then sorted and separated the waste. The main difference between the two years is mainly the location of the final destination of the CDW. In 2013, the major part of the CDW is transported to Amersfoort, while in 2018 all the CDW remained within the Amsterdam region. In short, the CDW treatment network in 2013 consisted of a local and regional network, while in 2018 the network was only local. The consequence of this is that the transport distances are reduced, with the consequence that less CO2 is emitted.

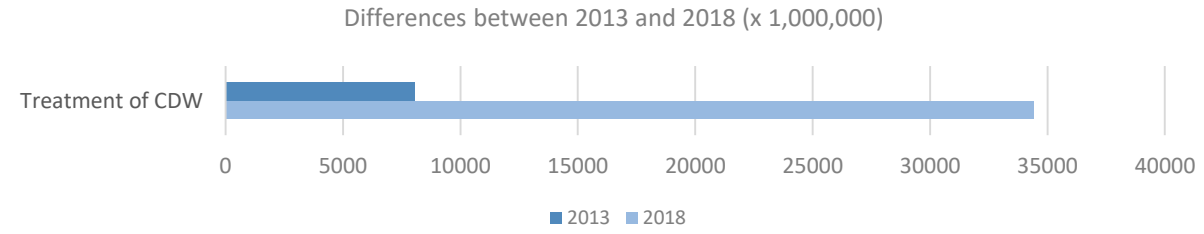


Figure 31 Differences between 2013 and 2018 regarding the treatment of CDW (Based on data Sileryte et al., 2020)

4.5 Challenges and tensions between local and regional scale levels

In recent decades, the population of Amsterdam has risen sharply, from approximately 730,000 inhabitants in 2000 to nearly 850,000 inhabitants in 2020 (Amsterdam conjunctuur, n.d.). In addition, the number of inhabitants is expected to increase significantly in the coming decades: a forecast shows that there will be approximately 1.1 million inhabitants in Amsterdam in 2040 (NH Nieuws, 2019). Due to a lack of space, Amsterdam's expansion is increasingly focusing on the port area, with the result that certain port activities are disappearing from the vicinity of the city (Savini, Majoor & Salet, 2015). This is the case, for example, in Noordelijke IJ-oever West, which will be transformed as a former port site into a mixed-function area. In the context of the ambitious sustainable and circular objectives of the municipality of Amsterdam, various sustainable and circular principles must be implemented for the development of areas in and around Amsterdam. Examples include emission-free mobility, rainproof areas, zero waste neighbourhoods with closed material cycles and self-sufficient areas (Gladek et al., 2015). In addition, existing and planned processes in the built environment are retained in order to create value during area developments (Personal communication, Respondent 1, 2020; Gemeente Amsterdam, 2020b). In other words, all functions that exist in a linear economy are also necessary for a circular economy, but it is necessary that ecosystem thinking is central. Examples of functions that are required are parties that collect, separate, transport, process, recycle, produce and develop. (Personal communication, Respondent 4, 2020).

Uncertainties in current policy and vision documents about crucial aspects of circular area development

In the future, the area of Noordelijke IJ-oever West will be provided with at least 30,000 additional homes. In order to align the area development with the sustainable and circular ambitions of the municipality of Amsterdam, Noordelijke IJ-oever West will become an area where circular construction solutions will be applied for the realization of buildings, infrastructure and public space. In order to make this possible, innovation is stimulated in the city (Gemeente Amsterdam, 2016a; Gemeente Amsterdam, 2020b). In addition, the implementation of circularity in area development is stimulated by flexible zoning plans and the use of circular criteria when issuing and tendering construction projects. An example of a flexible zoning plan is allowing 'hubs' in an area to support and stimulate circular activities. Hubs can be used for reuse and repair or for local facilities to recover nutrients (Gemeente Amsterdam, 2019c).

However, the policy, visions and implementation strategies of the municipality of Amsterdam are unclear on crucial aspects of circular area development. More specifically, the policy and vision documents do not clearly describe how to build circularly and how an area can function circularly (figure 32). This is confirmed by respondent 1 who stated that the municipality of Amsterdam currently has no explicit definition of a circular area and, besides, that there are currently only assumptions instead of guidelines for circular construction (Personal communication, Respondent 1, 2020). As a result, it is unclear during area developments which existing and innovative activities contribute to the circular functioning of an area on a local scale.

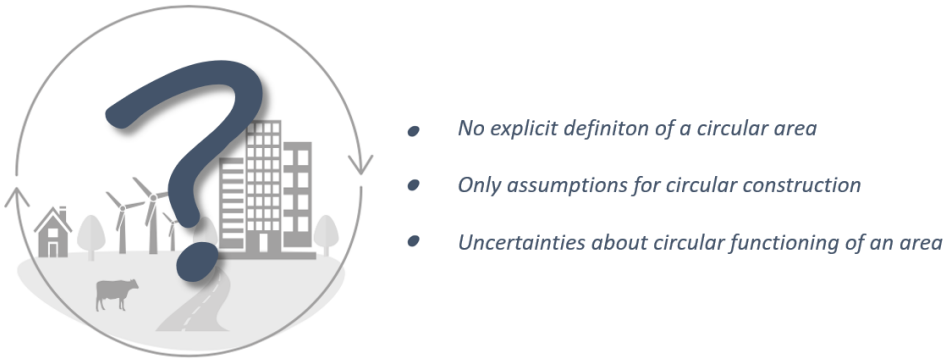


Figure 32 Uncertainties in current policy and vision documents about crucial aspects of circular area development

To reduce the ambiguities, The municipality of Amsterdam recently published a report in which more specific objectives are described. For example, the municipality of Amsterdam wants to apply a standard of 0.5 or lower

for ‘MilieuPrestatie Gebouwen’ (MPG). The legally required MPG is an existing national instrument that Amsterdam wants to use to reduce the use of primary raw materials in the short term (Personal communication, Respondent 1, 2020; Gemeente Amsterdam, 2020b). However, the definitive standard for Amsterdam will only become known later in 2020. In addition, the municipality wants to formulate circular ambitions for each area as a basis for development, transformation and management. The starting point is to draw up urban criteria and to formulate preconditions for the circular built environment. Nevertheless, the circular ambitions will not be formulated explicitly until 2022 at the latest (Gemeente Amsterdam, 2020b).

Collisions between residential functions and industrial functions

For the case study of this research, the current ambiguities in the policy and vision documents of the municipality of Amsterdam have consequences for the circular functioning of the area. The analyses in section 4.4 show that the metabolic flows of CDW in the area have increased considerably between 2013 and 2018, while the data from section 4.3 show that the area's program will increase in the future. As a result, the total amount of flows will grow significantly in the future. However, the circular activities related to the processing of industrial material flows, such as CDW, organic and plastic waste, require industrial spaces. These industrial spaces are still located in Noordelijke IJ-oever West in 2020, but cannot remain in the same place in the future due to the planned area developments. This is because industrial processing processes do not go along with residential areas due to external effects that are produced, such as noise or smell (Van den Berghe et al., 2020), as shown in figure 33. Consequently, this type of business is moving to other places, outside the city centre, whereby the port of Amsterdam is the most logical location (Personal Communication, Respondent 2, 2020). Relocations of this type of activities, which is located close to the city centre, will increase the size of the system of flows, resulting in more regional, national or, in the worst case, even international transactions. However, each respondent (1, 2, 3 and 4) mentions that it is important to consider the scale in which the company operates. If a company operates on an urban level, the disappearance will have a greater impact on the circular functioning of an area compared to the disappearance of a company operating on a national level.

Even though the majority of industrial circular activities will disappear from Noordelijke IJ-oever West, exceptions have been made in the zoning plan for the sub-area Buiksloterham. An exception has been made in the current zoning plan for existing companies with a higher environmental category 3.1. No company is obliged to relocate, with the exception that urban care companies are preferred to footloose industries that can be located in any location without negative effects on production factors (Gemeente Amsterdam, 2019a). In this way, current industrial activities for the area related to extending the life of products (repair, reuse, refurbish) or transforming waste into raw materials are preserved (Circle Economy & EHERO, 2018). As a result, the area can be characterized as a (re)productive neighbourhood that contributes to the circular functioning of the area, because production and consumption are located close to each other (Gemeente Amsterdam, 2019a).

However, it should be possible that new businesses in, for example, Haven-Stad can be combined with housing (Personal communication, Respondent 2, 2020), and therefore, must fall under environmental category 3.1 or lower. In addition, according to Gemeente Amsterdam (2019a), a large part of the existing companies with an environmental category higher than 3.1 have already left the area. Hence the question can be asked whether there will actually be industrial circular activities in the area in the future.

The interviews with respondents 2, 3 and 4 confirm that 'heavy' industries with a high environmental category cannot be mixed with residential functions. Respondent 2 also states that it is not feasible to take measures for the combination of housing with industry. Consequently, the 'heavy' industry will eventually leave, provided that dwellings will be realized in the area in the future (Personal communication, Respondent 2, 2020). In addition to the collision between residential functions and industrial activities, according to respondent 2, the land price is also an obstacle during area developments that are focused on circularity. Land prices are changing due to the urban densification in Amsterdam (figure 33). It is therefore questionable whether the increasingly higher land prices are financially feasible for companies, while it is important to create diversity of activities with, among other things, well-earning ICT industries (which are likely to be able to pay the land prices) and manufacturing industries (Personal communication, Respondent 2, 2020). Furthermore, according to respondent 3, land ownership can also be seen as a barrier in area development (figure 33). Land ownership sometimes makes it

difficult to carry out a development, since in most cases landowners must agree to the development plans (Personal communication, Respondent 3, 2020).

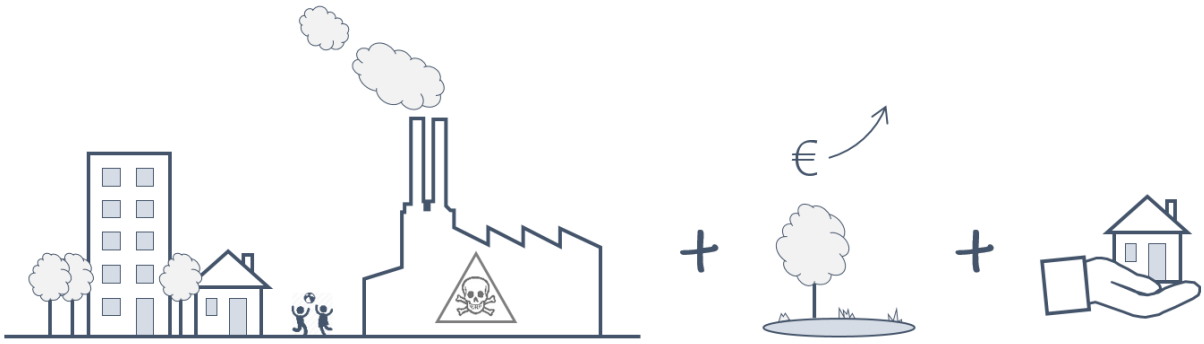


Figure 33 Three collisions between residential and industrial functions: nuisance (e.g. toxic emissions), increase land price & land ownership

Circular potentials of Port of Amsterdam

In recent years, the port of Amsterdam has increasingly been seen as a circular hub. The port is in fact part of the 'Circulaire Westas', an area that can contribute to a transition to a circular economy through networks and innovations (Metropoolregio Amsterdam, 2017). In short, the port can contribute to achieve various sustainable ambitions for Amsterdam, and besides, plays an important role in the current and future economy of Amsterdam, the Amsterdam Metropolitan Area, the Netherlands and Europe (Gemeente Amsterdam, 2020b).

In both an interview and literature is mentioned that the city of Amsterdam cannot become circular without the port, as an industrial area is required to achieve circular activities and collaborations (Personal communication, Respondent 4, 2020; Gemeente Amsterdam, 2020b). The potential of the port of Amsterdam concerning circularity arises because many producing activities and storage spaces are located in the port (Personal communication, Respondent 1, 2020), and besides, products can be transported by water and the nearby located highways (Personal communication, Respondent 2, 2020). In addition to the existing activities and the logistics connections, there are also developments with regard to knowledge, skills, technology and innovation in the port (Personal communication, Respondent 4, 2020; Gemeente Amsterdam, 2020b).

However, as mentioned earlier, challenges and tensions arise between local and regional scale levels because industrial circular activities do not mix with residential functions. In addition to the area development of Noordelijke IJ-oever West, an area transformation is currently also taking place in Haven-Stad: from an industrial area to a mixed function area. In the future, between 40,000 and 70,000 extra dwellings will be realized in Haven-Stad (Gemeente Amsterdam, 2017). As in Noordelijke IJ-oever West, the current industrial activities in Haven-Stad will not correspond to the residential functions.

In Haven-Stad, however, various measures are being taken to allow industries to mix with residential functions. An example of this is that future residents must sign that they are aware of the fact that there will be more noise in the area due to the industrial activities (Personal communication, Respondent 2, 2020). Nevertheless, this does not mean that all industrial companies will be preserved, as the living environment that is likely to be created in the future must ultimately be really liveable without, for example, the emission of harmful substances next to dwellings (Personal communication, Respondent 1, 2020).

Consequently, multiple companies with an environmental category higher than 3.1 depart from both Noordelijke IJ-oever West and Haven-Stad to, from the city centre, a more distant location. These ‘heavy’ industries are then partially replaced by companies with a lower environmental category that are suitable for placing close to living functions.

4.6 Conclusion case study and predictions for the future

This section first describes the conclusion of the conducted case study. The conclusion is based on the analyses and interviews from sections 4.1 to 4.5. Subsequently, based on the conclusion, various forecasts for the future are formulated with regard to the circular functioning of Noordelijke IJ-oever West and its surroundings. The formulated predictions are ultimately used to formulate recommendations that can be used to improve the circular functioning of an area.

4.6.1 Conclusion case study

The program of Noordelijke IJ-oever West has increased slightly between 2013 and 2018 and will increase enormously in the future (section 4.3). As a consequence of the increasing program, material consumption and waste generation are increasing, as evidenced by a comparison of AS-MFAs between 2013 and 2018 (section 4.4). As a result, it can be stated that with regard to the circular functioning of Noordelijke IJ-oever West, more processing of materials and waste should take place as locally as possible in the future.

However, the analysis of contemporary plans and elaborations in the area development of Noordelijke IJ-oever West shows that actors who carry out existing industrial circular activities are increasingly disappearing from the area. This is primarily because the current policy and vision documents of the municipality of Amsterdam do not clearly describe how circular construction can be created and how an area can function circularly. Hence, it is not known what the local existing fundamental activities are that make the area circular and, moreover, stimulate innovations. The ambiguities will be reduced in the coming years, as the municipality of Amsterdam wants to formulate circular ambitions with associated criteria by 2022 at the latest (Gemeente Amsterdam, 2020b). Nevertheless, the result of the current uncertainties is that the current development plans have created a mix of living and working in the area. However, the existing industrial processing processes are not compatible with the residential areas due to external effects that are produced, such as noise or smell, which means that this type of business has to move to other areas.

An exception has been made for existing companies with a higher environmental category 3.1 in the current zoning plan for one of the subareas in Noordelijke IJ-oever West, namely Buiksloterham. No company is obliged to move (Gemeente Amsterdam, 2019a). However, due to the mix with housing, new businesses in the sub-area must fall under environmental category 3.1 or lower. In addition, according to gemeente Amsterdam (2019a), a large part of the existing companies with an environmental category higher than 3.1 have already left the area. Furthermore, both the increasing land price due to the urban densification in Amsterdam and land ownership are barriers to circular area developments. For example, due to the increasing land price, well-earning ICT industries are able to locate more easily near the city centre compared to manufacturing industries, which, in addition to producing relatively lower profits, also require more land to perform the work. Hence the question can be asked whether there will actually be industrial circular activities in the area in the future.

Despite the negative facts about the relocation of different types of industrial activities, there are also initiatives in the current area development plans to improve the circular functioning of the area. For example, the introduction of flexible zoning plans offers the opportunity to locate circular hubs in the area. By using a hub, firstly, it becomes possible to use space more efficiently, and secondly, transport distances are generally reduced which contributes to lesser negative climate effects (Gemeente Amsterdam, 2019c).

The port of Amsterdam has enormous potential to contribute to the transition to a circular economy. This is because the port can develop itself into a circular ecosystem, in which companies can use waste flows from each other and from elsewhere. The creation of an ecosystem makes it possible to apply a targeted approach at different scale levels, since both production (from chemical to material elements) and processing (high-quality reuse of materials, raw materials and residual flows) take place in the port of Amsterdam. It is therefore illogical from a circular perspective to transform parts of the port area, in which industrial activities are carried out, into mixed areas.

In short, the increasing program in Noordelijke IJ-oever West will increase the number of metabolic flows, so that more and more activities and transactions must take place internally in the area, or as locally as possible.

However, because the existing industrial activities collide with residential functions, industrial activity disappears from the area. This is also the case for the adjacent future area development of Haven-Stad. This means that a large part of the nearest port area with industrial activities will be further located in relation to the city of Amsterdam in the future. The result: the distances of the network between actors will increase, which means that more transactions will take place regionally, nationally or even internationally, while the circular future requires more local transactions.

