Circular urban area development; Myth or reality?

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A research into the factors and management of circular urban area development in Dutch practice

Personal Data

Master Thesis

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Preface

In front of you lies the result of one year of research in the master track Management in the Built environment, TU Delft. This research is part of the graduation lab 'Sustainable Area Transformation'.

6 years ago, I arrived at the Faculty of Architecture with the dream to become an architect. During my studies, my passion for shaping the built environment increased, however after an architecture internship, I discovered that being an architect is not the perfect role for me. Besides designing, my love for managing and combining different disciplines arose. I wanted to be the 'spider in the web' and therefore decided to start the MBE master track.

During the management game in the first year of the MBE master I got in touch with urban area development. The intensive collaboration and negotiation between public and private parties were complex and challenging. However, the complexity of such a development and many disciplines that were involved, got my interests.

Three years ago, I got into first contact with the concept of circularity by an interesting conversation with S. Mohammadi. When I started this research, I thought the knowledge on this subject would have been further developed, however this was not the case. Furthermore, my awareness about the effects of climate change raised and therefore my interest into sustainable development and the circular economy. Therefore, I wanted to combine the worlds, of urban area development and circularity, into a research into the possibilities and limitations of circular urban area development.

This past year and this research would not have been so interesting and successful without the help of some important people: my mentors, the interviewees, my internship company and my family and friends.

First, I would like to thank my graduation mentors, Erwin Heurkens and Hide Remøy, for their support and interesting insights throughout the whole research process. Their positive feedback and enthusiasm guided me through the difficulties of circularity and made every graduation meeting helpful and fun. Second, I would like to thank all the interviewees and experts that participated in my explorative interviews, case studies and expert panel. Without their insights, knowledge and stories this research wouldn't have been a success. Third, I would like to thank my family and friends for the past 6 years. My family for supporting me and who were always willing to discuss my results. My friends, in -and outside the faculty, with who I had the privilege of studying together and the study association BOSS which always facilitated fun and informal moments, next to studying. Last, I would like to thank my internship company, Kondor Wessels Vastgoed, who gave me the opportunity to experience an urban area development process in Dutch practice and for their network.

This research is the last step of my student career and by completing this research I will obtain my Master of Science degree. From September onwards, I will try to apply all the things that I've learned about circular urban area development in practice, when I start working for Kondor Wessels Vastgoed.

Enjoy reading!

Heleen Luijt
June, 2019

Glossary

Adaptability: Flexibility in architecture as something that keeps the building functional for their users over time referred to as the ability of a building to continuously adapts its space layout and structure to evolving needs.

Circular economy: Is the holistic economic system in which there is a closed loop in the whole economic system where products and materials retain the highest value at all time. This means that there is no loss in value, efficiency or the effectiveness of these products and they are maintained in the economy for as long as possible without turning into waste.

Circularity: The concept of circularity is a derivative of the circular economy. In the built environment, circularity, is focused on reducing the environmental impact of building materials and resources taken their whole production process into account. The final step of this process is the high-quality re-use of these building materials and the closing of resource lifecycles.

Ecosystem approach: Cities are seen as a big open system (ecosystem) consisting of several subsystems with determined system boundaries.

Industrial flows: In the circular economy these flows refer to the energy, water and material flows that are 'flowing' in and out of the area.

Linear economy: Is the economic system in which the emphasize is on take, make, use and waste, where demolition waste is the final step of the material lifecycle. It is often illustrated as a line, with a beginning and an end - from extraction to disposal where the potential returns to the Earth are lost through pollution.

Recycle-economy: In this approach materials and resources are being recycled however these recycling processes still generating waste and materials and resources are experiencing a down-grade in quality and value.

Sustainable development: Sustainable development is a comprehensive concept that attempts to reconcile and combine three dimensions of development: economic prosperity, environmental quality and social equity (people, planet, profit). In sustainable development there is strived for development in which standards of living for current and future generations within the planet's carrying capacity are realised.

Urban area development: Scale of an urban area is in between a building and the city scale. Therefore, an urban area development is a public-private initiative focused on product and process. Often, many stakeholders are involved, and an integrated development approach is needed.

Abstract

Context - As a result of the human behavior of the past century, in which linear approaches were used, we're facing environmental challenges due to global warming. Since the awareness of climate change, planning departments are focusing on sustainable development in which the social, economic and environmental dimensions are combined. In the Netherlands, the naturally polluting building industry is designated as one of the critical sectors that need to change to a more circular way of working. In 2050 the Dutch government wants to be 100% circular. Circular urban area development can contribute to the achievement of these goals.

Objective – This research aims to define the concept of circular urban area development by identifying and explaining the factors of circular urban area development and the management tools that can be used to apply them in Dutch practice. The research question that is answered: *"What are the factors that contribute to the development of a circular urban area and how can these factors be managed in practice?".* These findings are summarized in a circular urban area development guideline.

Methods – this research is divided in two parts. First, a literature review is done providing an overview of the physical components of a circular urban area development. Second, the circular urban area development factors and their management tools are investigated by conducting explorative interviews, case study analysis and an expert panel.

Results – to define the concept of circular urban area development the concept of 'adaptable buildings' by Brand (1994) can be combined with the ecosystem approach of van Bueren (2012) creating an overview of the physical components of a circular urban area: (1) adaptable buildings (2) public space and (3) industrial flows: energy, water and materials. Further findings state that sustainable urban area development is closely related to circular urban area development. In the Randstad area, urban areas are being redeveloped because of the housing shortage. In these developments the concept of circularity is used as a condition for sustainable development. When special focus is set on implementing circularity, the development can be called a circular urban area development.

Conclusions – Out of this theoretical and empirical research, six factors of circular urban area development can be distinguished that can be divided into two different cycles: building -and use-cycle. In the building-cycle the focus is on the lifecycles of building components and materials that are log and have long lifecycles. In the use-cycle the focus is on resources and products used on a daily-basis by the inhabitants of the urban area. These resources are characterized as volatile and have short life-cycles. The factors that are part of building-cycle are: (1) circular building material cycle and (2) spatially adaptive urban area. The factors that are part of the use-cycle are: (3) efficient energy system, (4) closed water-system (5) re-use, collection and logistics of waste and (6) stimulating the local economy. Applying these six factors in Dutch practice can be organized by the use of different management instruments. For every factor several possible management instruments found that make it possible to apply these factor in Dutch practice. These management instruments can be divided into four different groups: (1) legal instruments, (2) organizational instruments, (3) financial incentives and (4) design tools.