4.6.2 Predictions for the future

1. Knowledge-based circular activities will take place in the city, while manufacturing industries will take place outside the city
First, industrial activities create various nuisance, such as noise, smell, traffic and toxic emissions. Due to the nuisance, it is almost impossible to realise a living environment, in which children can play outside safely, for example. From this perspective, it is therefore better not to mix residential and industries functions in an area. *Secondly, partly due to a shortage of space in the city, the land price is rising in Amsterdam. This often makes it financially more attractive to realize dwellings in an urban area. Moreover, due to the high land price, it is sometimes not financially feasible for manufacturing industries to be located in the city because these types of companies need a relatively large amount of space and have reasonable costs. From a financial point of view, it is therefore more attractive to locate manufacturing industries outside the city and to locate knowledge-based circular activities, which often earn better, require less space, and do not cause nuisance, in the city.*
2. There will be no more space for business parks around the centre of Amsterdam
Due to urban densification, former industrial sites are being transformed into mixed areas, such as Buiksloterham, Hamerkwartier and Overamstel. The construction of new neighbourhoods with homes, offices and commercial functions means that space for business parks around the centre of Amsterdam will disappear. It is expected that there will be no more space for new companies, such as craft companies, manufacturing industry and repair shops, in Amsterdam in 2025. In addition, it is predicted that the city will have at least a shortage of 150 hectares of business park in Amsterdam in 2040 (Het Parool , 2019). *Because most of the companies that carry out industrial activities are less able to pay the rapidly rising rents compared to offices and catering. There is a danger that lower paid employment will increasingly leave the city (Het Parool, 2019).*
3. The quays along the water around the centre of Amsterdam will not contain any industrial activities
Due to urban densification, current and former industrial areas located in or around the city centre are being transformed into mixed residential areas. As previously concluded, however, industrial functions collide with residential functions on various aspects. That is why certain quays, where industrial activities take place, will eventually not contain, for example, manufacturing industries, while the quays have the potential to stimulate a circular economy by, among other things, connecting actors. In short, the potentials of the quays and harbour will not be fully utilized with regard to a transition to a circular economy.
4. The transactions of flows will increasingly take place on a larger scale level for Noordelijke IJ-oever West and its surrounding areas
The case study has shown that the program (housing, office space, catering, etc.) will increase significantly. As a consequence, the total material consumption will enhance in the area. However, the majority of actors carrying out circular industrial activities have disappeared or will disappear from the area due to conflicts between industrial and residential functions. Consequently, fewer circular processes such as collecting, separating, refurbishing, repairing, producing, and recycling will take place in the area, while these activities will be more necessary due to the increasing consumption of materials. As a result, due to the reduction of circular processes and the increase in material flows in the area, transactions will take place on a larger scale to obtain products and services for Noordelijke IJ-oever West and surrounding areas in the future.

Table 12 Predictions with regard to the circular functioning of Noordelijke IJ-oever West and its surroundings

CHAPTER 5

RESULTS

5 RESULTS

In this chapter, all findings from the literature study (chapter 3) are brought together with the results from the case study and the interviews (chapter 4). In other words, the theory is confronted with practice and vice versa. First, the results of chapters 3 and 4 are compared to identify similarities and differences. Second, based on the conclusions from chapters 3 and 4 and the findings in section 5.1, results conclusions are formulated in the form of recommendations that can be applied to improve the circular functioning of an area during area development.

5.1 Confronting theory with practice and vice versa

In this section, the results of the literature study are combined and compared with the results of the case study and interviews. For the comparisons, the structure of the literature review is applied since this structure is based on the conceptual model of this research (section 1.5) and contributes to answering the main and sub-questions (chapter 7).

5.1.1 The concept of a circular economy

On the one hand, the literature review of this study states that in a circular economy, products, materials and resources are kept in the economy for as long as possible, without losing value, whereby system thinking is central (EMF, 2013; European Commission, 2018; Geissdoerfer et al., 2017). On the other hand, in this study, the vision and policy documents of the municipality of Amsterdam have been analysed and it emerges that the municipality focuses on seven different aspects to achieve a transition to a circular economy in the city in the future. These seven aspects consist of: (1) there is no waste in a circular economy, (2) all energy comes from renewable sources, (3) raw materials are used to generate value, (4) using modular and flexible designs, (5) transition from ownership of goods to services, (6) region-oriented service and returns logistics, and (7) human activities contribute to ecosystems and ecosystem services (Gemeente Amsterdam et al., 2015). In short, the seven aspects from practice are aimed at retaining products, materials and resources in the economy for as long as possible, without losing value, in which system thinking is central. Hence, a circular economy can be seen as the opposite of a linear economy, which has a take-make-waste principle (Sauvé et al., 2016).

In recent years, the concept of a circular economy has been defined in different ways in literature, resulting in no consensus about the definition. However, the majority of literature states that the three R's: reduce, reuse and recycle, are the main principles of a circular economy (Kirchherr et al., 2017). Other principles and strategies of, for example, EMF (2015) and Potting et al. (2017) are supplementary to the three R's. In practice, for example, the municipality of Amsterdam does not specify the definition of a circular economy, but specifies what the principle of a circular economy is. The reports of the municipality of Amsterdam show that the three R's (reduce, reuse and recycle) constantly return in the principle of a circular economy.

Both theory and practice show that a transition to a circular economy is stimulated by innovation. Murray et al. (2017) state that innovation brings together technical, social and economic aspects. In practice, the municipality of Amsterdam has released the report 'Circulair innovatieprogramma 2016-2018' to encourage innovations in the city. The circular innovation program is the joint deployment of knowledge institutions, companies and the municipality of Amsterdam that reinforces and accelerates innovation, research and circular activity. Examples of this are circular living labs to test innovations in the physical city (Gemeente Amsterdam, 2016a).

In addition to the principle of a circular economy, the concept of circularity exists. The concepts of a circular economy and circularity are closely related, but both have a different focus. The circular economy is mainly focused on economic prosperity, while circularity focuses on the reusability of materials and the closing of cycles of products and resources. In other words, circularity focuses on achieving higher environmental quality by reducing the environmental impact of a production process on a micro-scale, while the concept of a circular economy aims at the prosperity of the economy.

5.1.2 Geographical function of a circular economy

From theory, area development can be described as a complex process involving many stakeholders from both public and private parties, each with their own interests and influence on the process (Winch, 2010). For the realization of sustainable area development in practice, the municipality of Amsterdam has written the report 'Programma Duurzame Gebiedsontwikkeling'. In this document, Gemeente Amsterdam (2019b) describes area development as the (re)development of a location into a new area in which all kinds of functions such as living, working, retail, infrastructure, social facilities, green areas and recreation come together.

Since there is already no consensus on what the definition of a circular economy is in literature (Kirchherr et al., 2017), there is no agreement at all on what circular area development is. Nevertheless, based on both the literature study and the conducted case study, it can be concluded that circular area development consists of a circularly designed environment and a circularly functioning environment, in which the use of resources and energy is minimized by closing, slowing down and narrowing cycles (EMF, 2017; Geissdoerfer et al., 2017).

In addition, both the literature study and the case study show that circular area development is linked to the geographical area of a city. More specifically, EMF (2017) states that a circular area consists of as much local production and transactions as possible, creating opportunities for the highest possible reuse of products, materials and resources. In order to implement circular area development in practice, the municipality of Amsterdam focuses on creating region-oriented service and local return logistics (Gemeente Amsterdam et al., 2015), whereby the area contributes to the local economy (Gladek et al., 2015). In Noordelijke IJ-oever West are flexible zoning plans introduced in order to allow, for example, hubs to support and stimulate local circular activities. Hubs can be used for reuse and repair or for local facilities to recover nutrients (Gemeente Amsterdam, 2019c).

Literature mentions that 'old initiatives', such as craft companies, which have been established in an area for years are often not recognized as circular, while these companies do contribute to a circular economy (PBL, 2019). This fact is also confirmed in an interview with an expert who focuses on the implementation of circular principles in a port area. Therefore, during an area development it is important to look at what is already established in the area (Runhaar et al., 2009), how it can contribute to the circular economy, and if it contributes to the circular economy it needs to be safeguarded or kept close (North, 2010). In the case study of this research, Noordelijke IJ-oever West, the area will be transformed as a former port site into a mixed function area. The 'old' industrial spaces that are still located in Noordelijke IJ-oever West in 2020, cannot remain in the same place in the future due to the planned area developments. This is because industrial processing processes do not go along with residential areas due to external effects that are produced, such as noise or smell (Van den Berghe et al., 2020), as shown schematically in figure 34.

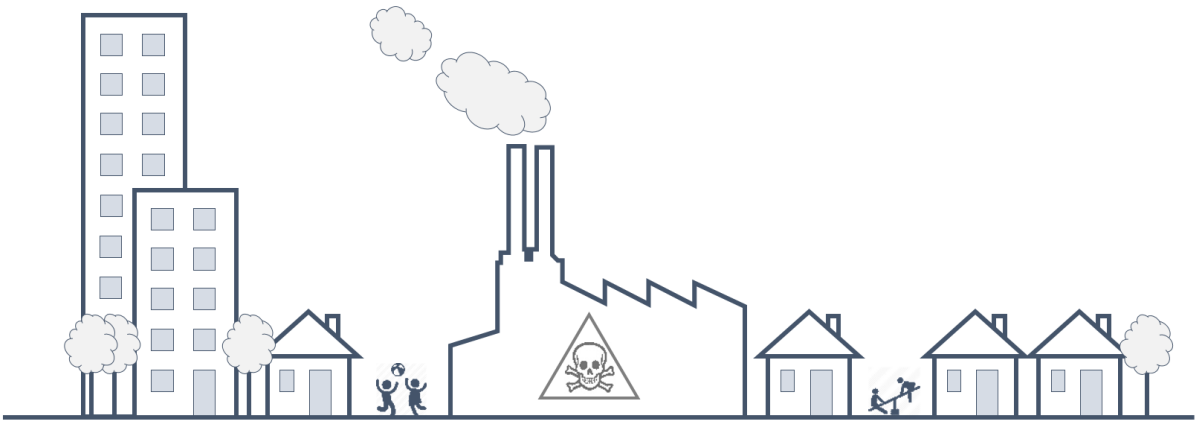


Figure 34 Collisions between residential and industrial functions

In addition to the clashes between industrial activities and residential areas, interviews have shown that both the increasing land price in Amsterdam and land ownership are also obstacles to circular area developments. On

the one hand, due to urban densification, the former and partly current industrial site of Noordelijke IJ-oever West is being transformed into a mixed residential area, with the result that the land price is increasing considerably. Industrial companies that need a lot of land to carry out their activities can sometimes not pay this increasingly higher land price, while knowledge-based companies that need much less space, for example, could pay this land price. On the other hand, land ownership sometimes makes it difficult to carry out a development, since in most cases landowners must agree to the development plans. Partly because of the increasing land price, it is usually financially more attractive for landowners to realise dwellings and offices on their land instead of a business site where industrial activities take place.

Consequently, companies that carry out circular industrial activities will eventually move to other places, outside the city centre. In addition, the municipality of Amsterdam has indicated that the majority of this kind of companies have already left the area (Gemeente Amsterdam, 2019a). Hence the question can be asked whether there will actually be industrial circular activities in the area in the future. This can be seen as a missed opportunity for the area, since the industrial processes of the existing companies could have had a contribution to a circular economy in the area.

Finally, in the literature review is stated that several guidelines and frameworks can be used to design and implement area development in practice. Hereby, every planning tool has a step-by-step plan (Runhaar et al., 2009). However, an analysis of the policy, visions and implementation strategies of the municipality of Amsterdam shows that no step-by-step plan has been included for circular area development. In addition, the reports are unclear about the implementation of circularity in area developments: the documents do not clearly describe how to build circularly and how an area can function circularly. Consequently, in practice, there is confusion about how to build circularly and which local existing fundamental companies and activities contribute to the circular functioning of the area, and moreover, stimulate innovation.

5.1.3 Networks in a circular economy

On the basis of the literature review, it can be claimed that a network comprises three interdependent features: (1) actors, (2) resources and (3) activities (Harland, 1996). A crucial aspect upon which should first be aimed at in a circular economy is that actors work together to create closed material cycles. According to Ghisellini et al. (2016), industrial symbiosis is an appropriate approach to close material cycles. In this approach, the goal is to optimise energy and material consumption and minimise waste (Chertow, 2000).

The second essential aspect of a circular economy is that actors carrying out activities should be located close to each other, i.e. as locally as possible. Once actors are located as locally as possible together, the transport distances are reduced. Localism must be aimed at localizing production and the availability of services as locally as possible (North, 2010). In the case study of this research, however, several actors that carry out industrial activities have disappeared from the area or will do so in the future because the industrial activities clash with the future planned residential functions. As a result, the networks of Noordelijke IJ-oever West are expanding, as the products produced by the actors now have to be imported from other areas. In other words, since the products are no longer produced on a local scale, transactions for the area arise on a regional, national or, in the worst case scenario, even an international scale. However, literature states that international transactions only serve as an alternative if the required products or services are not available in the local region (North, 2010). In short, in a circular economy, the aim should be on achieving transactions between actors that are located as locally as possible. Nonetheless, it is important to note that closing material cycles cannot have strict boundaries (Chertow, 2000). It is, for example, impossible to reuse all residual flows optimally from Noordelijke IJ-oever West. For this reason, the area must cooperate on a local or regional scale with surrounding areas, such as Haven-Stad, in order to exchange residual flows for optimal reuse.

Flexible zoning plans have been introduced in the area development of Noordelijke IJ-oever West to allow, among other things, hubs in the area. A hub can be seen as the central node in a network where resources and materials of an area are brought too. Various activities can be performed in a hub: from repairs to transhipment for transport. The use of hubs in Noordelijke IJ-oever West makes it possible to use the space more efficiently

(Municipality of Amsterdam, 2019c). Furthermore, hubs improve the efficiency of local transport flows, resulting in less negative climate effects (Allen, Browne, Woodburn & Leonardi, 2014).

From an environmental viewpoint, it is in some cases preferable to keep specific products or services in external areas (North, 2010). As a consequence, different regions within a circular economy will more or less specialize in certain activities. Nevertheless, it is important that local specialities offer the potential to realise new circular economy activities in the area. The new activities must therefore contribute, firstly, to increase employment and, secondly, to knowledge development (Burger et al., 2019).

With regard to the case study, the presence of the nearby port area and the quays along Noordelijke IJ-oever West have potential to contribute to the circular functioning of the area (table 13). More specifically, firstly, there are production, processing (e.g. reuse of materials) and storage spaces located in the port of Amsterdam and Noordelijke IJ-oever West. This makes it possible to create a circular ecosystem, in the form of for example industrial symbiosis, in which waste flows from one actor are used by the other actor in the same area or an adjacent area. Second, raw materials and resources can be transported by water to other areas in and around Amsterdam. Thirdly, due to the fact that the area is mostly specialized in industrial activities, developments arise in knowledge, skills, technology and innovation. These circular activities contribute to employment in both the port of Amsterdam, Noordelijke IJ-oever West and surrounding areas, as Burger et al. (2019) state as an important criteria of an area in a circular economy.

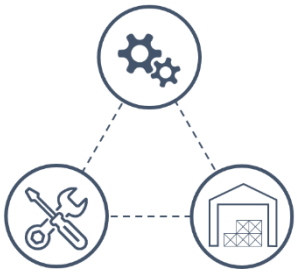
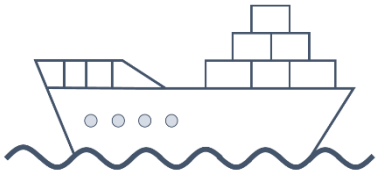
Presence of actors who perform different activities 	**Transport by water** 
Development of knowledge, skills and technology 	**Job opportunities** 

Table 12 Potentials of a port area to contribute to a transition to a circular economy

5.1.4 The principle of urban metabolism

From the literature review emerges that urban metabolism examines all flows of socio-economic processes that enter and leave an area or city. The goal of urban metabolism is reducing the current consumption of urban resources by realizing closed cycles, which is in accordance with the principle of a circular economy (Ness & Xing, 2017). In order to realise closed cycles within an area or city, the different flows must be determined. A material flow analysis (MFA) can be used to visualize the flows within a city.

AS-MFAs performed by REPAiR are available for the case study of this research, the area development of Noordelijke IJ-oever West. Since construction and demolition waste (CDW) is one of the key waste fractions in Amsterdam (REPAiR, 2016), it has been decided to analyse AS-MFAs of CDW for the case study for the years 2013 and 2018. By analysing and comparing the AS-MFAs from 2013 and 2018, it can be determined how the

production and treatment of CDW in the area are developed and what the consequences are for Noordelijke IJ-oever West. In addition, the advantage of analysing the AS-MFAs is that the data of flows and networks can be used to formulate recommendations in order to optimize the processes (Suh, 2005). Subsequently, process optimization can contribute to closing material cycles as locally as possible.

5.1.5 Urban metabolism: combining a geographical area with a network perspective according to the concept of a circular economy

By combining a geographical area with a network perspective according to the concept of a circular economy, based on the principle of urban metabolism, all flows of socio-economic processes entering and leaving a specific area are analysed. The goal of urban metabolism is to use the analysis to find solutions to reduce the current consumption of urban resources by closing cycles (Ness & Xing, 2017).

On the one hand, regarding a geographic circular area, section 5.1.2 concludes that a circular area consists of a circularly designed environment and a circularly functioning environment, in which the use of resources and energy is minimized by closing, slowing down and narrowing cycles (EMF, 2017; Geissdoerfer et al., 2017). Figure 35 shows the principle of a geographic circular area in the left column. These areas initially include a built environment that is designed in a modular and flexible manner. Secondly, the energy systems in the areas are resilient, renewable, localized, distributed and have a positive impact on the area. Thirdly, each area consists of an infrastructure system that is accessible, affordable and effective (EMF, 2017). In short, a geographic circular area focuses on the reusability of materials and the closing of cycles of products and resources, which is in accordance with the concept of circularity.

On the other hand, a network consists of actors, resources and activities (Harland, 1996) and this principle is illustrated in the right column of figure 35. From a network perspective, the aim should be in a circular economy to firstly ensure that actors work together to close cycles, and secondly, that actors are located as locally as possible. In other words, production of products and the presence of services are located as close to each other as possible, with international transactions only serving as an alternative if a product or service is not available in the local region. Due to environmental and climate conditions, it is not possible to produce or place all products and services in one specific area (North, 2010). Consequently, certain regions will in a circular economy specialize in specific activities. The specialization of an area in a particular product can contribute to improve the local economy by firstly increasing employment in the area, and secondly, by knowledge development (Burger et al., 2019).

In the middle column of figure 35, the fusion of a geographical area with a network perspective according to the concept of a circular economy is depicted. The figure shows that the actors are locally located and work together to close or slow down cycles. However, it is impossible to close material cycles in strict boundaries of an area. Therefore, the actors located in Noordelijke IJ-oever West must cooperate with actors from surrounding areas in order to optimally close cycles.

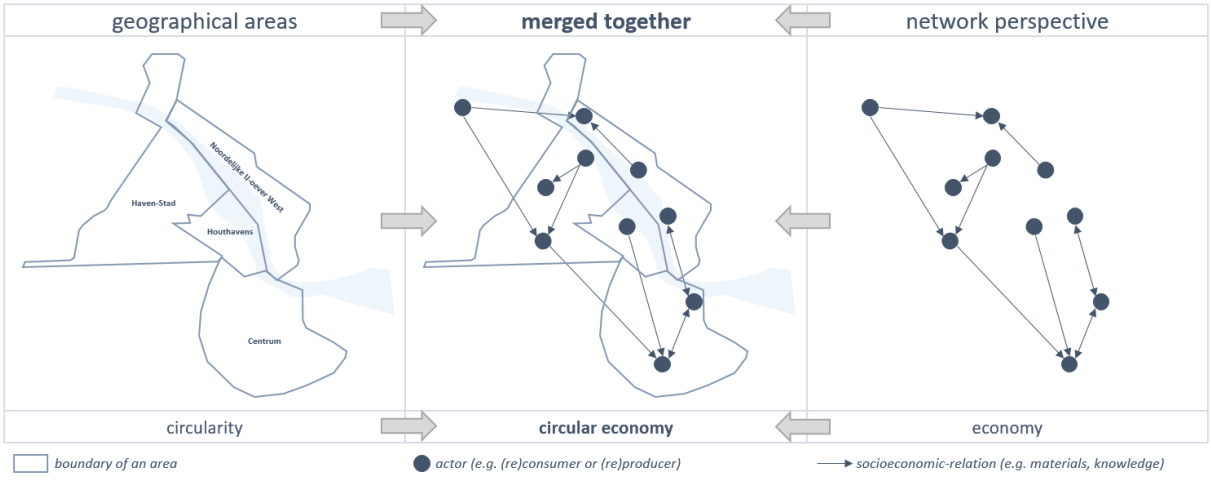


Figure 35 Combining a geographical area with a network perspective according to the concept of a circular economy (Own illustration, adapted from Van den Berghe et al., 2020)

By confronting practice with theory, it emerges that in the case study of this research, the programme (e.g. number of dwellings, offices, retail, businesses, etc.) has increased slightly between 2013 and 2018 and will expand immensely in the future. As a result of the rising programme, material consumption and waste production will grow, as can be seen from a comparison of AS-MFA between 2013 and 2018 (section 4.4). As a result, it can be argued that with respect to the circular functioning of Noordelijke IJ-oever West, more processing of materials and waste should be carried out as locally as possible in the future.

However, the analysis of contemporary plans and elaborations in the area development of Noordelijke IJ-oever West show that actors who carry out industrial circular activities are increasingly disappearing from the area. This is because industrial activities clash with future planned residential functions. These clashes are caused by (1) nuisance from industrial activities, such as noise and smell, (2) increasing land prices due to urban densification, and (3) land ownership, as mentioned in section 5.1.2. As a consequence, more and more actors that carry out circular industrial activities will disappear from areas that are transforming into mixed functions. The result of this is shown in a notional manner in figure 36. The figure shows what the impact could be on the scale level of the networks if various actors with a higher environmental category than 3.1 disappear from Noordelijke IJ-oever West and surrounding areas. It can be noted that if a number of actors move to a different area, region, or even country, the distances between the actors increase, and as a result, the scale level of the network also increases. However, it is important to note that figure 36 is fictional and only illustrates what could happen if the current policy and development plans are continued in Amsterdam in the future.

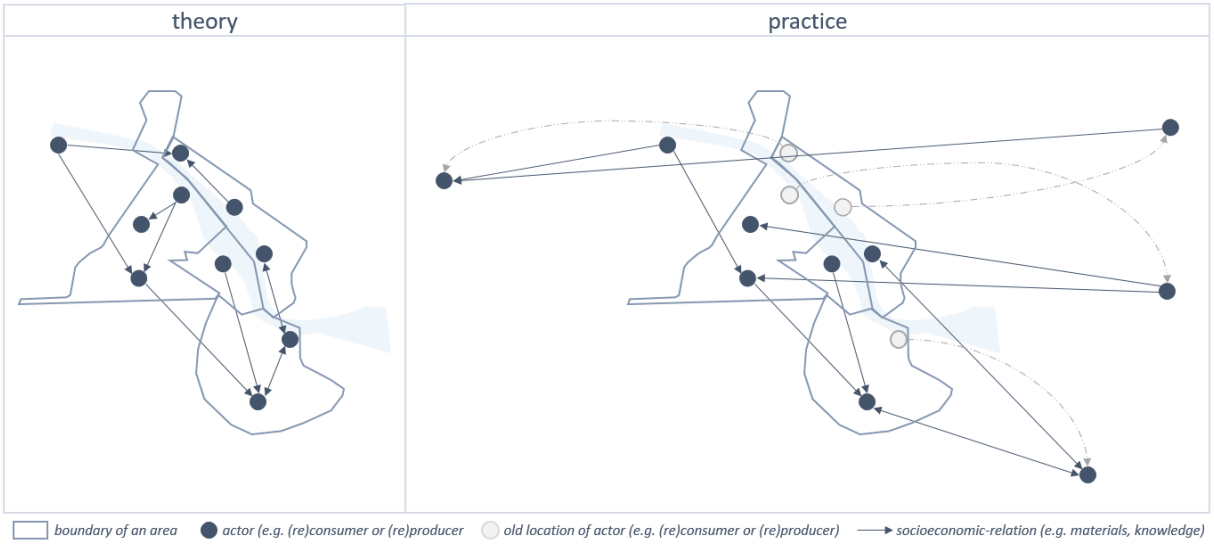


Figure 36 Theoretical networks during area developments versus practical networks during area developments

5.2 Conclusion

This section consists of recommendations for creating a circular functioning area. The recommendations have been drawn up on the basis of section 5.1 and the literature study, case study and interviews. Within this research, the recommendations in this section serve as input for the expert panel, in which the results are validated. Partly based on the validated results, the main question of this study is answered in chapter 7. This section provides a division in three different types of categories for recommendations. In addition, each recommendation per category is explained individually.

5.2.1 Overarching recommendations

The recommendations in this section focus primarily on policymakers working at the government or municipalities and are overarching to the other recommendations. In addition, the recommendations in this section do not apply specifically to circular area development, but to the total of circular area developments in the Netherlands.

Formulate specifically how sustainable and circular objectives can be achieved in circular area developments

The literature study and the case study have shown that there are still ambiguities about how the sustainable and circular objectives can be achieved. Consequently, it is not clear how to actually build in a circular way and which local existing fundamental activities contribute to the circular functioning of an area, which also stimulates innovations. Therefore, it is a recommendation that governments and municipalities explain more specifically how the objectives can be achieved.

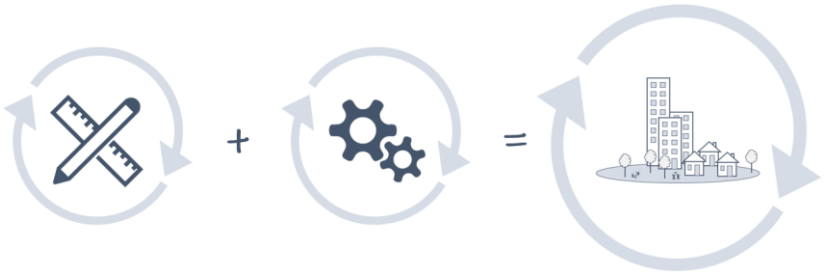
In other words, circular construction assumptions need to be more specifically formulated into circular construction guidelines. Furthermore, it needs to be made clear which activities and services can contribute to the circular functioning of areas. Based on an overview it could be possible to determine which activities and services an area needs during an area development. Moreover, a recommendation is that the potential of infrastructures in areas in relation to a transition to a circular economy needs to be clarified.

Stimulate innovations

A transition to a circular economy is stimulated by innovation. Hence, it is recommended that governments and municipalities stimulate and encourage circular innovations. For example, a municipality could focus on a joint effort by knowledge institutions, companies and the municipality itself to strengthen and accelerate innovation, research and circular activities. These innovations can then be tested in an area to monitor, evaluate and thereafter improve it.

5.2.2 Focus on creating both a circularly designed area and a circularly functioning area

Although this chapter focuses on recommendations for creating and improving the circular functioning of an area, the circular design of an area is also included. This is because a circularly designed area and a circularly functioning area are inextricably linked: together, a circular area is created. Moreover, a circularly designed area contributes to the circular functioning of an area by, for example, generating energy using solar panels. In short, during a circular area development, it is important to create both a circularly designed environment and a circularly functioning area.



This section first describes recommendations for achieving a circularly designed environment. Subsequently, recommendations are defined with regard to the realization of a circularly functioning area. It is important to note that the order of recommendations in this section is not a step-by-step approach for circular area developments.

Circular design: Re-think: analyse what is already in the area and extend its lifespan

Analysing what is already located in the area applies to both the recommendations of circular design and the creation of a circular functioning of an area. With regard to a circular design, it should first be made clear what kind of buildings, infrastructure and public facilities are already present in the area. Subsequently, it is recommended to assess whether it is possible and desirable to extend the lifetime of the existing buildings, infrastructure and public facilities. The lifespan of the current built environment can be upgraded using circular design and construction principles, with a particular focus on closing, slowing down and narrowing material, resource and energy cycles. In short, the 'Re-think' principle is central to this recommendation.

Circular design: use of circular criteria for land issues and tenders

During the development of buildings, infrastructure and public functions, it is recommended to apply circular criteria in land issues and tenders. By including circular criteria in a land issue and tender, the development of the built environment focuses on circular design and construction. This will, among other things, increase the amount of recycled and renewable building materials in the area. This leads to closing, slowing and narrowing of cycles, and besides, to less greenhouse gas emissions because the production of new building materials is reduced. Finally, the use of circular criteria in land issues and tenders stimulates innovations; parties are encouraged to consider possible solutions to meet the circular requirements. In addition, the circular criteria can be tightened and supplemented over the years, which in turn leads to even more innovations.

Circular design: design and build buildings, infrastructure and public spaces according to circular principles

As described in the overarching recommendation, governments and municipalities must draw up guidelines for circular construction. Based on guidelines, buildings, infrastructure and public spaces can be designed and built according to circular principles. Examples of designing according to circular principles are (1) application of as many recycled and biobased materials as possible, (2) development of buildings with adaptable functions and systems, and (3) climate-proof constructions. Designing and building according to circular principles mainly focus on closing, slowing down and narrowing material, resources and energy cycles.

Circular design: use new forms of financial value assessment

The case study of this research has shown that both the land price and land ownership can be barriers to circular area development. Partly for this reason, it is advisable to develop new forms of financial value allocation for a circularly built environment. Total cost of ownership or total cost of use can be taken as the starting point for the new forms of financial value allocations.

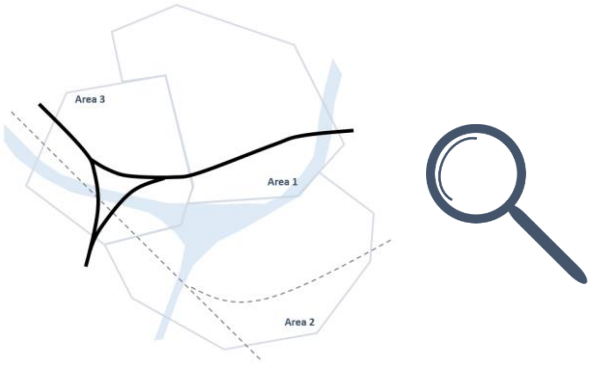
Circular functioning: Re-think: analyse which facilities are established in the area and the surrounding areas and which facilities are missing and needed

Existing 'old' initiatives which have been established in an area for years are often not recognized as circular, while these companies do contribute to a circular economy. Therefore, during a circular area development, it is important to determine which facilities are already located in the specific area and how they can contribute to a circular economy. In addition, it is essential to analyse whether activities and services of an area are available in adjacent areas, and besides, assess whether the actors act at a local, regional or national level. The analysis can subsequently be used to show what the impact on the circular functioning of the area will be on a small and large scale as soon as an actor disappears from the area. In other words, if an actor contributes to a circular economy, especially on a local scale, it needs to be safeguarded or kept close.

Furthermore, it is advisable to carry out the analysis the other way around: which facilities that can contribute to a circular economy on a local scale are not located in the area and the adjacent areas. Based on the analysis, it can then be determined which activities and services could be realized during the area development to improve the circular functioning of the area. This could be assessed, for example, by using an overview drawn up by the government, municipality or an organization that provides insight into which activities and services contribute to the circular functioning of an area, as described in the first recommendation of section 5.2.1.

Circular functioning: Re-think: analyse the present infrastructure in and around the area

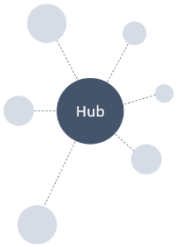
It is recommended to analyse what kind of infrastructure is present in and around the specific area and how this, in combination with facilities (production of products and availability of services), can contribute to a circular economy. In a circular economy, certain areas specialize in specific activities, partly due to environmental aspects. In addition, clusters of specialities arise in a circular economy because of the existing infrastructure. More specifically, ports are created along deep water close to a shore to transport goods and products via cargo ships, while a campus is created by the presence of knowledge infrastructure (universities and companies). In short, it is advisable to analyse during a circular area development what the existing infrastructure consists of in the area and beyond, and thereafter determine how the infrastructure can contribute to a circular economy. Subsequently, the potential of the existing infrastructure, in combination with the existing and to be realized facilities, must be optimally utilized in order to improve the circular functioning of the area and the surrounding areas.



Circular functioning: introducing flexibility in the zoning plan

By introducing flexibility in the zoning plan of the area, the possibility arises that certain companies with an environmental category higher than 3.1 can be located close to dwellings and vice versa. This allows certain existing activities to remain located in the area to contribute to a circular economy. However, this possibility must be subject to the condition that the environment remains liveable; as little nuisance as possible without emitting toxic substances near homes.

In addition, the introduction of flexibility in a zoning plan can lead to the possibility of allowing 'hubs' in the area to support and stimulate circular activities. A hub can be considered as the central node in a network where resources and materials of an area are brought too. Several activities can be performed in a hub: from repairs to transhipment for transport. By realizing a hub, firstly, it becomes possible to use space more efficiently, and secondly, hubs improve the efficiency of local transport flows, resulting in less negative climate effects. In short, this recommendation focuses on making maximum use of and supporting existing and new initiatives in the area.



Circular functioning: stimulate local partnerships to close cycles

A circular area comprises as much local production and transactions as possible, which creates opportunities for the maximum possible reuse of products, materials and resources. Therefore, during circular area developments, it is recommended to encourage actors working together on a local scale to close cycles. Hereby, the aim of the local partnerships is to optimize energy and material consumption and to minimize waste by closing, slowing and narrowing cycles.

However, from the literature study of this research, it can be concluded that there are technical, informational and economic barriers to closing local cycles (Fraccascia, 2018). From the perspective of technical obstacles, constructing an urban waste recycling system is essential. The urban waste recycling system can be applied to collect sufficient waste and then deliver it to the designated actor (Dong et al., 2013). For information barriers, governments can establish online information platforms in which data is collected about the supply and demand of waste in an area. The data can then be shared with local companies to close, slow down and narrow cycles (Fraccascia, 2018). For economic barriers, governments can stimulate actors to work together in order to close cycles by; (1) introducing mandatory recycling targets for waste for cities (Dong et al., 2013), (2) introducing taxes on environmental emissions (Dong et al., 2016) and (3) making financial subsidies available (Dong et al., 2013).

5.2.3 Monitor, evaluate and improve

In order to assess whether sustainable and circular objectives of an area development have been or will be achieved in the future, it is important to monitor, evaluate and subsequently improve, if possible, various aspects.

Monitor, evaluate and improve: incoming and outgoing material and energy flows in the area

In order to monitor, evaluate and improve the circularity of the area, data is required about both the input and output of raw materials and energy in the area. In other words, insight is required into the incoming and outgoing flows of the area, as is referred in literature as a material and energy flow analysis (MEFA). The advantage of a MEFA is that the incoming and outgoing flows can be analysed and then optimize the processes of networks, which can subsequently contribute to closing, slowing down and narrowing of local cycles.

Monitor, evaluate and improve: existing and future raw materials in the area

It is advisable to gain insight into the raw materials that have been processed in the area for both the current situation and the future situation. According to Metabolic (2019), the application of material passports are suitable for providing insight into data for buildings, public spaces and infrastructure, whereby the data can be kept continuously up-to-date for the future. A material passport lists, among other things, the raw materials used in a building with the associated origin, instructions for maintenance and possibilities for reuse. By monitoring the raw materials on the basis of material passports, the possibilities and opportunities for the reuse of raw materials in the area can then be analysed and, finally, any improvements can be made.

Monitor, evaluate and improve: energy consumption in the area

It is recommended to map the energy consumption in the area of both buildings and public facilities (e.g. street lighting) with regard to energy use per part, share of renewable energy and greenhouse gas emissions from energy use. By analysing the energy consumption, it is possible to implement any improvements, such as making street lighting smart and making certain buildings more energy efficient. Consequently, the energy consumption will be reduced in the area with the ultimate goal that the area is self-sufficient in its energy needs.

Monitor, evaluate and improve: climate adaptation of the area

Without the use of plants and possible forests, biodiversity can be lost during circular area developments. This reinforces climate change on a local scale, but can ultimately also lead to climate change on larger scale levels. On a local scale, natural capital makes residents and visitors to an area happier and healthier, as well as contributing to climate adaptation by anticipating local changing weather conditions. In short, this recommendation focuses

on providing insight into the total green space area, water use and air quality in the area to assess whether this is sufficient and to improve it if possible.

Monitor, evaluate and improve: health and well-being of residents in the area

It is advisable, if dwellings and businesses that carry out industrial activities are located close to each other, to investigate the effects on the health and well-being of the residents of the area. This can be investigated by, among other things, monitoring the air quality and noise pollution. The data can then be evaluated. Based on the evaluation, the impact on the health and well-being of the residents can be investigated. Subsequently, additional studies can be conducted to identify opportunities that reduce the impact on health and well-being. This could eventually lead to innovations, allowing certain companies that carry out industrial activities with residential functions to be combined during circular area developments.