Keywords: Circular economy, circularity, sustainable development, sustainable urban area development, circular urban area development

Management summary

Introduction

As a result of the human behavior of the past century, reducing the effects of climate change is a much discussed topic in politics. Here in the Netherlands, which is located below sea level, we will immediately face the effects of global warming. In 2009, a group of environmental scientists established the 9 planetary boundaries which refer to 9 essential Earth systems that need to stay stable to sustain a safe and sound future for next generations. Some Earth systems are already beyond the zone of uncertainty and therefore create enormous environmental risks (Steffen et al., 2015). Since, the awareness of climate change and its risks, politics and planning departments are focusing on sustainable development in which the social, economic and environmental dimensions are combined. In this, cities can play an important role in developing sustainable urban areas where these three dimensions are combined (Hoornweg et al., 2016). At the moment, many urban areas are being developed in the Netherlands and due to the housing shortage in the Randstad area 1 million new dwellings are planned. Unfortunately, the building industry, who will build these houses, is for a large part responsible for these environmental effects. The building industry is responsible for 25% of the CO2 emissions, 60% of the material demand and 80% of the embodied energy in buildings is generated by the production processes of building materials (Hawken et al., 2013; EMF, 2013). These numbers belong to the linear economy in which the focus is on resource consumption and where waste is the final step of the material lifecycle. Because of this polluted character of the building industry, they are designated as one of the critical sectors that need to change to a circular economy approach where the value of resources and materials is maintained in the economy (Schokker, 2018; Sauve et al., 2016). Together with 192 other world leaders, The Netherlands agreed to the 17 sustainable goals for a better world by 2030. Further, the Dutch government declared to become 100% circular in 2050. Developing urban areas in a circular way can contribute to the achievement of these goals (Rijksoverheid, 2016; Global Goals, 2015).

Problem statement

In recent years the concept of circular economy emerged and is much used in the context of sustainable development (Hoornweg et al.,2016). Applying the principles of the circular economy in an urban area development can be called a ‘circular urban area development’, which is a relatively new concept. According to Kirchnerr et al. (2017) 114 different definitions of the circular economy can be found in literature. The main of the circular economy, which is identified by Kirchnerr et al. (2017) is the aim for economic prosperity, however valuing circularity in our current business models is difficult and often not feasible, which is a reason why where still using traditional approaches in our urban development processes (Personal communication, O. Wagenaar and B. Terpstra, 10 January 2019). Furthermore, circular principles are already applied on the building and city scale, however knowledge and research about circular urban area development is lacking (Schokker, 2018).

Research goal and question

The main aim of this research is to define the concept of circular urban area development by identifying and explaining the factors of circular urban area development and the management tools that can be used to apply them in practice. These findings are summarized in a circular urban area development guideline that can be used in Dutch practice. The next objectives were formulated: (1) to get a comprehensive definition of the circular economy and circularity in the built environment, (2) to get a comprehensive definition of circular urban area development, (3) to get an overview of the factors that contribute to the development of a circular urban area and (4) to get insight into the instruments and tools that can be used in practice to steer on the factors of circular urban area development.

The research question that is answered by this research is: ***"What are the factors that contribute to the development of a circular urban area and how can these factors be managed in practice?"***

To provide an answer on the main question five sub-questions were formulated:

- *What are the characteristics of a circular economy and circularity?*
- *What is circular urban area development?*
- *Which performance indicators, that could possibly be used in circular urban area development are available?*
- *Which factors contribute to the development of a circular urban area?*
- *Which instruments can be used to manage these factors of circular urban area development in Dutch practice?*

Methodology

The aim of this research it to define the concept of circular urban area development by identifying the circular urban area development factors and their applicability in Dutch practice. Because circularity in urban area development is a relative new concept, where no consensus is yet be established, this research has an explorative character (Kumar, 2014). This results in the development of new theories, the reason why a qualitative research approach is chosen (Bryman, 2012). The theoretical part is focused on defining the concept of circular urban area development. Because the scale of an urban area is in between a building and city scale, circular concepts on these two scales are used to establish a circular urban area development framework.

The empirical part of this research consists of several methods: explorative interviews, case study analysis and an expert panel. First, because of the newness of this concept, explorative interviews are held with 11 practitioners with different backgrounds, but all employed in real estate and experienced with circularity. The interviews were semi-structured and aimed to make a first draft of the factors that contribute to the development of a circular urban area. Second, these found factors were validated and sharpened by conducting an in-case and cross-case analysis of three case studies in Dutch practice: (1) Lincolnpark in Haarlemmermeer, (2) Beurskwartier in Utrecht and (3) Kabeldistrict in Delft. For every case analysis multiple methods were used to collect data, so that findings can be cross-checked (Bryman, 2012). The next techniques were used: (1) project analysis, (2) policy document review and (3) semi-structured interviews with three involved stakeholders per case. Lastly, an expert panel was organized to validate the found factors of circular urban area development and to define the managerial tools that can be used to steer and manage them in practice. The invited participants were all individual experts who are experienced with steering and measuring tools used in real estate development. As a result, conclusions were drawled to design the circular urban area development guideline for Dutch practice.

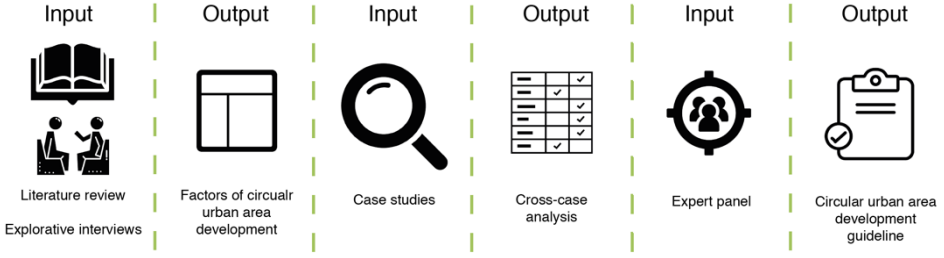


Fig. 1: Research process (Own ill.)

Theoretical framework

The goal of the theoretical framework is to gain insight into the concept of circular economy, circularity and circular urban area development.