Monitor, evaluate and improve: local economy

A circular economy, as the term already mentions, is an economy and it is important to determine which local parts of the economy are circular. In short, it is advisable to clarify which local circular activities create value, what kind of circular jobs this creates and what this can mean for local employment.

CHAPTER 6

EXPERT PANEL

6 EXPERT PANEL

In this chapter the results of the executed expert panel are described, in which the draft recommendations from chapter 5 have been validated. The results are used as input for formulating final recommendations (chapter 7) with regard to creating and improving the circular functioning of an area during circular area development. First, the results of the expert panel are discussed, whereby the structure is based on the expert protocol (Appendix III). Secondly, a conclusion about the expert panel has been written.

6.1 Outcomes expert panel

In this section, the results of the expert panel are presented. The expert panel is hold with two experts from practice. First of all, it is described what the results of the expert panel are with regard to the clarity of the recommendation list. Subsequently, it is discussed how to improve both the structure of the list and specific recommendations. Thereafter, it is described which recommendations are missing in the list. Finally, it has been written whether the list can contribute to improving the circular functioning of an area in practice.

6.1.1 General clarity of the recommendation list

During the expert panel, the respondents were asked whether, without the researcher explaining the list of recommendations, they wanted to give an explanation of the draft recommendation list according to their interpretation. This question makes it possible to assess whether or not the overview of the recommendation list is understandable for outsiders of the research team.

One of the respondents immediately indicated that the list is divided into three boxes, or categories. The other respondent agreed and indicated that the structure is clear. More specifically focused on the different categories of the recommendation list, the respondents saw the overarching recommendations as the starting point of an area development, which forms the basis for the rest of the development process. The second aspect, creating both a circularly designed and a circularly functioning area, described one of the respondents from his own perspective as the initiative and design phases during a development. Finally, both respondents saw the category monitoring, evaluation and improvement as a structural process consisting of a structural plan-do-check-act (PDCA) process. A PDCA can be seen as an iterative process for the control and continuous improvement of processes and products.

However, the respondents stated that a few of the recommendations are unclear by only seeing the recommendation list without additional information. Therefore, they have claimed that for each recommendation, an individual description is needed in order to both prevent uncertainties about the recommendations and enhance the clarity of the list.

6.1.2 Improvements to the structure of the recommendation list

Initially, a respondent indicated that the box of ‘overarching recommendations’ must clearly indicate that these are overarching recommendations. In doing so, the respondent outlined the possibility of extending the box of ‘overarching recommendations’ as a whole downwards, with all other recommendations ending up in that specific box. Another possibility could be to give the box a different colour or shape, or a combination of these options.

Thereafter, a discussion started during the expert panel. First, one of the respondents stated that the list demonstrates a kind of linear approach. This fact reinforced the respondent by arguing that the majority of the images of a circular economy are round or circle-like, while the respondent cannot identify a round or circle-like shape from the recommendation list in a quick eye-turn in the list. However, the other respondent disagreed and argued that it will be difficult to illustrate this recommendation list in a circular image. In addition, the respondent indicated that due to the 'monitor, evaluate and improve' section, the list has a plan-do-check-act process, which clearly has a circular approach, according to the expert.

Secondly, one of the respondents mentioned that it may be clarifying if the different phases of an area development are indicated in the recommendation list. The other respondent disagreed with this because after every phase in an area development there is an evaluation moment, in which reference is made to the third category 'monitoring, evaluation and improvement'. During this moment in an area development, it is determined whether the current approach and implementation of the plans are sufficient and whether improvements are still needed and possible. In other words, the third category of 'monitoring, evaluation and improvement' does not take place after the completion of the second category of 'creating both a circularly designed and circularly functioning area', but are fairly well acquired. This creates an iterative process by using the recommendation list that ensures that the circular functioning of an area is continuously improved per phase. Hence, it is not possible to indicate the different phases of an area development in the recommendation list.

6.1.3 Improvements to the recommendations

During the expert panel, improvements were proposed by the experts for two recommendations. First, for the recommendation 'design and construction according to circular principles', the application of a circular layout, which is relatively often forgotten according to one of the respondents, should be added in the description. The respondent stated that this aspect focuses on organizing and positioning the built environment as circular as possible. Consequently, as little material and energy as possible is needed in an area. An example of this is the best possible positioning of solar panels so that it can achieve maximum efficiency.

Secondly, an improvement is proposed for the recommendation 'introduce flexibility in the zoning plan'. This recommendation is mainly aimed at bringing industrial activities with residential functions closer to each other. One of the respondents, however, indicated that nuisance circles for certain companies have been drawn up for a reason. According to the respondent, obstacles have arisen from a public health perspective. In other words, from the recommendation, it seems like public health is at stake to create innovations. That is why it is important, according to the expert, to specifically mention that the condition of this recommendation is that the environment remains habitable for the inhabitants, in which there is as little nuisance as possible and no toxic substances are produced near homes.

6.1.4 Missing recommendations

One of the respondents claimed that he misses an overarching recommendation for the overarching recommendations. According to the expert, this is: 'formulating a common goal', so that everyone involved knows what the goal is of the area development. This could be, for example, that it is emphasized once again that the Dutch government wants to be fully circular by 2050. The result of formulating a common objective is that the various parties involved will work together more in order to ultimately achieve the goal.

6.1.5 Contribution of the list regarding improvements of the circular functioning of an area

Both respondents argued that the recommendation list can contribute to improving the circular functioning of an area. In addition, the respondents acknowledged that the recommendation list is generic, which means that it can be used for different area developments. However, the application of the recommendation list still depends on the involved local policy of the municipality and the local market situation.

In addition, the recommendation list asks for a specific description of the recommendations; what is the purpose of the recommendations, how can the recommendations be applied in practice and how does the recommendation contribute to circular area development.

Moreover, one of the respondents reported that the recommendation list makes clear that there are more aspects in a circular area development than just circular design. In that respect, according to the experts, it provides a clear picture for policymakers involved in circular area development.

6.2 Conclusion

First of all, regarding the general clarity of the recommendation list, it can be concluded based on the expert panel that the distribution of the three components in the recommendation list is clear, recognizable and understandable. In addition, the descriptions of the various components given by the respondents correspond to the focus of each component, as described in section 5.2. Nevertheless, the respondents indicated that certain recommendations are fairly unclear and vague at the sight of the recommendation list. Consequently, it is important to describe each recommendation individually, in addition to the recommendation list, with an explanation of how the recommendation can be implemented and what the contribution will be for circular area development.

Secondly, according to the respondents, the structure of the recommendation list can be improved by having the 'overarching recommendations' box more clearly indicates that it concerns overarching recommendations. Furthermore, it emerged from the expert panel that the category 'monitor, evaluate and improve' ensures that the recommendation list has a circular approach. More specifically, since the recommendation list is not a step-by-step plan and a continuous 'evaluate and improve' moment occurs, choices made and to be made during the area development can be improved. Therefore, the 'monitor, evaluate and improve' category creates an iterative process that ensures that the circular functioning of an area can be continuously improved.

Third, improvements have been suggested by the experts for two recommendations. Hereby, it has been advised to mention for the recommendation ‘design and construction according to circular principles’ that this includes a circular layout and positioning of objects. Concerning the recommendation 'introduce flexibility in the zoning plan', which is mainly focused on bringing industrial functions and residential functions closer together, the respondents stated that it is important to explicitly mention in this recommendation that the health of the residents are not put at stake. In other words, the respondents proposed to clearly state that the condition of this recommendation is that the environment remains habitable for residents, in which there is as little nuisance as possible and no toxic substances are produced near homes.

Finally, it emerges from the expert panel that it is important to emphasize the purpose of the list in the recommendation list so that its use is encouraged. In addition, both respondents claim that the recommendation list can contribute to improving the circular functioning of an area and, moreover, that the recommendation list can be applied generically for different area developments. Nevertheless, the application of the recommendation list does depend on the local policy of the municipality and the local market situation, partly due to the fact that, in 2020, the implementation of circularity in area development is still in its infancy.

CHAPTER 7

CONCLUSION

7 CONCLUSION

This chapter focuses on formulating conclusions based on the validated research results. First of all, the five sub-questions are answered and, thereafter, the main question of this research is answered.

7.1 Answering the sub-questions

In order to answer the main question of this research, the sub-questions must first be answered. Therefore, this section contains answers to the five sub-questions.

7.1.1 Sub-question 1: What is the concept of a circular economy?

The concept of a circular economy can be considered as the opposite of the concept of a linear economy, which is based on a take-make-waste principle. In other words, in a circular economy, products, materials and resources are kept in the economy for as long as possible, without losing value, whereby system thinking is central. The concept of a circular economy has three main principles, namely: (1) reduce, (2) reuse, and (3) recycle. In addition to these three main principles, there are additional principles, such as repair, refurbish, remanufacture and recover.

In addition, the shift to a circular economy and the development of the concept of a circular economy are stimulated by innovation. This is because innovation brings together technical, social and economic aspects.

7.1.2 Sub-question 2: What is the geographical function of a circular economy?

A schematic geographical area is illustrated in figure 37. The geographic function of a circular economy focuses on minimizing the use of resources and energy by closing, slowing and narrowing down cycles, as locally as possible. In other words, the geographic function in combination with a circular economy can be considered as a circular area consisting of a circularly designed environment and a circularly functioning environment. In a circular area, material and energy cycles are resilient, renewable, local, and have a positive impact on the circular functioning of the area itself and its surrounding areas.

Figure 37 Schematic geographical area

7.1.3 Sub-question 3: What is the network perspective of a circular economy?

A schematic network perspective is shown in figure 38. The network perspective of a circular economy focuses, firstly, on closing cycles by allowing actors to work together, and secondly, that the actors who work together are localized as locally as possible. In other words, production and service actors are located as close together as possible, with international transactions only serving as an alternative if a product or service is not available in the local region.

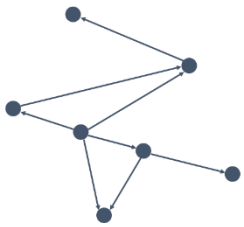


Figure 38 Schematic network perspective

However, it is not possible to produce or place all products and services in one specific area, partly because of environmental and climatic conditions. As a result, certain areas and regions will specialise in specific activities in a circular economy.

7.1.4 Sub-question 4: What is the principle of urban metabolism?

The purpose of urban metabolism is to reduce the current consumption of urban resources by creating closed cycles. To achieve this goal, the principle of urban metabolism aims at both providing insight into and investigating all flows of socio-economic processes entering and leaving an area or city. Based on the data of various flows, socio-economic processes can be optimized, which subsequently can reduce resource consumption.

7.1.5 Sub-question 5: How can the principle of urban metabolism combine a geographical area with the network perspective according to the concept of a circular economy?

By combining a geographical area with a network perspective according to the concept of a circular economy, based on the principle of urban metabolism, all flows of socio-economic processes entering and leaving a specific area are made transparent. The data of all flows of socio-economic processes can be analysed in order to define possibilities to reduce the current consumption of urban resources.

In figure 39, the left column displays a schematic geographical area (section 7.1.2), while the right column shows a schematic network perspective (section 7.1.3). In the middle column of figure 39, the fusion of a geographical area with a network perspective according to the concept of a circular economy is illustrated. The figure shows that the actors are located locally together and work together to close cycles. Since it is impossible to close cycles in strict boundaries of a specific area, actors cooperate with actors from adjacent areas.

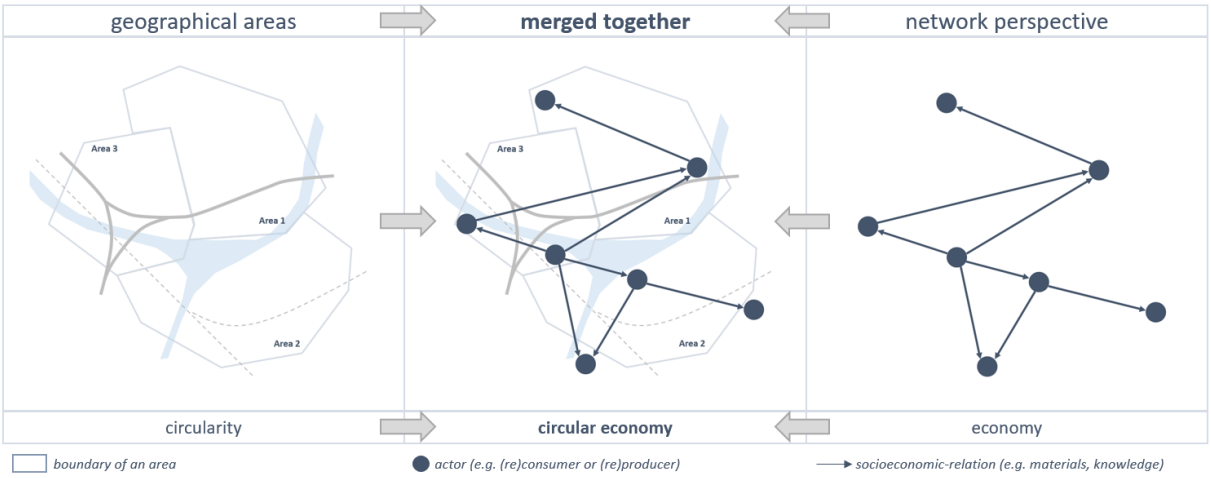


Figure 39 Combining a geographical area with a network perspective according to the concept of a circular economy

7.2 Answering the main question

Which recommendations can contribute to an area development with regard to the circular functioning of an area?

The recommendations that contribute to the circular functioning of an area during an area development can be divided into three parts: (1) overarching, (2) creating a circular area, and (3) monitoring, evaluation and improvement. First, each item is explained individually and secondly an overview of the recommendations is illustrated in figure 40.

Overarching recommendations

The overarching aspect is mainly aimed at policymakers who work for governments or municipalities. The overarching recommendations, therefore, do not focus on a specific area development, but together form a basis for circular area developments. Hereby, it is important that the basis of the overarching recommendations is drawn up by the government. Via a top-down approach, the basis of the overarching recommendations will be communicated with municipalities, whereby the municipalities have the freedom to impose higher requirements on the recommendations. A top-down approach is important, since each municipality has its own policy with regard to sustainability and a circular economy, which can influence circular area developments.

The first recommendation for this part is that governments and municipalities specifically formulate how sustainable and circular objectives can be achieved in circular area developments. This can be achieved, for example, by drawing up guidelines for circular construction or checklists with the potentials of activities, services

and existing infrastructures that contribute to a local circular economy. Secondly, governments and municipalities should stimulate innovations during area developments, since a shift to a circular economy is stimulated by innovation.

Realizing a circular area: focus on creating both a circularly designed and a circularly functioning area
Although the main question focuses on recommendations that contribute to the circular functioning of an area, recommendations for circular design are also given. This is due to the fact that a circularly designed area and a circularly functioning area are inextricably linked: together, a circular area is created.

For this part, it is initially recommended to re-think the area development plans. More specifically, first, analyse what buildings, infrastructure, public facilities, activities, and services are already located in an area. Subsequently, assess how the existing built environment and existing initiatives can contribute to the local circular economy. If contributions are made, the life of the existing built environment should be extended, while existing activities and services in an area should be maintained or kept close. In addition, it is advisable to analyse which functions, infrastructure and activities an area lacks with regard to a local circular economy. The missing aspects can then be implemented in the area development plans to subsequently realize a more circular area.

Secondly, for this part, it is recommended to apply different aspects in an area development to create a circular area. For example, the application of circular criteria in land issues and tenders for the development of buildings, infrastructure and public functions can ensure that the development of the built environment focuses on circular design and construction. In addition, it is recommended to design the built environment according to circular principles, with particular attention to closing, slowing down and narrowing material and energy cycles. Furthermore, it is advisable to develop new forms of financial value allocation for a circular built environment, so that obstacles from both land price and land ownership are reduced or even prevented during circular area developments. Moreover, the advice is to introduce flexibility in the zoning plan, so that opportunities arise for placing certain activities and functions, such as hubs, close to residential functions. This means, among other things, that existing initiatives that contribute to the circular functioning of an area can remain located in the specific area without having to leave because of the collisions with housing construction. However, this possibility must be subject to the condition that the environment remains liveable; as little nuisance as possible without emitting toxic substances near homes. Finally, a recommendation is to encourage local partnerships to optimize energy and material consumption and to minimize waste by closing, slowing and narrowing cycles.

Monitor, evaluate and improve
The third part focuses on monitoring, evaluating and improving certain aspects in order to be able to assess whether the sustainable and circular objectives of an area development are being achieved. In total, six different aspects are identified in this study to monitor and evaluate, to subsequently, improve if possible.

First, it is recommended to monitor the type, quantity and origin of the incoming material and energy flows in an area and vice versa for the outgoing flows. The data from the incoming and outgoing flows can then be analysed to optimize network processes, which can ultimately contribute to closing, slowing or narrowing local cycles. Secondly, it is advisable to monitor which existing and future raw materials have been processed in an area, so that local reuse of raw materials can be stimulated. Third, map the energy consumption in the area of both buildings and public facilities. By analysing the energy consumption, it is possible to implement any improvements, which results in a reduction of the energy consumption in the area with the ultimate goal that the area is self-sufficient in its energy needs. Fourth, the advice is to gain insight into the climate adaptation of the area, or in other words, monitor and evaluate the total green space, water use and air quality in an area to assess whether this is sufficient and to improve it if possible. Fifth, it is recommended to investigate the effects on the health and well-being of the residents of the area if dwellings and businesses that carry out industrial activities are located close to each other. The data can thereafter be evaluated. Based on the evaluations, improvements could be implemented which could eventually lead to innovations, allowing certain companies that carry out industrial activities with residential functions to be combined during circular area developments. Finally, it is advisable to clarify which local circular activities create value, what kind of circular jobs this creates and what this can mean for local employment.