Circular economy and circularity

The building industry is designated as an industry that is for a large part responsible for the effects of climate change. The building industry has a pollution nature which is a result of the linear approach there using to produce building materials. This linear approach is part of the linear economy which is focused on resource consumption, extraction of raw materials and where demolition waste is the final step of the material lifecycle. In this linear approach a lot of value, embedded in materials and resources, is lost during the process (Schokker, 2018; Sauve et al., 2016). Therefore, a switch from a linear to a circular economy is needed to preserve the worlds resources and to maintain their value. In the circular economy there is a closed loop in the whole economic system where products and materials retain the highest value at all time meaning there is no loss in value, efficiency or effectiveness of these products and no waste is generated (Geisdoerfer et al., 2017). Resources and materials will have a second life after their first lifecycle by being reduced, re-used, recycled or recovered (Kirchnerr et al., 2017). Besides the concept of the circular economy, exists the concept of circularity. These two concepts are closely related; however, they have a slightly different meaning and aim. Circular economy is the holistic economic system in which products and materials retain the highest value at all time. The main aim of the circular economy is to gain economic prosperity. The concept of circularity is a derivative of the circular economy. In the built environment this concept has a focus on the reduction of the environmental impact of building materials throughout the whole production process: delving > transport > manufacture > construction > in use > 2nd lifecycle. Further, there is a focus on the closing of resource-cycles. The main aim of the concept of circularity is gaining environmental quality (Kirchnerr et al., 2017). Both concepts are used in the context of sustainable development (Hoornweg et al., 2016).

Circular urban area development

To understand the concept of circular urban area development, first the scale of an urban area needs to be explained. An urban area is a physical scale in the built environment in between the building and city scale and therefore has characteristics of both: public-private initiative, focused on product and process (Heurkens, 2018). In the last 10 years the importance of sustainable development in city planning has become an important topic. Therefore, authorities are focusing on developing sustainable urban areas in which the three development dimensions: social (people), environmental (planet) and economic (profit) are combined (Hoornweg et al., 2016). In this, the concept of circularity is often used as condition for sustainable development (Geisdoerfer et al., 2017).

Because an urban area is in between the building and city scale special attention is paid to circular principles on these two scales. First, on the building scale, circular principles derive from the concept of creating ‘adaptable buildings’ that refers to the ability of a building to continuously adapt its layout to evolving needs and changing circumstances. Duffy (1990) and Brand (1994) stated that a building as an own entity doesn’t exist. A building consists of “shearing layers of change”, which means that every building component has its own lifecycle. These components are flexible and cannot have fixed connections. Urban areas consist of the following components: (1) buildings, (2) publics space and (3) underground infrastructure, that all have their own lifecycles. Second, on the city scale, the ecosystem approach of van Bueren (2012) is often used. In this approach a city can be seen as a big open system consisting of several subsystems mostly referred to the industrial flows: energy, water and materials (EMF, 2013). These subsystems are seen as flows that all have

their own input – throughput – output. By creating closed-loops with these flows, the value and quality of these resources can be maintained in the economy for as long as possible.

A circular urban area development is a part of a sustainable urban area development in which the focus is on applying the principles of the circular economy (Hoornweg et al, 2016). Applying the thoughts of Brand (1994) on the urban area scale, combining it with the system approach of van Bueren (2012) the next summarizing figure can be drawled of the physical components of a circular urban area.

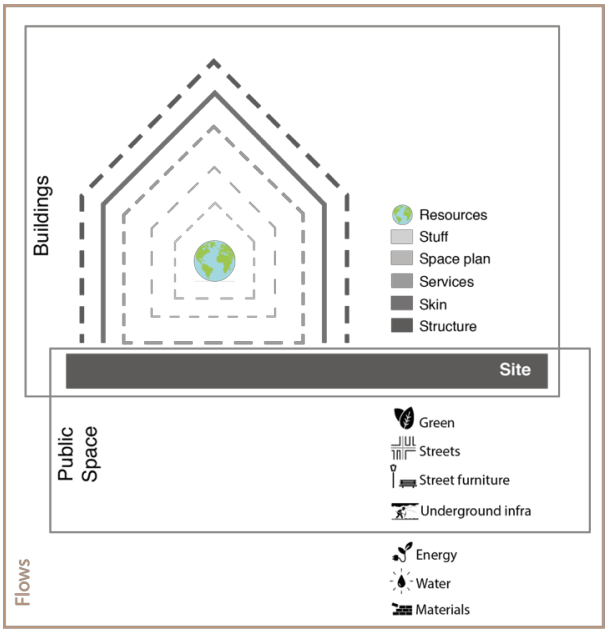


Fig. 2: Components of a circular urban area

Empirical research

In this part the empirical research is explained: explorative interviews, case study analysis and an expert panel, to find the factors of circular urban area development and their applicability in Dutch practice.

Explorative interviews

Out of 11 explorative interviews 7 factors of circular urban area development could be distinguished. The 11 interviewees all had experience with circularity. To get an understanding of circularity throughout the whole real estate sector, experts with different background were interviewed: municipality, developers and consultants. The next factors were found:

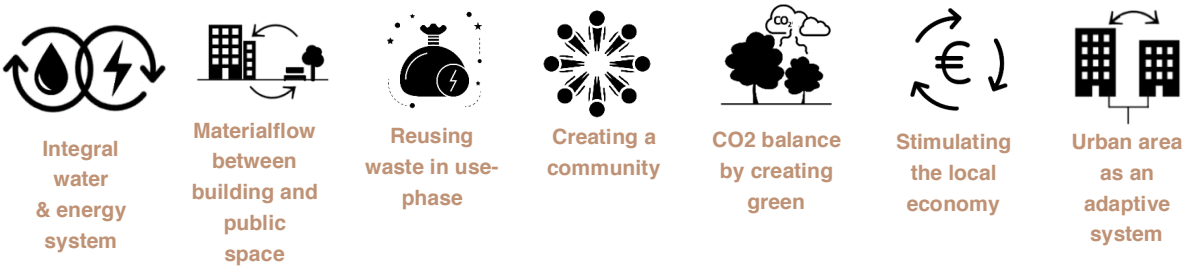


Fig. 3: Factors of circular urban area development found by explorative interviews (Own ill.)

Case studies

In the case study analysis three circular urban area developments, all located in the Randstad area were researched by an in-case and cross-case analysis. The aim for every case is to: (1) Analyze each project by gathering information about the specifications and characteristics of the urban area (re)development project, (2) get insight into the sustainability and circularity policy documents of the municipality, (3) get insight into the sustainability and circularity objectives of the project and (4) evaluate the significance of the 7 circular urban area development factors found in earlier research. For every case the municipal policy, project ambitions and opinions of thee involved stakeholders are compared to define the factors of circular urban area development.

Lincolnpark, Haarlemmermeer

This case is a new built project located in the municipality of Haarlemmermeer which is part of the Metropolitan region Amsterdam. Lincolnpark is part of the larger development called “de Parken” and is called a circular urban area development. In Lincolnpark 850 new dwellings, retail, a school, a restaurant and a care center will be realized that will be delivered in 2025 (Gemeente Haarlemmermeer, 2017). The plot of Lincolnpark is the last plot that is owned by the municipality which means that they can set the boundaries for the development. The aim of the development of Lincolnpark is to create the “neighborhood of the future” that can easily adapt to changing demands of its residents.

> *“The development itself can be seen as a sustainable urban area development in which the principles of the circular economy are being applied. In this, circularity is used as a principle to be able to act sustainable. Circularity is not the main aim but a means to achieve sustainability in the urban area development” (Personal communication, M. Korse, 25 March 2019 and I. Groet, 3 Aprll 2019).*

According to Lincolnpark the next factors of circular urban area development can be distinguished:

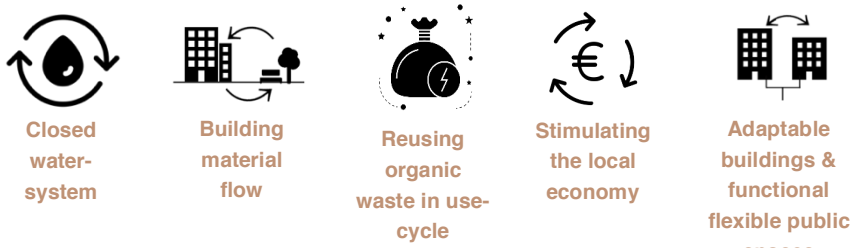


Fig. 4: Factors of circular urban area development according to Lincolnpark (Own ill.)

Beurskwartier, Utrecht

This case is a redevelopment project which is located in the municipality of Utrecht next to Utrecht central station. As G4 city, Utrecht has the responsibility to build 70.000 new dwellings. In Beurskwartier 3.000 new dwellings will be realized and 50.000 m2 of workplaces and 10.000 m2 of other facilities. This will be finished by 2025. In anticipation of the redevelopment many researches in the form of ‘living-labs’ were organized by the municipality. A living lab into the possibilities of the implementation of the circular economy was called: “Circular Beurskwartier”, where circularity is defined by creating an (almost) zero waste neighborhood.

> *“The circular economy is not the main aim of the development. The aim of the redevelopment of the Beurskwartier is to create Healthy Urban Living. The circular economy is used as a tool to organize society in such a way that it is sustainable” (Personal*

communication J. Hekhuis, 30 april 2019, G. de Zoeten, 9 aprl 2019 and R. Kapel, 10 april 2019).

According to Beurskwartier the next factors of circular urban area development can be distinguished:

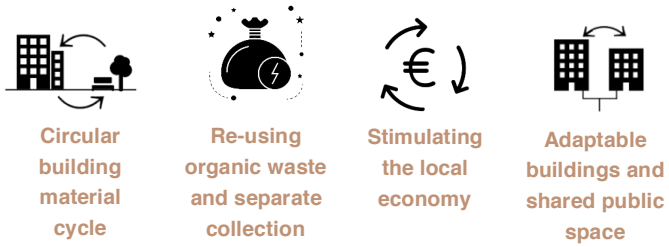


Fig. 5: Factors of circular urban area development according to Beurskwartier (Own ill.)

Kabeldistrict, Delft

This case is located in the municipality of Delft and is the first plot that will be developed on the Schieoevers Noord. In Delft 10.000 new dwellings have to be build and 3.000 – 4.000 are planned in Kabeldsitrict which is the redevelopment of the old Dutch cable factory. Besides dwellings, another 60.000 m2 of workplaces including the manufacturing industry will be realized. Despite, at the time of writing, no policy documents have been written on circular economy, Schieoevers Noord is designated as a place where the principles of the circular economy can be applied on a large scale.

"Schieoevers Noord needs to become a vibrant area where living and the manufacturing industry are mixed. This creates opportunities for the circular economy" (M. van den Berg, Personal communication, 1 April 2019).

"The old cable factory is a goldmine of material resources that can be upgraded and re-used in the new development" (M. van Loon, Personal communication 23 April 2019).

According to Kabeldistrict the next factors of circular urban area development can be distinguished:

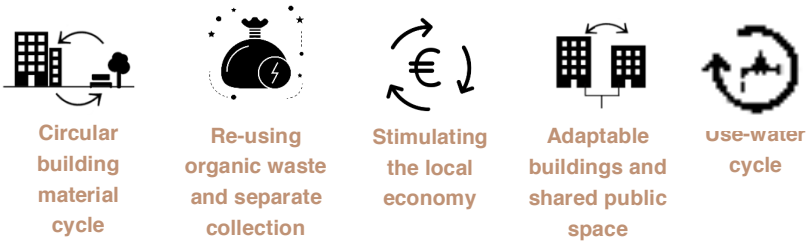


Fig. 6: Factors of circular urban area development according to Kabeldistrict (Own ill.)

Expert panel

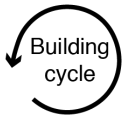
Preconditions for the development of a circular urban area development were discussed during the expert panel. According to the experts the next preconditions must be set:

- Define the boundaries of the circular urban area and look beyond the line on the map because 'flows' are flowing in and out of the area.
- The role of the public space is key in the development of a circular urban area and solutions can be found in the public space.

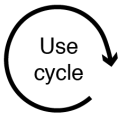
- Involve stakeholder(s) with long-term perspectives, such as investors or housing corporations, to be able to create feasible circular business cases.
- Consensus between the different stakeholders about the definition of circularity is key.
- Create value in the design of the urban area.

Conclusion

Circular urban area development and sustainable urban area development are closely linked. According to the outcomes of this research, most urban areas are being developed with the aim of building new houses in the Randstad area, because of the increasing housing shortage. In these developments several sustainability themes, with its own subfactors, are used to create a sustainable urban area. The next sustainability themes can be distinguished: climate neutral, biodiversity, circularity, social sustainability and mobility. In this, circularity is used as a condition to develop a sustainable urban area. When special focus is set on implementing circularity, the development can be called a circular urban area development. A circular urban area development consists of several factors. These factors can be divided into two different cycles: building -and the use-cycle. This division is made because they differ in characteristics:

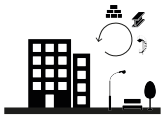


In the building-cycle the emphasize is on the high-quality re-use of building materials. In this building-cycle, the focus is on the lifecycles of buildings components and building materials that are log and mostly have long lifecycles.



The use-cycle is about the lifecycles of resources and products used on a daily-basis by the residents and employees in the urban area. Resources and products used on daily basis in the use-cycle are volatile and have short lifecycles.