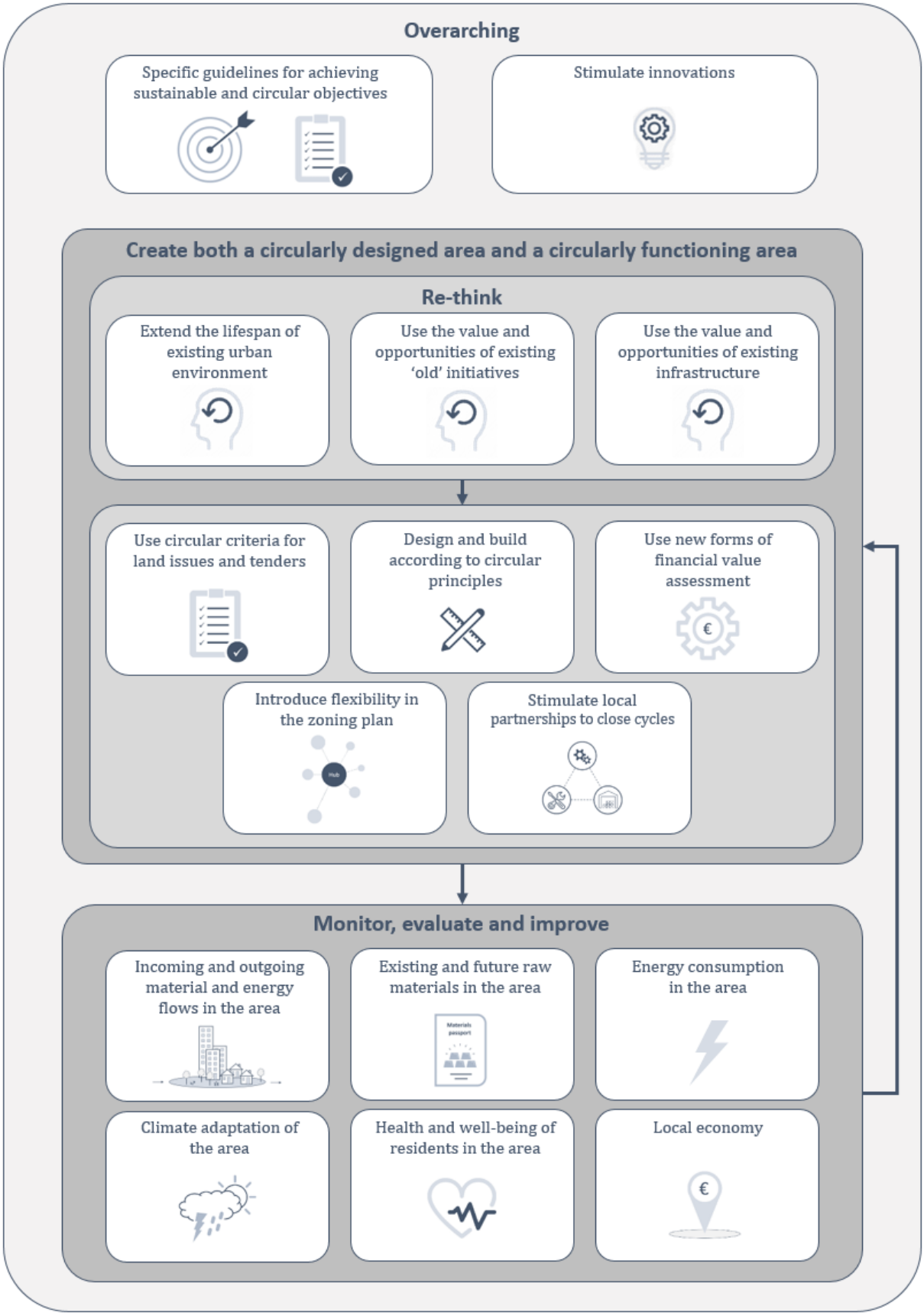


Figure 40 Recommendation list for creating or improving the circular functioning of an area

CHAPTER 8

DISCUSSION

8 DISCUSSION

The results of this research are discussed in this chapter. First of all, the validity of the research outcomes is argued. Subsequently, the outcomes are compared with existing theories and practice and the application of the recommendation list in practice is discussed. Third, the limitations of this research have been described. Thereafter, the implications of this study are discussed, and finally, this chapter contains suggestions and recommendations for future research.

8.1 Validity

To demonstrate that the study results are reliable, this section focuses on the validity of the research results. The validity of the research results is initially explained internally, and is subsequently described from an external perspective.

8.1.1 Intern validity

Bryman (2012) describes internal validity as: *"[...] whether a finding that incorporates a causal relationship between two or more variables is sound"* (Bryman, 2012, p. 712). In other words, the internal validity of a study shows whether the chosen research methods are suitable for formulating correct conclusions. In order to increase the internal validity in this study, first of all, a conceptual model has been developed based on literature research, which provides an overview of the various topics of the study. The conceptual model has had a contribution to the choice of research methods to answer the research questions.

Secondly, in this research is chosen for a qualitative research approach, which consists of a literature review, case study, semi-structured interviews and an expert panel. For the case study carried out, the internal validity is enhanced by formulating selection criteria in advance that the case study had to meet, while the internal validity for the semi-structured interviews is increased by first drawing up an interview protocol, and second, to select respondents based on their involvement and expertise in area developments. In addition, the internal validity has improved due to the expert panel carried out, in which experts, who had not previously been involved in the study, have validated the results of the research.

Finally, the internal validity of this research has improved because the qualitative research approach has been combined with quantitative aspects. More specifically, the alterations for the case study regarding the circular functioning of the area due to the area development have been demonstrated in both a qualitative and a quantitative way. The consequence of the combination of qualitative and quantitative aspects is that the validity, reliability and triangulation of the research results are increased (Bryman, 2012).

8.1.2 Extern validity

External validity can be defined as: *"[…] whether the results of a study can be generalized beyond the specific research context"* (Bryman, 2012, p. 47). In order to increase the generalization for other Dutch circular area developments, criteria were drawn up prior to the case study selection, which the case study had to meet. First, a criteria was that the case should be localized around a city in the Netherlands, so that the impact of the area development could be clearly visualized.

Secondly, a selection criteria was that the municipality involved has sustainable and/or circular ambitions. However, due to the fact that little is known about the implementation of circularity at an area level (Pomponi & Moncaster, 2017), few municipalities are actually executing circular area developments. As a result, a case study in Amsterdam was chosen, as the municipality of Amsterdam has a circular vision and circular ambitions for the city, and actually wants to implement them. In addition, the external validity, like the internal validity, has been improved by the expert panel, in which external experts from outside the research team validated the research results.

8.2 Research outcomes

The results of this research are discussed in this section. Firstly, the results have been compared with the literature review (chapter 3) to identify similarities and differences, and secondly, the results are discussed in relation to practice.

8.2.1 Discussion on theory

The theoretical framework (chapter 3) of this research contains four different components, namely; (1) the concept of a circular economy, (2) circularity in the built environment, (3) networks, and (4) urban metabolism. Within this section, the outcomes of this research are discussed in relation to each part of the literature review.

Circular economy literature

In recent decades, many research has been conducted into the concept and principles of a circular economy. However, both in literature and practice, many different definitions are used with regard to a circular economy, resulting in little agreement about the definition, which in turn leads to different interpretations. Hence, the research by Kirchherr et al. (2017) can be considered valuable for theory, practice as well as for this research, as they have identified 114 different definitions based on an analysis of 147 different publications. Within their research, they have concluded that the three principles reduce, rethink, and refuse are most linked to a circular economy. This is in line with the results of this study, as the three principles play an important part in the recommendation list (section 7.2) of this research.

In addition, the literature study shows that the shift to a circular economy is stimulated by innovation (Murray et al., 2017). This corresponds to the outcomes of this research. More specifically, in the recommendation list, the aspect of innovation has a crucial role in creating a circularly functioning area. Therefore, stimulating innovations is an overarching recommendation.

Due to the worldwide outbreak of the coronavirus, the importance of a circular economy is extremely topical in the Netherlands in 2020. A report by DNB (2020) shows that the Netherlands has a volatile economy compared to its surrounding European countries. Part of the cause is that Dutch port cities are focused on economic activities that are highly dependent on global processes, such as services and logistics. That is why a circular economy built from regions can help with this. Bringing (re)consumption and (re)production back or closer to port cities not only contributes to the ecological aspect, but also to the local economy (Van den Berghe, 2020).

Circularity in the built environment literature

Since there is already no consensus on what the definition of a circular economy is in literature (Kirchherr et al., 2017), there is no agreement at all on what circular area development is. Therefore, this study did not elaborate on the definition of circular area developments. Nevertheless, studies by Geissdoerfer et al. (2017) and EMF (2017) mention that circular area development consists of a circularly designed environment and a circularly functioning environment, in which the use of resources and energy is minimized by closing, slowing down and narrowing cycles. In addition, literature shows that a circular area is linked to the geographical area of a city, which refers to circularity in value chains, creating opportunities for high-quality reuse of resources and energy (EMF, 2017). These facts are consistent with the results of this study since, firstly, a recommendation is to create both a circular area and a circularly functioning area with different sub-recommendations. Second, certain recommendations address the stimulation of local partnerships between actors, which relate to the geographical factor.

Furthermore, literature shows that old initiatives, like craft companies, in an area are often not seen as circular, while these companies do contribute to a circular economy (PBL, 2019). This fact has also been confirmed in practice during interviews. In addition, due to the fact that Dutch port cities are dependent on global processes, DNB (2020) has advised to focus on, among other things, the more traditional and less volatile manufacturing industry, which is extremely relevant anno 2020 due to the outbreak of COVID-19. Therefore, the item 'rethink' is included in the recommendation list of this research, which among other things focuses on analysing the existing situation in an area and how this can contribute to the circular functioning of the specific area.

Coming back to the advice given by DNB (2020) about focusing on a more traditional and less volatile manufacturing industry: this does not mean that only existing initiatives should be preserved during an area development. The manufacturing industry can also consists of new modern, competitive and innovative companies which can be implemented during an area development in order to improve the circular functioning of an area (Van den Berghe, 2020).

Networks literature
The literature study indicates that the principle of industrial symbiosis is a suitable approach to reduce energy and material consumption (Chertow, 2000) by having actors work together to close cycles (Ghisellini et al., 2016). A crucial factor that is also mentioned in literature about closing cycles is that in a circular economy the aim should be on closing cycles as local as possible (North, 2010). These facts are all reflected in the results of this research, since one of the recommendations is aimed at stimulating local partnerships to close cycles.

The importance of local partnerships is confirmed by the outbreak of the coronavirus in 2020. Due to the outbreak, the number of global services and transports have been significantly reduced, delayed or were even not possible (Bode & Luman, 2020). Consequently, nowadays it is even more important to aim at a more traditional and less volatile manufacturing industry, as advised by DNB (2020), which means that (re)production will be (re)located on a smaller scale. As a result, countries are less dependent on international processes and besides, the total number of international transactions will reduce. This given is in line with the principle of a circular economy.

Moreover, in the theoretical framework, various barriers have been identified with regard to closing cycles. The technical, informational, and economic barriers that arise in the realization of industrial symbiosis, according to Fracasscia (2018), are not specifically mentioned in the results of this study. However, different aspects of each barrier are indirectly included in the recommendations. In addition, the barriers have been used as input for the suggestions and recommendations for further research in section 8.5.

Urban metabolism literature
In the outcomes of this research, the principle of urban metabolism, which focuses on reducing the current consumption of urban resources by realizing closed cycles, which is in accordance with the principle of a circular economy (Ness & Xing, 2017), is included in the research results. More specifically, partly on the basis of the principle of urban metabolism, the case study of this research has been analysed. From this analysis, various conclusions have been formulated, which contributed to answering the main and sub-questions. In addition, the principle of urban metabolism is incorporated in the 'monitor, evaluate and improve' section of the recommendation list, because an analysis of all flows and networks in a city can be used to optimize the processes (Suh, 2005). The process optimization can then contribute to closing material and energy cycles.

8.2.2 Discussion on practice
In this section, the applied research methods that relate to practice are discussed and compared with the research results. Furthermore, the added values of both the case study, interviews and the expert panel on the research results are discussed.

Case study
Before the case study was conducted, several objectives have been formulated (section 2.2.3). Thanks to the previously formulated objectives, the added value of the case study has increased for this research. First of all, the case study showed what the sustainable and circular objectives and policy of the municipality of Amsterdam is. Thanks to the gained knowledge about current policy and visions, this study concluded that no clear guidelines are currently being used by the Dutch government and the municipality of Amsterdam with regard to the implementation of circularity at an area level. This creates ambiguities during circular area developments. Consequently, an overarching recommendation has been drawn up for the specific formulation of guidelines for achieving sustainable and circular objectives in this research.

However, for the case study, the ambiguities will be reduced in the coming years, as the municipality of Amsterdam wants to formulate circular ambitions with associated criteria by 2022 at the latest (Municipality of Amsterdam, 2020b). Nevertheless, it is important to mention that the municipality of Amsterdam is one of the forerunners in the field of sustainability and circularity, while the recommendation list of this research is to be considered generic. Hence, the overarching recommendation is included in the recommendation list.

Secondly, the case study has demonstrated the changes that can occur in an area in relation to the program due to an area development. Furthermore, due to the increasing program in the case study, material consumption and waste generation are also increasing, which is proven by analysing AS-MFAs of the case study for 2013 and 2018. According to the case study, it can be stated that with regard to the circular functioning, more processing of materials and waste should take place as locally as possible in the future due to an area development. This fact is in line with the results of the study, which state, among other things, that actors who carry out industrial activities must be located as locally as possible together in order to close local cycles.

Finally, the case study revealed that the implementation of circularity in area development can be stimulated by flexible zoning plans, as stated in the report of Gemeente Amsterdam (2019c). Partly on the basis of this fact, the recommendation list of this study (section 7.2) includes the recommendation 'introduce flexibility in the zoning plan'. However, a zoning plan is legally binding for government, citizens and companies and serves as a framework for assessing building plans and gives an idea of the expected spatial developments, while a circular economy is stimulated by innovations that could collide with a zoning plan. Hence, the recommendation included in the list only focuses on the possibility of bringing industries/companies with residential functions closer, provided that the liveability of the residential environment has no adverse consequences. For example, existing industrial initiatives that contribute to the circular functioning of an area can be preserved during an area development.

Semi-structured interviews

The semi-structured interviews performed mainly served to gather additional information about the case study. The interviews with four respondents made an important contribution to the collection of information on various subjects, and in particular on the clashes between residential functions and industrial activities. From the literature available on the case study, not much can be found on this subject, which is why the respondents' answers are considered valuable for this study. Before the interviews were held, an interview protocol was drawn up. As a result, the same questions were asked to every respondent. The interviews show that the respondents unanimously agree that companies with a high environmental category cannot be mixed with residential functions. However, little is known about how residential functions can be mixed with this type of industrial activity. That is why the recommendation list includes the recommendation to stimulate innovations in order to find possible solutions for bringing those two worlds closer together, with the condition that this will have no adverse effects on the health of the residents.

Expert panel

In the expert panel, the draft recommendations and results have been validated that have arisen from the literature review, interviews and the case study. During the expert panel, various questions have been asked to the two respondents who participated in the panel, based on a previously drawn up protocol. The answers given by the respondents have added value to validating recommendations that have emerged from literature and practice. In addition, the respondents supplemented the recommendations ‘design and construct according to circular principles’ and ‘introduce flexibility in the zoning plan’ with information based on their experiences. This has improved the recommendations on social, technical and economic aspects. Finally, respondents have also played an important role in clarifying the recommendation list by indicating that the ‘overarching recommendations’ should more clearly indicate they are overarching recommendations. Hence, the structure of the recommendation list has changed after the expert panel.

8.2.3 Application of the recommendation list

The output of this study are recommendations that can be taken into account to improve the circular functioning of an area during the development of circular areas. These recommendations are included in a list. The aim of the list is to accelerate a transition to a circular economy, especially within the field of area development. The recommendations can be used by people (working for public or private parties) who are involved in circular area developments to make choices with regard to improving the circular functioning of an area. However, in order to realize this, it is important that the recommendation list is generic, so that it can be used for any area development.

First, the overarching recommendations contribute to making the recommendation list for area developments generic. Hereby, the overarching aspect is mainly aimed at policymakers who work for governments or municipalities. The overarching recommendations, therefore, do not focus on a specific area development, but together form a basis for circular area developments. Nevertheless, it is important that the overarching recommendations should mainly come from the government in the form of a top-down approach, so that municipalities will apply them. This is because each municipality has its own policy regarding a circular economy, which can influence circular area developments.

Second, the recommendation list consists of three categories (one of which is overarching and the other two are aimed at a specific area development), but does not have a strict step-by-step plan to follow. However, it is important that certain choices are continuously commemorated. In other words, depending on the area development, after the item 'rethink', you can choose with which recommendation/criteria will be started first. This is because the recommendation list has an iterative process: evaluating each choice over time and improving it if possible. If an area development, for example in Groningen, is a brownfield, then the aspect rethink with regard to the existing built-up area can be skipped since the value of the existing area cannot be reconsidered due to the fact that nothing has yet been established in the area. However, it is important to rethink certain choices in the development process, where among other things the question can be asked: do the current plans and choices actually have a contribution to the circular functioning of an area and its surroundings? In addition, it is important to mention that it is not a requirement that every recommendation is implemented during an area development. In some area developments it may not be possible to introduce flexibility in the zoning plan or create local partnerships, for example because few companies are located in the surrounding area. However, it is advisable to apply all recommendations in an area development in order to create a circularly functioning area as possible.

8.3 Limitations

The results of this research are clear, but have several limitations. Firstly, little research has been carried out into circular area development, with the result that uncertainties may arise about what is actually circular area development. In order to mitigate this limitation, this study did not initially address the definition of circular area development. Furthermore, in the theoretical framework, multiple sources have been collected, compared and combined to provide insight into the principle of circular area development.