The factors that are part of the building-cycle are:



Circular building material cycle

Spatially adaptive Urban area

The factors that are part of the use-cycle are:

Efficient Energy system

Closed water system

Re-use, collection and logistics of waste

Stimulating the local economy

Applying these six factors in Dutch practice can be organized by the use of different management instruments. For every factor several possible management instruments are explained that make it possible to apply these factor in Dutch practice. These management instruments can be divided into four different groups: (1) legal instruments, (2) organizational instruments, (3) financial incentives and (4) design tools.

Legal instruments can be used to set quantitative requirements for some factors; for example the EPC (energy performance). For other factors existing laws and regulations need to change to make implementation of these factors possible. For example, to create a closed water-system, the laws and regulations are now not allowing it to connect tap and waste-water into one system.

Organizational instruments can be used to organize the public space in such a way that separate collection of waste is possible. This instrument can also be used to set up an organizational structure for the companies in the urban area to collect their waste together.

The use of financial incentives can make certain products or applications financially more attractive for the residents or companies in the urban area. For example less taxes can be paid over local products which make them less expensive than imported products.

Design tools can be used in the design-phase of the urban area development to implement circular design principles. An online material database can for example be used to find buildings materials and the building circularity index can be used to design adaptable buildings.

An overview and explanation of these factors and their management tools can be seen on the next page in the circular urban area development guideline.

Guideline

Circular urban area development

	Factors		Measures
Building cycle		**Circular building material flow** High-quality re-use of building materials in the most environmentally friendly way. In redevelopment projects existing structures can be re-used for the new design or can be stored in a nearby material hub.	→	Material passports for all buildings Material passports for all materials in the public space Use online data tool to find existing materials to re-use in own developent
		**Spatially adaptive urban area** Creation of adaptable buildings and flexible public spaces. The concept of Brand (1994) can be used to define which urban area components need to be robust and which need to be flexible.	→	Use the Building Circularity Index of Alba Concepts to design adaptable buildings Use the term redundancy to optimize the design of the public space
Use cycle		**Efficient energy system** An efficient and environmentally energy system can be selected based on the energy demand of the urban area. Energy generation and consumtion is influenced by the orientation of buildings and public spaces.	→	Use EPC or BENG to measure the energy perfomance of buildings Use EMG to measure the energy perfomance of the urban area Apply a smart flow analysis to design a smart energy system
		**Closed water-system** A closed water-system can be realised on the scale of an urban area. In this closed system, drinking-water, waste-water and the rainwater flow can be combined and connected. This watersystem has a strong relation with the flow of organic waste.	→	Change the 'hygiene code drinking water' to connect waste and drinking water Use crisis and recoveray law Introduce paying taxes over the amount of waste-water that is flushed into the sewer
		**Re-use, collection and logistics of waste** Households and companies producte waste on a daily-basis. Organic waste can be re-used in the urban area. Other waste flows, such as paper and plastics, need to be seperately collected in the urban area and can be recycled out of the area on a higher scale. The logistics of waste need to be organized in an efficient way.	→	Facilitate seperate waste collection is in the public space Change the law in Chapter 10 of Wet Milieu en beheer to make joint collection of residential and company waste possibble Set-up a VVE structure among the companies in the urban area to organize their waste disposal together
		**Stimulating the local economy** High-quality re-use of local products. In a mixed-use urban area places are created for repair cafes and the sharing-economy. Further, (roof) gardens can be designed to grow local products on that can be sold to local restaurants and shops.	→	Introduce less taxation over local products Calculate the environmental impact and pollution factor through the prices of products

Fig. 7: Circular urban area development guideline (Own ill.)

Discussion

Discussion on theory

The existing theories of Kirchnerr et al. (2017), Hoornweg et al. (2016) and Geisdoerfer et al. (2017) provided a comprehensive overview of the terms ‘circular economy’, ‘circularity’ and ‘sustainable development’ and their mutual relations and differences in the built environment. The insights gained by this research deepen the existing knowledge of these terms in relation to circular urban area development. The used literature of van Bueren (2012) has been found partly useful. Despite, all industrial flows are reflected in the found factors, a connection between the material and energy or water flow cannot be made. Further, the factors ‘waste collection’ and ‘stimulating the local economy’ have not been found in studied literature.

Discussion on practice

First, the 11 experts that were interviewed during the explorative interviews gave varied answers. Because of the newness of the subject, the interviewees were biased by what they have experienced in practice or have read in papers leading to broad outcomes. Nevertheless, this step of the research was indispensable to get a first feeling by the concept of circular urban area development

Second, because no circular urban area developments are in the execution or exploitation phase yet, three cases were conducted that were in the initiation or design phase. Therefore, the found factors have not been implemented and tested in practice.

Third, according to the experts of the expert panel ‘consensus is key’ for the development of a circular urban area. Unfortunately, no consensus could be establishing among the experts. Some used a broad definition which contained many sustainability themes while others used a smaller approach.

Although, many market parties are currently talking about the implementation of circular principles in their urban area developments, the actual execution of circular urban area development is not taken place because the next mismatches occur in practice: (1) public parties want to make use of qualitative measurements while private parties need quantitative measurements to justify their circular expenses, (2) researchers are using a broad definition of circular urban area development which is too vague for practitioners to use in real life and (3) the found factors of this research are still based upon linear norms instead of circular ones and therefore it is hard to state whether these factors are real circular.

Recommendations

The next recommendations for further research can be stated:

- Conduct this research again when the projects are completed or in further stage of development to test whether these factors can really be used.
- More research into the relation between flows and scale levels to investigate which scale it the most efficient and suitable for which circular flow.
- More research into the possibilities of implementing circular principles in the public space, because ‘public space is key’ for the development of a circular urban area.
- Research into the role of smart data tools that can support decisions making and can be used to make it easier to manage circularity in urban area development.

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Table of Content

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PART I: INTRODUCTION

1. Research proposal

1.1. Introduction

Today, many politicians and citizens are aware and concerned about the risks of global warming. According to many researchers global warming is the result of the human behaviour of the past century. Since the industrial revolution, we rapidly innovated and therefore extracted a lot of non-renewable resources from the Earth. In 2009 a group of environmental scientists designed the concept of the 9 planetary boundaries in which they established 9 Earth systems that need to stay stable to sustain a safe and sound future for the next generations. Crossing these boundaries will lead to irreversible environmental effects on our planet (Steffen et al, 2015). According to Hoornweg, Hosseini, Kennedy and Behdadi (2016) the built environment can contribute to sustainable development in which *"standards of living for current and future generations within the planet's carrying capacity"* are realised. Cities trying to achieve these missions by focussing on bio-physical themes such as biodiversity, climate neutrality and the circular economy. Besides bio-physical themes also social-economic themes play a role in the development of sustainable cities such as safety and mobility (Hoornweg et al., 2016). The focus on the building industry is understandable, because the built environment is for a large part responsible for these environmental effects. In the Netherlands 25% of the CO2 emission and 60% of the material demand comes from the build environment. Furthermore, 80% of the embodied energy in buildings is a result of the production processes of materials (Hawken, Lovins & Hunter Lovings, 2013; EMF, 2013). These numbers belong to the linear economy which is focused on - take, make, use and waste - where take is about the extraction of resources from the Earth and waste is the final step of the material lifecycle (Schokker, 2018; Sauvé, Bernard & Sloan, 2016). Therefore, we need to transfer to a more circular economy approach where the goal is to maintain resources and materials in the economy for as long as possible without losing value and quality (EuropeanCommission, 2018).

An overall definition of the circular economy cannot be found. According to Kirchnerr, Reike & Hekkert (2017) 114 different definitions can be found in literature. Furthermore, many people are confusing the terms circular economy and circularity, while these two are having a different meaning and aim. Circular economy is the holistic economic system aiming for economic prosperity while circularity in the built environment is about the high-quality reuse of buildings materials and other resources (Bosch, 2017).
The government-wide program *circular economy* stated that the Netherlands should be 100% circular in 2050, designating the building industry as one of the five critical sectors that need to switch to a circular approach (Rijksoverheid, 2016).

Our built environment is shaped out of different dimensions that are all interrelated and therefore condition each other. From a circular perspective the following dimensions can be distinguished: Materials, components, products, buildings, urban areas and cities (van Bueren, 2012; Heurkens, 2018). In between the building and the city is the urban area scale that has characteristics of both. An urban area development is derived from a public-private initiative and is focussed on processes and products. Because of the larger scale many stakeholders can be involved what can make urban area developments complex (Heurkens, 2018). From a circular economy perspective most researchers are focussing on the smaller component and larger city scale (Pomponi & Moncaster, 2017). When looking at the building scale the focus is mostly on adaptability. Brand (1994) designed the "Shearing Layers of Change" in which every building component is isolated and has its own lifecycle. With this in mind buildings can be designed for adaptability and re-use. On the other hand, the city scale is more focussed on nature's metabolism with flows that are both input and output, that are closing resource cycles and are part of the bigger city system (van Bueren, 2012).

The scale of an urban area is a much-used scale for project development in the Netherlands. At the moment many (industrial) areas on the edge of larger cities are being redeveloped into mixed-use urban areas due to urbanisation and the growing housing demand. In the development of these urban areas there is an opportunity to use the principles of the circular economy, what we can call a 'circular urban area development' (Bouwcampus, 2018).

In this research the factors that contribute to the development of a circular urban area identified and explained. Because the urban area scale is in between the building and city scale, in literature special attention is paid to the ideas and applications on these two levels. Furthermore, Dutch practice will be used to identify the factors and their applicability. This results in a guideline for circular urban area development factors and the management tools that can be used to steer on them in Dutch practice.

1.2. Problem statement

A shift from a linear to a circular economy is needed to stop the effects of climate change and to preserve the world's resources (EuropeanCommission, 2018; Steffen et al, 2015). Together with 192 other world leaders the Netherlands agreed to the 17 sustainable goals, composed by the United Nations, for a better world by 2030 (Global Goals, 2015). Furthermore, the Dutch government declared to become 100% circular in 2050. In their Government-wide program they designated five industries where special action will be taken. The building industry is one of them (Rijksoverheid, 2016). Cities can contribute to these goals by developing sustainable urban areas in which a sustainable future for next generations within the planet's carrying capacity is realised by focussing on the environmental, economic and social dimension of development. In recent years the concept of the circular economy emerged and is much used in the context of sustainable development (Hoornweg et al., 2016).

Unfortunately, in the building industry there is no consensus about the definition of circular economy. Kirchnerr et al. (2017) have found 114 different definitions in literature and also identified four different aims. The most mentioned aim in literature is the aim for economic prosperity which aims for feasible business cases behind circular developments. Unfortunately, valuing circularity in our current business models is difficult and many times not feasible, which makes it more understandable that we are still using traditional approaches in our urban developments (Personal communication, O. Wagenaar and B. Terpstra, 10 January 2019).

Where circular principles are already applied on the smaller scales and city scale, knowledge and research about the implementation of circularity on the urban area scale is lacking (Schokker, 2018). In practice, some parties are claiming to develop urban areas in a circular way, however which 'circular factors' contribute to these circular urban area developments are vague and not tangible. Van Bueren (2018) asked the question: *"From circular economy to circular buildings and urban areas: a matter of up-scaling?".* However, how to approach circularity in urban area development is unclear. Therefore, sufficient research in this field is needed to get clarification about the concept of circular urban area development and the applicability in Dutch practice.

1.3. Relevance

Scientific relevance

In the past years many papers have been written on circular economy. However, there is no consensus about the definition of it in the building industry (Kirchnerr et al., 2017). Second, circularity in the built environment is discussed as a hot item but lacking real initiatives and concrete solutions. Several circular concepts and business models are applicable on the smaller scales such

as the product and building scale. However, circularity on larger scales is lacking initiatives. According to Lotteau, Pouse, Loubet, & Sonnemann (2015) our built environment consists of two levels: buildings and urban areas. While research about circularity on the building level is increasing, publications about the implementation of circularity on the urban area scale are missing (Pomponi & Moncaster, 2017). Hence, this research is aiming at filling this gap in literature by identifying the factors that contribute to the development of a circular urban area and the management tools that are needed to steer on them in practice.

Societal relevance

In the Netherlands most of the large urban area developments are redevelopment projects of old industrial areas and brownfields. Because of the urbanisation and the housing shortage, municipalities rapidly allocate these grounds for redevelopments and the construction of new houses. To create an inclusive and high-quality living environment in these dense urban areas, the aim is to create mixed-use urban areas that are good accessible, green and inclusive. To achieve these ambitions, the principles of the circular economy can be used (Bouwcampus, 2018). These redevelopments can contribute to the climate goals of the Netherlands and can be used as pilots and showcases of circularity. However, what the factors are of these circular urban area developments and how they can be managed in practice is unknown. Therefore, research into this subject is needed.

1.4. Research objectives

This research aims to investigate the opportunities of circular urban area development. Therefore, the definition of a circular urban area development needs to be clarified by doing scientific and empirical research. Out of this research a set of circular urban area development factors and their managerial tools are established, that can be summarized in a circular urban area development guideline. First, the factors that contribute to the development of a circular urban area development are identified and explained. Second, the applicability of these 'factors' in practice is researched so that this guideline can be used in Dutch practice.