Secondly, the research focuses on an initial phase in area developments regarding a transition to a circular economy. In other words, the tensions and challenges that arise at different scales during area developments are only emerging or will arise in the future. Hence, some conclusions and recommendations of this study can be considered as hypothetical. However, the certain hypothetical conclusions and recommendations demonstrate important consequences for current development and transformation plans of areas with regard to the circular functioning of an area.

Thirdly, only one case study has been analysed in this study, causing that no cross-case analysis could be performed to compare and validate the results, for example. A possible explanation for this is that few case studies were available that met the selection criteria of the case study (section 2.3.3). In addition, the available

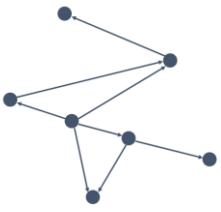
case studies that met the criteria were all located in Amsterdam. This would lead to almost the same conclusions, since the municipality of Amsterdam has been involved in every possible case study.

Finally, the coronavirus outbreak has posed several barriers. The outbreak can be considered as an obstacle to conduct an additional case study, partly due to the fact that it has become more difficult to approach experts for interviews. Next to the fact that experts had less time for interviews, it was often not possible to approach an expert for the expert panel. In short, due to the outbreak, fewer interviews were conducted to validate the results and fewer experts attended the expert panel to validate the draft conclusions and recommendations. However, despite the fact that fewer interviews were conducted and fewer experts were involved in the expert panel, all pre-formulated questions (before the virus outbreak) are answered during the interviews and the panel.

8.4 Implications

It may have consequences for the future if the recommendations of this research are not applied in current and future area developments. More specifically, first, as described in section 4.6.2, knowledge-based circular activities will take place in the city, while manufacturing industries will take place outside the city in the future. In other words, there will be no more space for business parks in and around city centres in the future. The consequence of this is that lower-paid activities, which are generally linked to manufacturing industries, will increasingly leave the city.

Secondly, quays along the water around the centre of cities will increasingly contain no industrial activities in the future. Partly due to urban densification, current and former industrial areas located in or around city centres are increasingly being transformed into mixed residential areas (de Beer, Ekamper & van der Graag, 2017). As previously concluded, however, industrial functions collide with residential functions on various aspects. Consequently, certain quays, where industrial activities take place, will eventually not contain, for example, manufacturing industries, while the quays have the potential to stimulate a circular economy by, among other things, connecting actors.



Third, in the future, transactions of flows will generally take place on a larger scale in areas due to current approaches in area developments. Area developments generally increase the program in an area, which in turn leads to an increase in the total material consumption in an area. In a circular economy, this means that more activities and transactions must take place internally in an area, or as locally as possible. However, because existing industrial activities collide with residential functions, industrial activities increasingly disappear from areas with contemporary area transformations. As a result, the distances of the network between actors will increase, and as a consequence, more transactions will take place regionally, nationally or even internationally, while the circular future requires more local transactions.

8.5 Recommendations for future research

This research has identified several possible ‘research gaps’ for theory and practice, which are described in this section. First, follow-up research could focus on how to stimulate local and regional economies to accelerate a transaction towards a circular economy. On the one hand, it can investigate how innovation can be stimulated to make the local economy more circular. This could relate to possible solutions to establish industrial functions closer to residential functions or create new circular jobs. On the other hand, it could focus on stimulating local

collaborations between actors to close cycles by mitigating or removing the technical, informational, and economic barriers of industrial symbiosis referred to in section 3.3.3.

Second, in future, more detailed research could be conducted into the conflicts and challenges between different scales during area developments. This can focus on providing insight into the various factors and motives that play a part in the conflicts and challenges and how they can subsequently be mitigated and/or prevented. A similar study could, among other things, contribute to the conservation of existing actors who carry out industrial activities in an area during an area development. Subsequently, these 'old' initiatives can contribute to the circular functioning of the area.

Finally, during an interview with respondent 1, it emerged that it is interesting to investigate which scale per material flow is most suitable for closing cycles in a circular economy. More specifically, a follow-up study could focus on examining the relationship between different flows and different scales. The output of a similar study could be a list of all activities required per scale level, including recommendations on how to close cycles (e.g. which activities and business categories are needed per scale level to close cycles). This list could then be used during area development to analyse whether the identified local and regional functions are already available. If there are missing functions, these can be implemented in development plans to ultimately improve the circular functioning of the area and surrounding areas by closing, slowing or narrowing cycles.

CHAPTER 9

REFLECTION

9 REFLECTION

A reflection is written in this last chapter of the thesis. This reflection starts with the position of the research within the graduation laboratory. Subsequently, the research process is reflected per phase, and finally, a reflection is written about the applied research methods.

9.1 Position of research within graduation laboratory

This research is conducted in the graduation laboratory of 'sustainable urban development and cities'. This laboratory is divided into two parts: (1) sustainability and (2) the development of areas and cities. In this research, the first part, sustainability, is discussed by conducting intensive research into the principles of a circular economy and circularity. Hereby, Geissdoerfer et al. (2017) argue that circularity can be seen as one of the requirements for sustainable development. The second part of the graduation laboratory, the development of areas and cities, is captured by firstly conducting literature research on area developments, and secondly, conducting a case study on an area development and then analysing it.

In short, in this research both aspects of the graduation laboratory 'sustainable urban development and cities' are captured by formulating recommendations that can be taken into account to improve the circular functioning of an area during area development.

9.2 Research process

In this section the process of the research is discussed per period of the research. The reflection is written from a personal perspective.

9.2.1 Preparation

A few months before the start of the graduation process, I started orientating on possible subjects for my graduation thesis. During the orientation, first of all, I asked a number of second-year master students, who were writing a master's thesis at that time, for advice regarding the choice of a subject. All the advice I received was fairly consistent, with each student indicating that it is of great importance that I find the subject interesting. Subsequently, in the last period of the first academic year of the master, I have had the course 'urban area development game', which mainly focused on area development. Partly because of my background at a developing contractor, I found this part of the master very fascinating. Therefore, I decided to use area development as the subject of my master's thesis.

From this starting point, I started to orient myself on possible topics and directions within area developments. During my bachelor period, I have written a thesis on circular construction, in which I read a lot of literature about the principles of a circular economy. The developments of a circular economy have inspired and interested me ever since, so I finally decided to focus specifically on a circular economy within the area development area, or in other words, circular area development.

Afterwards, orienting on a topic has brought me several advantages. First, I have conducted a research on a topic that I find interesting, fascinating, and most of all very enjoyable, so I never regretted choosing the topic. Secondly, in the follow-up phase (towards P1) I was able to start studying literature more quickly since I had already chosen quite a certain direction.

9.2.2 Towards P1

In the first week of this period, each student had to make important choices with regard to the research direction and the choice of a first supervisor. I experienced this week as stressful because during the lectures / workshops of the research directions, not all teachers were often present. As a result, it was not possible to get in direct contact with potential supervisors. At the end of this stressful week, I came into contact with Karel van den Berghe. I had indicated by e-mail that I wanted to write a study about circularity in combination with area

development. Karel was interested in my message and a personal conversation soon followed. During this conversation, I told in more detail what I wanted to investigate and Karel provided input with challenging possibilities for an investigation. Based on the personal conversation, I decided to choose Karel as my first supervisor.

Subsequently, Karel and I made clear agreements with each other about how Karel could guide me during the investigation. In the period towards P1, I had weekly contact with Karel, whereby he gave me feedback on my written literature research. Thanks to the clear agreements, I was able to receive structured feedback and comments, as a result of which I was able to continuously improve the research.

As the research developed, I started looking for a second supervisor for the research. Partly based on a recommendation from Karel, I decided to approach Alexander Wandl to become my second supervisor, since Alexander is a specialist in geo-design for a circular economy in urban regions.

9.2.3 Towards P2

After the P1 phase, I received critical feedback from both Karel and Alexander on the proposed research plan. To be honest, I found the first weeks of this period difficult because, above all, I could not formulate my research questions specifically and feasibly. However, reading more literature on the different topics of the thesis gave me a better overview, and besides, I gained more knowledge, which ultimately made it easier to formulate specific research questions.

I tried to prepare myself as well as possible for meetings with Karel and Alexander by providing as much input as possible and writing down questions and ambiguities. This allowed me to receive targeted feedback during the meetings. Afterwards, this approach has helped me considerably during this period to eventually receive a GO after the presentation of the P2 report, which allowed me to continue the investigation.

9.2.4 Towards P3

In the first weeks of this period, the research had almost no progress, partly due to holidays and the start of an internship period. Afterwards, I should have picked up the investigation earlier, since the investigation was slightly behind schedule. This has been an important learning moment for me. In order to solve this, I contacted both Karel and Alexander during this period to select a suitable case study. One of the criteria was that sufficient information would be available about an area's incoming and outgoing material flows (chapter 2). Together with Alexander I subsequently opened a database of REPAiR to see which area was suitable for the research based on that criterion point. This ultimately showed that Noordelijke IJ-oever West was a suitable area.

After a case study was selected for the study, I started to analyse. The case study was examined on the basis of both literature and interviews. In the first weeks of the analysis, literature was mainly studied about the case study. Before the case study selection, several possible case studies were, mainly looking at the availability of information, mapped. As a result, after choosing the case study, the weeks of the analysis went without problems, because sufficient information was available.

However, a virus called COVID-19 broke out. On March 12, 2020, people across the Netherlands were requested to work from home as much as possible (Rijksoverheid, 2020). This had consequences for the research process, as it became more difficult to approach experts for an interview. Ultimately, during this period I was able to interview four experts via alternatives: by telephone or by Skype.

Looking back on this period, the progress for the P3 report should have started earlier. However, thanks to extensive prior research into possible case studies, a major catch-up was made at a later stage. At some point in this period, the research was even ahead of schedule, however, due to an external effect (COVID-19), it was ultimately impossible to be ahead of schedule.

9.2.5 Towards P4

This period can be categorized as a combination of producing with a lot of thinking and making considerations regarding formulating conclusions. First of all, in this period, the interviews were analysed and processed into the research. Subsequently, the research results were made transparent. During the elaboration of the results, I experienced a few problems; the majority of the required data had already been included in the study. However, the expert panel was also prepared during this period. The coronavirus outbreak had created difficulties in approaching and inviting experts, and partly, therefore, I decided to move the expert panel to the P5 period. Fortunately, there were already two experts who confirmed their participation in this period, which allowed the expert panel to be held anyway during the next period. In other words, the problem was solved and not carried forward to the next period. In short, this period mainly focused on elaborating the results, conclusions and discussions, with relatively few problems have arisen.

9.2.6 Towards P5

The last phase of the research process started with conducting an expert panel. Since respondents had already been approached in the P4 phase, and besides, a protocol had been drawn up, it was not necessary to make any preparations for the expert panel. After holding the expert panel, the panel was summarized and the results were incorporated in chapters 6, 7 and 8. After the expert panel was completed, this phase mainly consisted of checking, improving, sharpening and completing all chapters in this research. Since the expert panel was already held in the second week of this period, there was sufficient time for the other activities. As a result, the research is completed without time constraints, which ultimately had a positive contribution to the total quality.

9.3 Research methods

This section reflects on the applied research methods.

9.3.1 Literature study

Since there is still little literature available on circular area developments, it was difficult to find scientific literature on this subject at the start of the literature search. That is why, in the first instance, a lot of literature was read about a circular economy, in order to gain knowledge about the principles, and subsequently, to link these to area developments on the basis of available literature on cities. However, I experienced difficulties in selecting relevant literature regarding the topics of this study, as these are very different from a personal perspective (e.g. networks versus built environment). Partly because of this, it was difficult to determine what was and was not included in the theoretical framework. By developing a conceptual model and updating it weekly, this problem was eventually solved. As a result, due to the overview that is illustrated by the developed conceptual model, I was able to structure the literature study in such a way that it could provide as much input as possible for answering the main and sub-questions of this research.

9.3.2 Interviews

Before the interviews were conducted, experts were selected based on their function and professional background. This was done by, among other things, analysing available LinkedIn profiles of potential respondents and then approaching the experts. In retrospect, the selection of experts has been valuable, as each selected respondent interviewed provided useful input for the study.

However, due to the coronavirus outbreak, it was not possible to conduct face-to-face interviews. On the one hand, the first two interviews that were held were conducted by telephone (respondents preference). Reflecting on the telephone interviews, there were two drawbacks. Firstly, a personal atmosphere was lacking, as a result of which respondents were less accessible to answer questions. Second, these interviews were limited in duration to approximately 25-30 minutes. On the other hand, two respondents were interviewed via Microsoft teams. As a result, a personal atmosphere was created because the respondents were able to see me and vice versa. In my opinion, this made the respondents more approachable compared to the telephone interviews. In addition, both respondents had given at least an hour of their time for the interview, giving them more time to

answer questions in more detail. Added together, afterwards, the first two interviews should have been conducted via Microsoft teams (or alternative) to improve the quality of the interview. Personally speaking, I see this as a valuable learning moment.

9.3.3 Case study

Before a case study was actually selected for this study, selection criteria were initially drawn up. Thanks to the criteria, the relevance and suitability of the case study were increased, resulting in more useful input for the research results. In addition, a criteria point was that sufficient information about the case study was available. Hence, possible case studies were initially identified, and subsequently, extensive research was conducted into the availability of information on the case studies in question. This extensive investigation occasionally felt pointless while running, as no progress was made. In addition, it was sometimes very difficult to find information, which made this previous study very time-consuming. However, thanks to this prior extensive research, which contributed to the choice of a case study (Noordelijke IJ-oever West), the elaboration and analysis of the case study was almost problem-free. Thus, looking back, the pre-formulated criteria were very valuable to the case study.

9.3.4 Expert panel

With regard to the execution of the expert panel, information about the research (problem, objective, research questions) should have been sent to the respondents before the expert panel was held. This could have given the experts the opportunity to read and understand the background of the study. However, this was not done and consequently, all the background information of the research was explained during the expert panel. In retrospect, too much information was given in too short a time, resulting in questions from the respondents about certain points. As a result, too much time was spent on explaining the study, reducing the time available for the expert panel questions. In other words, as mentioned earlier, a summary of the introduction of the surveys should have been sent to respondents retrospectively so that they had a better understanding of the survey.

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LIST OF FIGURES AND TABLES

APPENDICES

APPENDICES

I: Standard format interview protocol case study – Municipality of Amsterdam

Standaard format interview protocol case studie – gemeente Amsterdam

Datum: ……..

Locatie: ……..

Naam: ……..

Bedrijf: ……..

Introductie
Allereerst wil ik u welkom heten en bedanken voor het meedoen met dit interview voor het onderzoek 'Circulaire gebiedsontwikkeling: aanbevelingen voor het creëren van een circulair functionerend gebied'. Dit onderzoek focust zich op hoe er rekening gehouden kan worden met het circulair functioneren van een gebied tijdens gebiedsontwikkeling. Voor dit interview zijn dertien vragen opgesteld en verdeeld in de volgende vier categorieën: (1) achtergrond geïnterviewde, (2) beleid en visie van de gemeente Amsterdam met betrekking tot duurzaamheid en circulariteit, (3) de omgang met bestaande functies en bedrijven tijdens gebiedsontwikkelingen en (4) de haven van Amsterdam.

Deel A Achtergrond respondent

A.1 Zou u mij iets willen vertellen over uw professionele achtergrond?

Deel B Beleid en visie van de gemeente Amsterdam met betrekking tot duurzaamheid en circulariteit

B.1 Wat is volgens de gemeente Amsterdam een circulair gebied?

B.2 Welke functies dienen in een circulair gebied aanwezig te zijn?

B.3 Hoe kan volgens de gemeente Amsterdam een gebied circulair functioneren?

B.4 Hoe kan er volgens de gemeente Amsterdam circulair gebouwd worden?

Deel C De omgang met bestaande functies en bedrijven tijdens circulaire gebiedsontwikkelingen

C.1 Welke bedrijven dragen bij aan het circulair functioneren van een gebied?
En waarom?

C.2 Hoe wordt er tijdens een circulaire gebiedsontwikkeling omgegaan met de bedrijven/functies die al in het gebied aanwezig zijn?

C.3 Wat voor soort bedrijven vertrekken veelal uit industrie gebieden die getransformeerd worden naar woon/werk gebieden?

En waarom vertrekken deze bedrijven?

C.4 Uit documenten van de gemeente Amsterdam blijkt dat voor bepaalde bedrijven met een milieucategorie hoger dan 3.1 een uitzondering gemaakt kan worden tijdens circulaire gebiedsontwikkelingen, zodat industrie en wonen dichtbij elkaar gelokaliseerd kunnen worden. Waarom wordt dat gedaan?

C.5 Hoe wordt er in een gebied omgegaan met nieuwe bedrijven met een milieucategorie hoger dan 3.1?

C.6 Indien een bedrijf met een milieucategorie hoger dan 3.1, waarvoor een uitzondering is gemaakt in het bestemmingsplan, bijvoorbeeld failliet gaat of besluit ergens anders te vestigen, is het dan mogelijk dat eenzelfde soort functie/bedrijf terug mag komen op diezelfde locatie?

Of wordt er dan uitgegaan van een 'nieuw' bedrijf, waardoor een milieucategorie van 3.1 of lager wordt gehanteerd?

Deel D Haven van Amsterdam

D.1 Waarom is de haven van Amsterdam onderdeel van de Circulaire West-as?

D.2 Hoe kan de haven van Amsterdam een bijdrage leveren aan de transitie naar een circulaire economie?

Einde van het interview

BEDANKT VOOR UW DEELNAME

II: Standard format interview protocol case study – Port of Amsterdam

Standaard format interview protocol case studie – Port of Amsterdam

Datum: ……..

Locatie: ……..

Naam: ……..

Bedrijf: ……..

Introductie
Allereerst wil ik u welkom heten en bedanken voor het meedoen met dit interview voor het onderzoek 'Circulaire gebiedsontwikkeling: aanbevelingen voor het creëren van een circulair functionerend gebied'. Dit onderzoek focust zich op hoe er rekening gehouden kan worden met het circulair functioneren van een gebied tijdens gebiedsontwikkeling. Voor dit interview zijn een aantal vragen opgesteld en verdeeld in de volgende vier categorieën: (1) achtergrond geïnterviewde, (2) beleid en visie van Port of Amsterdam met betrekking tot circulariteit, (3) circulaire gebiedsontwikkeling en de omgang met bestaande bedrijven tijdens ontwikkelingen en (4) de haven van Amsterdam.