In addition to the main research objective, each section of this research has its own sub-objective. The next sub-objectives can be distinguished:

1. To get a comprehensive definition of the circular economy and circularity in the built environment
2. To get a comprehensive definition of circular urban area development
3. To get an overview of the factors that contribute to the development of a circular urban area
4. To get insight into the instruments and tools that can be used in practice to steer on the factors of circular urban area development

1.5. Research question

The aim of this research is to gain more insight into the factors that contribute to the development of a circular urban area and how these factors can be applied and managed in Dutch practice. This will be researched through literature study, explorative interviews and case study analysis. Further, the instruments and tools that can be used in practice to steer and manage these circular urban area development factors are researched through an expert meeting.

The main research question is:

"What are the factors that contribute to the development of a circular urban area and how can these factors be managed in practice?"

To answer this research, question the next sub-questions are defined:

- *What are the characteristics of a circular economy and circularity?*
- *What is circular urban area development?*
- *Which performance indicators, that could possibly be used in circular urban area development are available?*
- *Which factors contribute to the development of a circular urban area?*
- *Which instruments can be used to manage these factors of circular urban area development in Dutch practice?*

1.6. Conceptual model

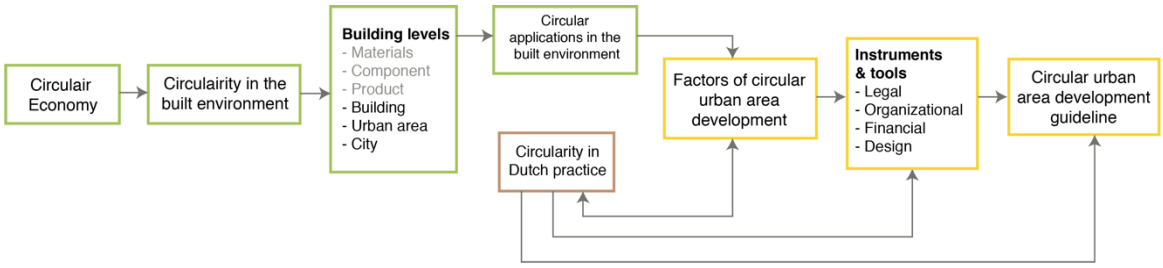


Fig. 1: Conceptual model (Own ill.)

To be able to identify and explain the factors of circular urban area development, first more knowledge about the characteristics of the circular economy need to be conducted. After, the concept of circularity in the built environment is explained. Our built environment can be subdivided into multiple scale levels that are all interrelated to each other. Because an urban area is in between a building and city scale, applications on these two scales are researched. Because, the subject of circular urban area development is new and therefore lacking scientific research, data need to be collected from Dutch practice. Therefore, explorative interviews, case studies and an expert panel are executed to identify the factors of circular urban area development and the measurement tools that that can be used to manage them in Dutch practice. Subsequently, a circular urban area development guideline is designed derived from the data found in literature and practice. This guideline can support projectteams with the development of a circular urban area.

1.7. Research output

The aim of this research it to define the concept of circular urban area development in Dutch practice that is summarized in a circular urban area development guideline. By conducting scientific and empirical research, factors that contribute to the development of a circular urban area are identified and explained. Further, managerial tools that can be used to steer and manage on these circular urban area development factors in Dutch practice are researched. This, all together can be summarized in a circular urban area development guideline. This guideline can be used by a projectteam that wants to emphasize on circular urban area development. During the development this guideline can help them with setting their circular ambitions.

1.8. Research design

In figure 2 the research design with the division of chapters is visualized. The first part of this research is focussing on identifying the concept of circularity in urban areas. The research starts with the research proposal (chapter 1) and methodology (chapter 2). Second, theoretical and

empirical research is conducted. In the theoretical part a literature study is done (chapter 3). The empirical research starts with explorative interviews to identify the factors of circular urban area development (chapter 4). After, these factors will be validated by doing case study analysis in Dutch practice (chapter 5). The factors are validated once more by an expert panel and the management tools that can be used to manage these factors are discussed (chapter 6). All these findings are summarized in a concluding circular urban area development guideline that can be used in Dutch practice (chapter 7). Last, recommendations and discussion on academic and practice is explained (chapter 8).

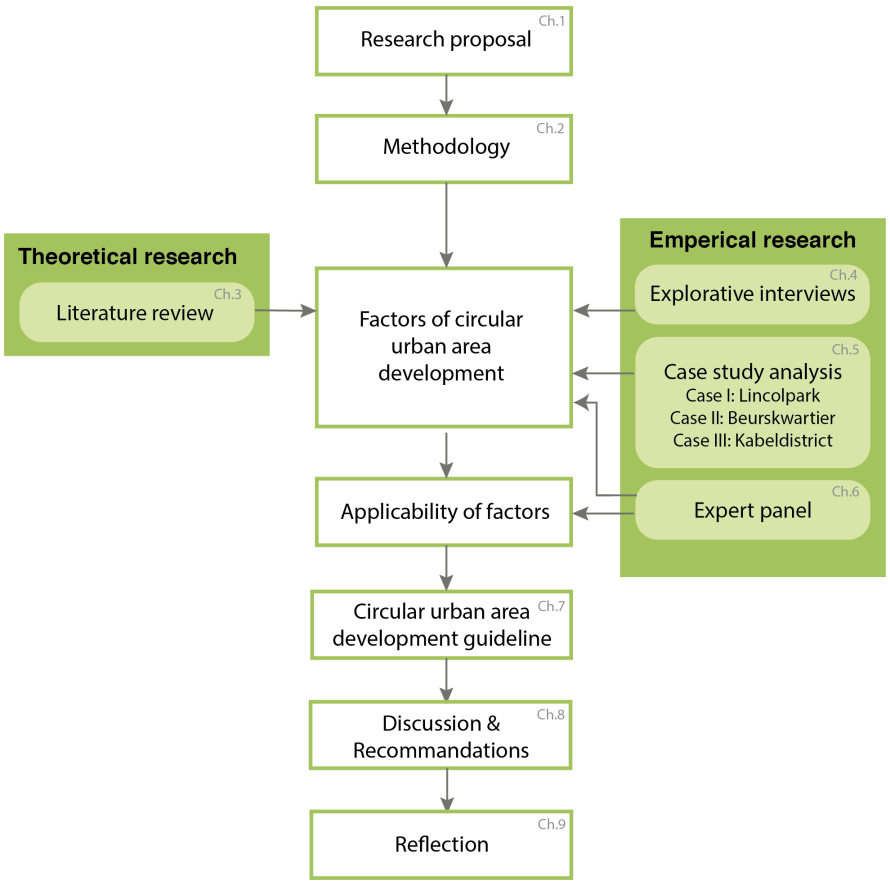


Fig. 2: Research design (Own ill.)