Deel A Achtergrond respondent

A.1 Zou u mij iets willen vertellen over uw professionele achtergrond?

Deel B Beleid en visie van Port of Amsterdam met betrekking tot circulariteit

B.1 Wat zijn de ambities van Port of Amsterdam met betrekking tot een circulaire economie?
Hoe wilt Port of Amsterdam zich positioneren ten opzichte van Amsterdam?

B.2 Wat is volgens Port of Amsterdam een circulair gebied?

B.3 Welke bedrijven/functies dienen in een circulair gebied aanwezig te zijn?

B.4 Hoe kan volgens Port of Amsterdam een gebied circulair functioneren?

Deel C Circulaire gebiedsontwikkeling en de omgang met bestaande bedrijven tijdens ontwikkelingen

C.1 Hoe is Port of Amsterdam betrokken bij circulaire gebiedsontwikkelingen van bijvoorbeeld Haven-Stad?

C.2 Welke eisen/criteria/factoren zijn belangrijk voor Port of Amsterdam in circulaire gebiedsontwikkelingen?

C.3 Hoe wordt er tijdens een circulaire gebiedsontwikkeling omgegaan met de bedrijven/functies die al in het havengebied aanwezig zijn?

C.4 Wat voor soort bedrijven vertrekken veelal uit industrie gebieden die getransformeerd worden naar woon/werk gebieden?

En waarom vertrekken deze bedrijven?

En waar vertrekken deze bedrijven heen?

Deel D Haven van Amsterdam

D.1 Waarom is de haven van Amsterdam onderdeel van de Circulaire West-as?

D.2 Hoe kan de haven van Amsterdam een bijdrage leveren aan de transitie naar een circulaire economie?

D.3 Wat zijn de potenties van de haven van Amsterdam met betrekking tot circulariteit?

D.4 Waarom worden veel 'zware' industrieën uit gebieden dichtbij het centrum van de stad (bijvoorbeeld Haven-Stad) verplaatst naar andere delen in de Amsterdamse haven?

Welke aspecten spelen hierin een rol?

Wie maakt de beslissingen om industrieën te verplaatsen?

Einde van het interview

BEDANKT VOOR UW DEELNAME

III: Interview protocol expert panel

Expertmeeting circulaire gebiedsontwikkeling
Master scriptie Sven van Bakel, Technische Universiteit Delft

Introductie
Allereerst wil ik u welkom heten en bedanken voor het meedoen met dit expert panel voor het onderzoek 'Circulaire gebiedsontwikkeling: aanbevelingen voor het creëren van een circulair functionerend gebied.' Dit onderzoek focust zich op hoe er rekening gehouden kan worden met het circulair functioneren van een gebied tijdens de ontwikkeling van circulaire gebieden.

Hoofdvraag onderzoek
''Welke aanbevelingen kunnen bijdragen aan een gebiedsontwikkeling met betrekking tot het circulair functioneren van een gebied?''

Doelstelling onderzoek

Product:	Aanbevelingen waarmee rekening kan worden gehouden om de circulaire werking van een gebied tijdens de ontwikkeling van circulaire gebieden te verbeteren.
Doel van het product:	Bijdragen leveren om de transitie naar een circulaire economie te versnellen, vooral op het gebied van gebiedsontwikkeling.
Gebruik van het product:	De aanbevelingen kunnen worden gebruikt door mensen (werkzaam voor publieke of private partijen) die betrokken zijn bij circulaire gebiedsontwikkelingen. Meer specifiek, de aanbevelingen kunnen hen helpen bij het maken van keuzes bij het verbeteren van de circulaire werking van een gebied tijdens het maken van circulaire gebiedsontwikkelingsplannen.

Deel A Achtergrond respondenten

A.1 Zouden jullie mij iets willen vertellen over jullie professionele achtergrond?

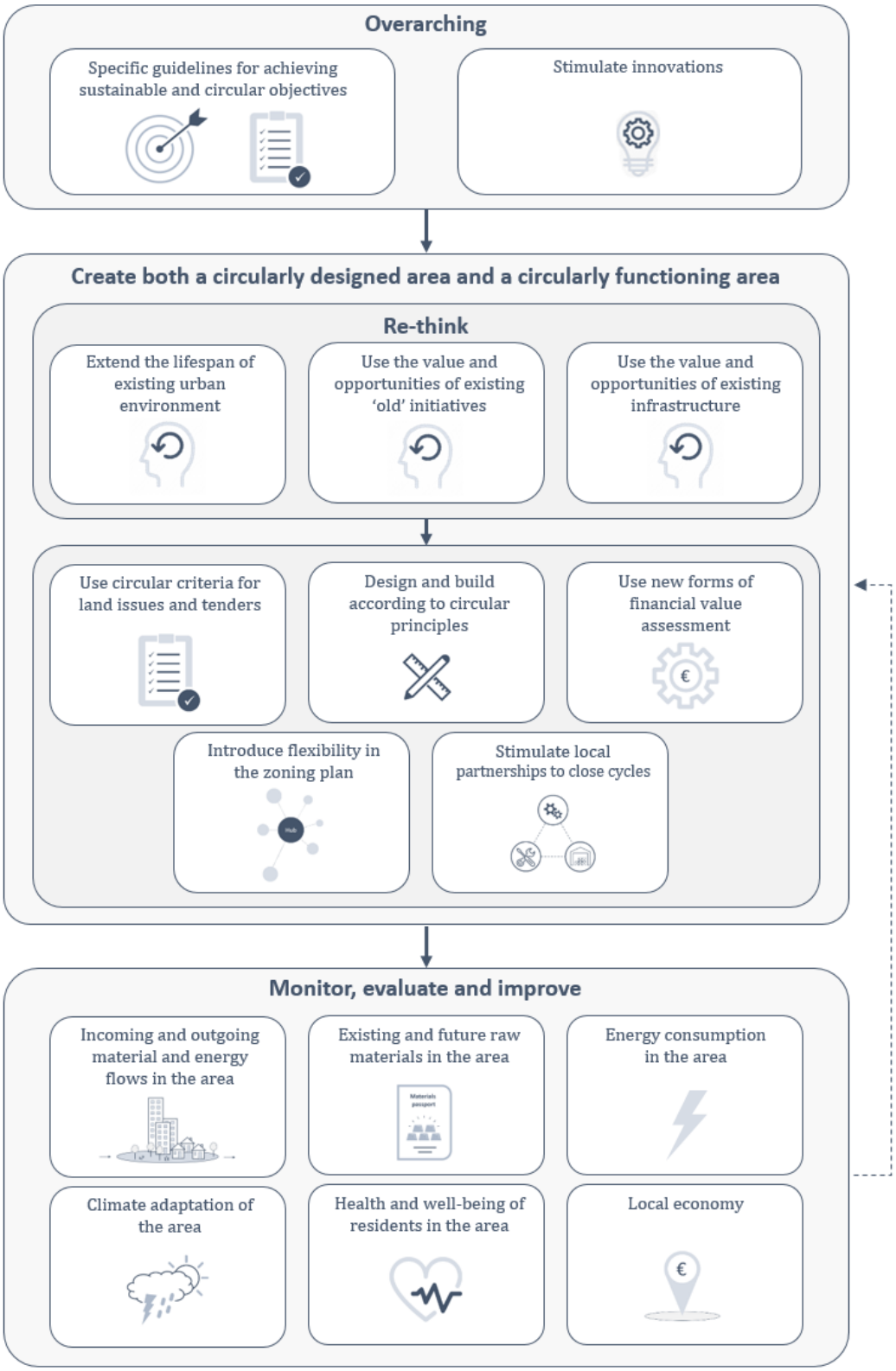
Deel B Algemene mening respondenten

B.1 Voordat ik de aanbevelingslijst zal toelichten zou ik jullie graag willen vragen of jullie, vanuit jullie perspectief, de aanbevelingslijst zouden willen toelichten. Hierdoor is het mogelijk om te beoordelen of het overview van de aanbevelingslijst begrijpelijk is voor buitenstaanders van het onderzoeksteam.

B.2 Wat zouden jullie aanpassen aan het overview van de aanbevelingslijst om de lijst te verduidelijken?

Deel C Toelichting draft aanbevelingen

C.1 Onderzoeker presenteert de draft aanbevelingen en ligt iedere draft aanbeveling individueel toe.
*De draft aanbevelingslijst is weergegeven op de volgende pagina van dit expert panel**


Overarching
Specific guidelines for achieving sustainable and circular objectives
Stimulate innovations
Create both a circularly designed area and a circularly functioning area
Re-think
Extend the lifespan of existing urban environment
Use the value and opportunities of existing 'old' initiatives
Use the value and opportunities of existing infrastructure
Use circular criteria for land issues and tenders
Design and build according to circular principles
Use new forms of financial value assessment
Introduce flexibility in the zoning plan
Stimulate local partnerships to close cycles
Monitor, evaluate and improve
Incoming and outgoing material and energy flows in the area
Existing and future raw materials in the area
Energy consumption in the area
Climate adaptation of the area
Health and well-being of residents in the area
Local economy

Deel D Inhoudelijke vragen

D.1 Hebben jullie aanmerkingen op specifieke aanbevelingen?
En zo ja, op welke aanbevelingen?

D.2 Wat kan er volgens jullie verbeterd worden aan de structuur en opbouw van de aanbevelingslijst?

D.3 Missen jullie bepaalde aspecten in deze aanbevelingslijst?
En zo ja, wat missen jullie?

D.4 Denken jullie dat de aanbevelingslijst een bijdrage kan leveren aan het verbeteren van het circulair functioneren van een gebied?
Waarom wel/niet?

D.5 Hoe realistisch is het dat deze aanbevelingslijst in de praktijk gebruikt zal gaan worden?
Hoe kan de kans worden vergroot dat dit in de praktijk zal worden toegepast?

Einde van het expert panel

BEDANKT VOOR UW DEELNAME

IV: Data AS-MFA of CDW in Noordelijke IJ-oever West for 2013 and 2018

Production of CDW in 2013

origin	origin_code	destination	destination_code	amount (t/year)
C-1623 Vervaardiging van ander schrijn- en timmerwerk (C-1623)	C-1623	A02 Overslag / opbulken (A02)	A02	8.050
C-1623 Vervaardiging van ander schrijn- en timmerwerk (C-1623)	C-1623	C01 Breken (C01)	C01	2.080
C-1623 Vervaardiging van ander schrijn- en timmerwerk (C-1623)	C-1623	C03 Sorteren / scheiden (C03)	C03	1.650
C-1812 Overige drukkerijen (C-1812)	C-1812	A02 Overslag / opbulken (A02)	A02	1.241
C-2550 Smeden, persen, stampen en profielwalsen van metaal, poedermetallurgie (C-2550)	C-2550	C03 Sorteren / scheiden (C03)	C03	14.340
C-3011 Bouw van schepen en drijvend materieel (C-3011)	C-3011	A02 Overslag / opbulken (A02)	A02	2.680
C-3012 Bouw van plezier- en sportvaartuigen (C-3012)	C-3012	A02 Overslag / opbulken (A02)	A02	1.640
C-3101 Vervaardiging van kantoor- en winkelmeubelen (C-3101)	C-3101	A02 Overslag / opbulken (A02)	A02	10.000
C-3315 Reparatie en onderhoud van schepen (C-3315)	C-3315	G01 Direct storten (G01)	G01	0.100
E-3700 Afvalwaterafvoer (E-3700)	E-3700	A02 Overslag / opbulken (A02)	A02	432.420
E-3700 Afvalwaterafvoer (E-3700)	E-3700	C03 Sorteren / scheiden (C03)	C03	307.343
E-3700 Afvalwaterafvoer (E-3700)	E-3700	D05 Extractief reinigen (grond) (D05)	D05	31.780
E-3820 Verwerking en verwijdering van afval (E-3820)	E-3820	A02 Overslag / opbulken (A02)	A02	22.992
E-3820 Verwerking en verwijdering van afval (E-3820)	E-3820	C01 Breken (C01)	C01	866.280
E-3820 Verwerking en verwijdering van afval (E-3820)	E-3820	C02 Shredderen / knippen (C02)	C02	180.760
E-3820 Verwerking en verwijdering van afval (E-3820)	E-3820	C03 Sorteren / scheiden (C03)	C03	11.407.940
E-3820 Verwerking en verwijdering van afval (E-3820)	E-3820	G01 Direct storten (G01)	G01	0.020
E-3821 Verwerking en verwijdering van ongevaarlijk afval (E-3821)	E-3821	A02 Overslag / opbulken (A02)	A02	871.980
E-3821 Verwerking en verwijdering van ongevaarlijk afval (E-3821)	E-3821	C02 Shredderen / knippen (C02)	C02	2.031.020
E-3821 Verwerking en verwijdering van ongevaarlijk afval (E-3821)	E-3821	C03 Sorteren / scheiden (C03)	C03	805.580
E-3900 Sanering en ander afvalbeheer (E-3900)	E-3900	G01 Direct storten (G01)	G01	63.720
F-4110 Ontwikkeling van bouwprojecten (F-4110)	F-4110	A02 Overslag / opbulken (A02)	A02	2.380
F-4120 Burgerlijke en utiliteitsbouw (F-4120)	F-4120	A02 Overslag / opbulken (A02)	A02	28.148
F-4120 Burgerlijke en utiliteitsbouw (F-4120)	F-4120	C01 Breken (C01)	C01	1.191.600
F-4120 Burgerlijke en utiliteitsbouw (F-4120)	F-4120	C02 Shredderen / knippen (C02)	C02	1.900
F-4120 Burgerlijke en utiliteitsbouw (F-4120)	F-4120	C03 Sorteren / scheiden (C03)	C03	249.720
F-4211 Bouw van autowegen en andere wegen (F-4211)	F-4211	A02 Overslag / opbulken (A02)	A02	91.500
F-4211 Bouw van autowegen en andere wegen (F-4211)	F-4211	C01 Breken (C01)	C01	3.675.660
F-4211 Bouw van autowegen en andere wegen (F-4211)	F-4211	C03 Sorteren / scheiden (C03)	C03	309.280
F-4311 Slopen (F-4311)	F-4311	C01 Breken (C01)	C01	5.967.540
F-4311 Slopen (F-4311)	F-4311	G01 Direct storten (G01)	G01	3.020
F-4322 Loodgieterswerk, installatie van verwarming en klimaatregeling (F-4322)	F-4322	A02 Overslag / opbulken (A02)	A02	1.520
F-4322 Loodgieterswerk, installatie van verwarming en klimaatregeling (F-4322)	F-4322	C03 Sorteren / scheiden (C03)	C03	1.480
F-4331 Stukadoorswerk (F-4331)	F-4331	C03 Sorteren / scheiden (C03)	C03	112.400
F-4332 Schrijnwerk (F-4332)	F-4332	C03 Sorteren / scheiden (C03)	C03	4.760
F-4391 Dakwerkzaamheden (F-4391)	F-4391	A02 Overslag / opbulken (A02)	A02	17.260
F-4399 Overige gespecialiseerde bouwactiviteiten, n.e.g. (F-4399)	F-4399	C02 Shredderen / knippen (C02)	C02	19.460
F-4399 Overige gespecialiseerde bouwactiviteiten, n.e.g. (F-4399)	F-4399	C03 Sorteren / scheiden (C03)	C03	38.120
G-4520 Onderhoud en reparatie van motorvoertuigen (G-4520)	G-4520	A02 Overslag / opbulken (A02)	A02	0.322
G-4612 Handelsbemiddeling in brandstoffen, ertsen, metalen en chemische producten (G-4612)	G-4612	A02 Overslag / opbulken (A02)	A02	1.360
G-4618 Handelsbemiddeling gespecialiseerd in andere goederen (G-4618)	G-4618	A02 Overslag / opbulken (A02)	A02	829.300

origin	origin_code	destination	destination_code	amount (t/year)
G-4618 Handelsbemiddeling gespecialiseerd in andere goederen (G-4618)	G-4618	C01 Breken (C01)	C01	2.845.780
G-4618 Handelsbemiddeling gespecialiseerd in andere goederen (G-4618)	G-4618	C03 Sorteren / scheiden (C03)	C03	30.188.800
G-4618 Handelsbemiddeling gespecialiseerd in andere goederen (G-4618)	G-4618	G01 Direct storten (G01)	G01	2.580
G-4638 Groothandel in andere voedingsmiddelen, met inbegrip van vis en schaal- en weekdieren (G-4638)	G-4638	A02 Overslag / opbulken (A02)	A02	7.196
G-4649 Groothandel in andere consumentenartikelen (G-4649)	G-4649	C01 Breken (C01)	C01	22.700
G-4649 Groothandel in andere consumentenartikelen (G-4649)	G-4649	C03 Sorteren / scheiden (C03)	C03	24.120
G-4752 Detailhandel in ijzerwaren, verf en glas in gespecialiseerde winkels (G-4752)	G-4752	A02 Overslag / opbulken (A02)	A02	1.660
G-4791 Detailhandel via postorderbedrijven of via internet (G-4791)	G-4791	D05 Extractief reinigen (grond) (D05)	D05	2.657.820
J-5911 Productie van films en video- en televisieprogramma's (J-5911)	J-5911	C02 Shredderen / knippen (C02)	C02	161.330
K-6420 Holdings (K-6420)	K-6420	A02 Overslag / opbulken (A02)	A02	0.290
K-6420 Holdings (K-6420)	K-6420	C03 Sorteren / scheiden (C03)	C03	67.740
K-6420 Holdings (K-6420)	K-6420	G01 Direct storten (G01)	G01	12.600
K-6619 Overige ondersteunende activiteiten in verband met financiële diensten, exclusief verzekeringen en pensioenfondsen (K-6619)	K-6619	A02 Overslag / opbulken (A02)	A02	3.960
L-6820 Verhuur en exploitatie van eigen of geleasd onroerend goed (L-6820)	L-6820	G01 Direct storten (G01)	G01	23.300
M-7010 Activiteiten van hoofdkantoren (M-7010)	M-7010	C03 Sorteren / scheiden (C03)	C03	0.740
M-7112 Ingenieurs en aanverwante technische adviseurs (M-7112)	M-7112	A02 Overslag / opbulken (A02)	A02	1.416.002
M-7112 Ingenieurs en aanverwante technische adviseurs (M-7112)	M-7112	C03 Sorteren / scheiden (C03)	C03	220.660
M-7311 Reclamebureaus (M-7311)	M-7311	C02 Shredderen / knippen (C02)	C02	0.700
M-7420 Fotografen (M-7420)	M-7420	C03 Sorteren / scheiden (C03)	C03	1.260
N-7739 Verhuur en lease van andere machines en werktuigen en andere materiële goederen, n.e.g. (N-7739)	N-7739	A02 Overslag / opbulken (A02)	A02	81.360
N-7739 Verhuur en lease van andere machines en werktuigen en andere materiële goederen, n.e.g. (N-7739)	N-7739	D05 Extractief reinigen (grond) (D05)	D05	30.660
N-8010 Particuliere beveiliging (N-8010)	N-8010	A02 Overslag / opbulken (A02)	A02	0.702
O-8411 Algemeen overheidsbestuur (O-8411)	O-8411	A02 Overslag / opbulken (A02)	A02	244.950
O-8411 Algemeen overheidsbestuur (O-8411)	O-8411	D01 Chemisch / fysisch scheiden (D01)	D01	4.680
O-8411 Algemeen overheidsbestuur (O-8411)	O-8411	D05 Extractief reinigen (grond) (D05)	D05	7.153.560
O-8411 Algemeen overheidsbestuur (O-8411)	O-8411	G01 Direct storten (G01)	G01	513.480
Q-8622 Praktijken van specialisten (Q-8622)	Q-8622	C03 Sorteren / scheiden (C03)	C03	25.920
R-9003 Scheppende kunsten (R-9003)	R-9003	A02 Overslag / opbulken (A02)	A02	3.020
S-9499 Overige verenigingen, n.e.g. (S-9499)	S-9499	A02 Overslag / opbulken (A02)	A02	116.280
W-0001 Buiten MRA (W-0001)	W-0001	A02 Overslag / opbulken (A02)	A02	9.140
W-0001 Buiten MRA (W-0001)	W-0001	C01 Breken (C01)	C01	136.420

Treatment of CDW in 2013

origin	origin_code	destination	destination_code	amount (t/year)
E-3820 Verwerking en verwijdering van afval (E-3820)	E-3820	C03 Sorteren / scheiden (C03)	C03	7.646.820
F-4211 Bouw van autowegen en andere wegen (F-4211)	F-4211	A02 Overslag / opbulken (A02)	A02	13.480
F-4322 Loodgieterswerk, installatie van verwarming en klimaatregeling (F-4322)	F-4322	C03 Sorteren / scheiden (C03)	C03	1.480
F-4331 Stukadoorswerk (F-4331)	F-4331	C03 Sorteren / scheiden (C03)	C03	112.400
F-4332 Schrijnwerk (F-4332)	F-4332	C03 Sorteren / scheiden (C03)	C03	4.760
F-4399 Overige gespecialiseerde bouwactiviteiten, n.e.g. (F-4399)	F-4399	C03 Sorteren / scheiden (C03)	C03	38.120
I-5621 Catering (I-5621)	I-5621	C03 Sorteren / scheiden (C03)	C03	0.980
N-8130 Landschapsverzorging (N-8130)	N-8130	C03 Sorteren / scheiden (C03)	C03	48.460
O-8411 Algemeen overheidsbestuur (O-8411)	O-8411	A02 Overslag / opbulken (A02)	A02	183.430
Q-8622 Praktijken van specialisten (Q-8622)	Q-8622	C03 Sorteren / scheiden (C03)	C03	25.920

Production of CDW in 2018

origin	origin_code	destination	destination_code	amount (t/year)
C-1623 Vervaardiging van ander schrijn- en timmerwerk (C-1623)	C-1623	C01 Breken (C01)	C01	4.320
C-2222 Vervaardiging van verpakkingsmateriaal van kunststof (C-2222)	C-2222	A02 Overslag / opbulken (A02)	A02	3.850
C-3011 Bouw van schepen en drijvend materieel (C-3011)	C-3011	A02 Overslag / opbulken (A02)	A02	67.304
C-3101 Vervaardiging van kantoor- en winkelmeubelen (C-3101)	C-3101	C03 Sorteren / scheiden (C03)	C03	0.960
D-3511 Productie van elektriciteit (D-3511)	D-3511	A02 Overslag / opbulken (A02)	A02	314.280
D-3511 Productie van elektriciteit (D-3511)	D-3511	D05 Extractief reinigen (grond) (D05)	D05	13.120
E-3600 Winning, behandeling en distributie van water (E-3600)	E-3600	A02 Overslag / opbulken (A02)	A02	3.112.120
E-3700 Afvalwaterafvoer (E-3700)	E-3700	A02 Overslag / opbulken (A02)	A02	492.660
E-3700 Afvalwaterafvoer (E-3700)	E-3700	C03 Sorteren / scheiden (C03)	C03	583.613
E-3700 Afvalwaterafvoer (E-3700)	E-3700	D05 Extractief reinigen (grond) (D05)	D05	51.880
E-3811 Inzameling van ongevaarlijk afval (E-3811)	E-3811	C01 Breken (C01)	C01	63.640
E-3820 Verwerking en verwijdering van afval (E-3820)	E-3820	A02 Overslag / opbulken (A02)	A02	1.108.400
E-3820 Verwerking en verwijdering van afval (E-3820)	E-3820	C01 Breken (C01)	C01	17.763.700
E-3820 Verwerking en verwijdering van afval (E-3820)	E-3820	C02 Shredderen / knippen (C02)	C02	5.960
E-3820 Verwerking en verwijdering van afval (E-3820)	E-3820	C03 Sorteren / scheiden (C03)	C03	45.439.210
E-3820 Verwerking en verwijdering van afval (E-3820)	E-3820	G01 Direct storten (G01)	G01	1.900
E-3821 Verwerking en verwijdering van ongevaarlijk afval (E-3821)	E-3821	A02 Overslag / opbulken (A02)	A02	830.660
E-3821 Verwerking en verwijdering van ongevaarlijk afval (E-3821)	E-3821	C02 Shredderen / knippen (C02)	C02	965.360
E-3821 Verwerking en verwijdering van ongevaarlijk afval (E-3821)	E-3821	C03 Sorteren / scheiden (C03)	C03	987.740
E-3821 Verwerking en verwijdering van ongevaarlijk afval (E-3821)	E-3821	G01 Direct storten (G01)	G01	7.200
F-4110 Ontwikkeling van bouwprojecten (F-4110)	F-4110	A02 Overslag / opbulken (A02)	A02	79.924
F-4110 Ontwikkeling van bouwprojecten (F-4110)	F-4110	G01 Direct storten (G01)	G01	0.800
F-4120 Burgerlijke en utiliteitsbouw (F-4120)	F-4120	A02 Overslag / opbulken (A02)	A02	167.020
F-4120 Burgerlijke en utiliteitsbouw (F-4120)	F-4120	C01 Breken (C01)	C01	1.835.060
F-4120 Burgerlijke en utiliteitsbouw (F-4120)	F-4120	C02 Shredderen / knippen (C02)	C02	6.160
F-4120 Burgerlijke en utiliteitsbouw (F-4120)	F-4120	C03 Sorteren / scheiden (C03)	C03	318.094
F-4211 Bouw van autowegen en andere wegen (F-4211)	F-4211	A02 Overslag / opbulken (A02)	A02	41.040
F-4211 Bouw van autowegen en andere wegen (F-4211)	F-4211	C01 Breken (C01)	C01	1.340.810
F-4211 Bouw van autowegen en andere wegen (F-4211)	F-4211	C03 Sorteren / scheiden (C03)	C03	147.680
F-4222 Bouw van civieltechnische werken voor elektriciteit en telecommunicatie (F-4222)	F-4222	A02 Overslag / opbulken (A02)	A02	66.420
F-4311 Slopen (F-4311)	F-4311	C01 Breken (C01)	C01	500.380
F-4312 Bouwrijp maken van terreinen (F-4312)	F-4312	A02 Overslag / opbulken (A02)	A02	44.240
F-4321 Elektrische installatie (F-4321)	F-4321	G01 Direct storten (G01)	G01	0.080
F-4322 Loodgieterswerk, installatie van verwarming en klimaatregeling (F-4322)	F-4322	C03 Sorteren / scheiden (C03)	C03	0.160
F-4329 Overige bouwinstallatie (F-4329)	F-4329	A02 Overslag / opbulken (A02)	A02	690.580
F-4331 Stukadoorswerk (F-4331)	F-4331	C03 Sorteren / scheiden (C03)	C03	44.480
F-4391 Dakwerkzaamheden (F-4391)	F-4391	A02 Overslag / opbulken (A02)	A02	3.340
F-4399 Overige gespecialiseerde bouwactiviteiten, n.e.g. (F-4399)	F-4399	C03 Sorteren / scheiden (C03)	C03	30.100
G-4618 Handelsbemiddeling gespecialiseerd in andere goederen (G-4618)	G-4618	A02 Overslag / opbulken (A02)	A02	3.820
G-4618 Handelsbemiddeling gespecialiseerd in andere goederen (G-4618)	G-4618	C01 Breken (C01)	C01	3.920
G-4618 Handelsbemiddeling gespecialiseerd in andere goederen (G-4618)	G-4618	C03 Sorteren / scheiden (C03)	C03	5.520
G-4638 Groothandel in andere voedingsmiddelen, met inbegrip van vis en schaal- en weekdieren (G-4638)	G-4638	A02 Overslag / opbulken (A02)	A02	3.694
G-4649 Groothandel in andere consumentenartikelen (G-4649)	G-4649	A02 Overslag / opbulken (A02)	A02	4.100

origin	origin_code	destination	destination_code	amount (t/year)
G-4649 Groothandel in andere consumentenartikelen (G-4649)	G-4649	C01 Breken (C01)	C01	13.280
G-4649 Groothandel in andere consumentenartikelen (G-4649)	G-4649	C03 Sorteren / scheiden (C03)	C03	3.580
G-4649 Groothandel in andere consumentenartikelen (G-4649)	G-4649	D05 Extractief reinigen (grond) (D05)	D05	5.480
G-4669 Groothandel in andere machines en werktuigen (G-4669)	G-4669	A02 Overslag / opbulken (A02)	A02	32.712
G-4673 Groothandel in hout, bouwmaterialen en sanitair (G-4673)	G-4673	A02 Overslag / opbulken (A02)	A02	131.220
G-4673 Groothandel in hout, bouwmaterialen en sanitair (G-4673)	G-4673	C01 Breken (C01)	C01	938.400
G-4779 Detailhandel in antiquiteiten en tweedehandsgoederen in winkels (G-4779)	G-4779	A02 Overslag / opbulken (A02)	A02	2.343
H-4939 Overig personenvervoer te land, n.e.g. (H-4939)	H-4939	B03 Inzetten als bouwstof (B03)	B03	1.015.140
H-4941 Goederenvervoer over de weg (H-4941)	H-4941	A02 Overslag / opbulken (A02)	A02	1.820
H-4942 Verhuisbedrijven (H-4942)	H-4942	D01 Chemisch / fysisch scheiden (D01)	D01	0.230
J-5911 Productie van films en video- en televisieprogramma's (J-5911)	J-5911	C02 Shredderen / knippen (C02)	C02	2.860
J-6201 Ontwerpen en programmeren van computerprogramma's (J-6201)	J-6201	C03 Sorteren / scheiden (C03)	C03	2.160
K-6420 Holdings (K-6420)	K-6420	A02 Overslag / opbulken (A02)	A02	7.716.400
K-6420 Holdings (K-6420)	K-6420	C01 Breken (C01)	C01	21.600
K-6420 Holdings (K-6420)	K-6420	D05 Extractief reinigen (grond) (D05)	D05	31.540
L-6810 Handel in eigen onroerend goed (L-6810)	L-6810	A02 Overslag / opbulken (A02)	A02	114.220
L-6810 Handel in eigen onroerend goed (L-6810)	L-6810	D05 Extractief reinigen (grond) (D05)	D05	1.202.300
L-6820 Verhuur en exploitatie van eigen of geleasd onroerend goed (L-6820)	L-6820	C03 Sorteren / scheiden (C03)	C03	25.720
L-6832 Beheer van onroerend goed voor een vast bedrag of op contractbasis (L-6832)	L-6832	D05 Extractief reinigen (grond) (D05)	D05	2.005.660
M-7112 Ingenieurs en aanverwante technische adviseurs (M-7112)	M-7112	A02 Overslag / opbulken (A02)	A02	196.783
M-7112 Ingenieurs en aanverwante technische adviseurs (M-7112)	M-7112	C01 Breken (C01)	C01	489.180
M-7112 Ingenieurs en aanverwante technische adviseurs (M-7112)	M-7112	C03 Sorteren / scheiden (C03)	C03	5.080
M-7112 Ingenieurs en aanverwante technische adviseurs (M-7112)	M-7112	D05 Extractief reinigen (grond) (D05)	D05	3.005.240
M-7112 Ingenieurs en aanverwante technische adviseurs (M-7112)	M-7112	G01 Direct storten (G01)	G01	0.560
M-7219 Overig speur- en ontwikkelingswerk op natuurwetenschappelijk gebied (M-7219)	M-7219	A02 Overslag / opbulken (A02)	A02	0.042
M-7220 Speur- en ontwikkelingswerk op het gebied van de maatschappij- en geesteswetenschappen (M-7220)	M-7220	C01 Breken (C01)	C01	0.080
M-7311 Reclamebureaus (M-7311)	M-7311	A02 Overslag / opbulken (A02)	A02	3.694
M-7410 Gespecialiseerde designers (M-7410)	M-7410	A02 Overslag / opbulken (A02)	A02	844.880
O-8411 Algemeen overheidsbestuur (O-8411)	O-8411	A02 Overslag / opbulken (A02)	A02	17.207.180
O-8411 Algemeen overheidsbestuur (O-8411)	O-8411	C01 Breken (C01)	C01	72.220
O-8411 Algemeen overheidsbestuur (O-8411)	O-8411	D05 Extractief reinigen (grond) (D05)	D05	3.912.120
O-8411 Algemeen overheidsbestuur (O-8411)	O-8411	F05 Uitgloeien (grond) (F05)	F05	85.120
O-8411 Algemeen overheidsbestuur (O-8411)	O-8411	G01 Direct storten (G01)	G01	0.220
P-8559 Overig onderwijs, n.e.g. (P-8559)	P-8559	A02 Overslag / opbulken (A02)	A02	51.880
Q-8622 Praktijken van specialisten (Q-8622)	Q-8622	C03 Sorteren / scheiden (C03)	C03	24.680
R-9001 Uitvoerende kunsten (R-9001)	R-9001	C01 Breken (C01)	C01	7.860
R-9002 Ondersteunende activiteiten voor uitvoerende kunsten (R-9002)	R-9002	A02 Overslag / opbulken (A02)	A02	17.240
R-9002 Ondersteunende activiteiten voor uitvoerende kunsten (R-9002)	R-9002	D05 Extractief reinigen (grond) (D05)	D05	129.620
R-9003 Scheppende kunsten (R-9003)	R-9003	A02 Overslag / opbulken (A02)	A02	4.540
R-9319 Overige sport (R-9319)	R-9319	A02 Overslag / opbulken (A02)	A02	0.660
S-9499 Overige verenigingen, n.e.g. (S-9499)	S-9499	A02 Overslag / opbulken (A02)	A02	1.907.520
S-9499 Overige verenigingen, n.e.g. (S-9499)	S-9499	D05 Extractief reinigen (grond) (D05)	D05	134.820
W-0001 Buiten MRA (W-0001)	W-0001	A01 Bewaren (A01)	A01	186.200
W-0001 Buiten MRA (W-0001)	W-0001	A02 Overslag / opbulken (A02)	A02	8.723.480

origin	origin_code	destination	destination_code	amount (t/year)
W-0001 Buiten MRA (W-0001)	W-0001	C01 Breken (C01)	C01	2.452.450
W-0001 Buiten MRA (W-0001)	W-0001	C02 Shredderen / knippen (C02)	C02	64.170
W-0001 Buiten MRA (W-0001)	W-0001	D05 Extractief reinigen (grond) (D05)	D05	1.906.540
W-0001 Buiten MRA (W-0001)	W-0001	G01 Direct storten (G01)	G01	8.720
X-0002 Route Inzameling (X-0002)	X-0002	C01 Breken (C01)	C01	2.680

Treatment of CDW in 2018

origin	origin_code	destination	destination_code	amount (t/year)
E-3820 Verwerking en verwijdering van afval (E-3820)	E-3820	C03 Sorteren / scheiden (C03)	C03	34.281.770
F-4211 Bouw van autowegen en andere wegen (F-4211)	F-4211	A02 Overslag / opbulken (A02)	A02	32.080
F-4322 Loodgieterswerk, installatie van verwarming en klimaatregeling (F-4322)	F-4322	C03 Sorteren / scheiden (C03)	C03	0.160
F-4331 Stukadoorswerk (F-4331)	F-4331	C03 Sorteren / scheiden (C03)	C03	44.480
F-4399 Overige gespecialiseerde bouwactiviteiten, n.e.g. (F-4399)	F-4399	C03 Sorteren / scheiden (C03)	C03	30.100
N-8130 Landschapsverzorging (N-8130)	N-8130	C03 Sorteren / scheiden (C03)	C03	17.020
Q-8622 Praktijken van specialisten (Q-8622)	Q-8622	C03 Sorteren / scheiden (C03)	C03	24.680

V: Transcripts interviews

This appendix contains confidential information.
For more information, please contact:

Sven van Bakel
Svenvanbakel@gmail.com
+31 (0)6 36 49 65 53

VI: Transcript expert panel

This appendix contains confidential information.
For more information, please contact:

Sven van Bakel
Svenvanbakel@gmail.com
+31 (0)6 36 49 65 53