PART II: METHODS

2. Methodology

This second chapter is focusing on the used methods for this research. The aim of this research it to define the concept of circular urban area development in Dutch practice by identifying the circular urban area development factors and their applicability. Because circularity in urban area development is a relative new concept, where no consensus is yet be established, this research has an explorative character (Kumar, 2014). This results in the development of new theories, the reason why a qualitative research approach is chosen (Bryman, 2012).

2.1. Methodological framework

In table 1 the methodological framework is designed to give insight into the methodological dimensions of this research. This framework consists of the conceptual analytical model and the used research methods and techniques. For every dimension the aims and questions are written down (Heurkens, 2012).

Table 1: Methodological framework (Own ill. based on Heurkens, 2012; Huijbregts, 2017; de Blok, 2018).

Concepts	**Conceptual analytical model**			
Aim	Analysis and understanding of the different building levels and their circular applications and performance indicators			
Question	Which models can be used to conceptualize the definition of circular urban area development?			
Methods	**Case studies [Circular urban area development in Dutch practice]**		**Lesson drawing**	
Aim	Data collection, analysis and comparison		Empirical lessons & inspiration	
Question	What are the factors that contribute to the development of a circular urban area in Dutch practice?		What empirical & inspiration lessons can be drawn from the current urban area development projects, for the determination of the circular urban area development factors and their applicability in Dutch practice?	
Techniques	**Literature & document review**	**Semi-structured interviews**	**Expert panel**	**Displaying tables & figures**
Aim	Document information	Practical experiences	Practical validation	Comprehensive overviews
Question	Which literature sources provide information and insight into circular urban area development?	What are the experiences of practitioners with circular urban area development?	What are the perspectives of experts on the preliminary findings of this research?	How to present retrieved data from the case studies to draw conclusions?

In this methodological framework a certain hierarchy can be found consisting of three parts. The first step is a conceptual analytical model to study cases comprehensively. Second, there are two main research methods chosen to collect, analyse, compare and draw empirical lessons. These research methods are further supported by four research techniques: literature review, semi-structured interviews with practice, expert panel and displaying tables and figures (Heurkens, 2012; Huijbregts, 2017). In the next sections the question, objective and methodology of every part is further explained.

2.1.1. Concepts: Theory & Methodology

The first part is focussed on the theory and methodology of this research in which the concept of circular urban areas development as main subject of this study is investigated. First, out of relevant professional and academic literature a definition is given to circular urban area development.

Objective:
The objective of this part is to define the research problem, objectives and questions. Further, theoretical concepts are used to explain the concept of circular urban area development.

Question:
How can circular urban area development be conceptualized, and which methodological framework can be used to explain the definition of this concept?

Methodology:
Literature review.

2.1.2. Practices: Circular urban area development

The second part of this research is focussing on practice. First, explorative interviews are held to establish a list of possible circular urban area development factors. Second, three case studies are conduced to identify the factors of a circular urban area development in Dutch practice. This collected data is analysed and a cross-case analysis is done. Out of these analysis empirical lessons and inspiration can be drawn.

Objective:
To get a better understanding of the factors that contribute to the development of a circular urban area development.

Question:

- What are the factors that contribute to the development of a circular urban area? [explorative interviews and case study analysis]
- What are the similarities and differences between the factors of circular urban area developments in Dutch practice? [cross-case analysis]

Methodology:

- Explorative interviews
- Case studies
  - Project analysis
  - Policy document review
  - Stakeholder interviews

2.1.3. Synthesis: Lessons & implications

The final step in this research is focussed on drawing lessons from the circular urban area developments from Dutch practice. Once the collected data is analysed and summarized, it is possible to draw first conclusions on the factors of circular urban area development. Last, these factors are once more validated by an expert panel. In this expert panel the possible management tools that can be used to steer on these factors are discussed and explained.

Objective:
To draw inspirational lessons out of existing circular urban area developments to define and explain the circular urban area development factors and their management tools for Dutch practice.

Question:

Which factors, that are found in existing urban area development projects, belong to a circular urban area development and how can these factors be managed in Dutch practice?

Methodology:

- Case based lesson drawing
- Expert panel

2.2. Research methods

The next section of this research provides information about the used research methods. According to Bryman (2012) research methods are used for the collection of relevant data. In this research the next methods are used: Literature review, semi-structured interviews, case studies and a focus group.

2.2.1. Literature review

In the first stage of this research a literature review is done to investigate what is already known about the subject of this research.

Moreover, by exploring the existing literature relevant theories, concepts, methods and strategies about the subject emerge. Furthermore, existing controversies, clashing evidence and possible unanswered research questions can be found that bring you further in identifying the goal and objectives of this research (Bryman, 2012). The output of the literature review can be used as basis for the empirical part of this research.

In this research, the literature review, is focused on defining the concept of circular urban area development. Because the scale of an urban area is in between a building and city scale, circular concepts on these two scales are used to establish a framework which consists of the physical components of a circular urban area. On the building scale the concept of adaptability and “Shearing layers of change” of Brand (1994) is used. On the city scale the “ecosystem approach” of van Bueren (2012) is used. Together they form the components of a circular urban area, which forms a basis for the empirical research.

2.2.2. Explorative interviews

In this research qualitative research methods are used and therefore several qualitative interviews with people from practice are held. In the first part of this research 11 explorative interviews were conducted to define the concept of circular urban area development. The conducted interviews are semi-structured which means that a series of questions in general form are prepared, however the sequence of these questions can vary (Bryman, 2012, p.212). In this interview, interviewees could openly give their opinion about circular urban area development. The questions tend to be flexible and during the interview new questions and topics could emerge. The interview protocol can be found in Appendix I.

For the first part of this research 11 semi-structured interviews were held with people all employed in real estate. The interviewees all had different backgrounds; public – private, client - contractor. However, they all had in common, that they were experienced with circularity in real estate development. In table 2 an overview of the interviewees, their functions and companies can be seen.

All the answers of the 11 interviews were analysed. An overview of the most important findings can be seen in Appendix VI. Out of these interviews a first draft of 7 factors of circular urban area

development could be summarized and explained. These factors were used in further research, to set up a framework for the semi-structured interviews held with involved stakeholders of the case projects.

Table 2: Interviewee overview explorative interviews (Own ill.).

Name	Function	Company
		Municipality of Amsterdam
		Merosch
		Amvest
		Re-born
		Fakton
		AM
		Alba Concepts
		Primum
		Rebel
		VerhoevenCS
		Local

2.2.3. Case studies

In this research, empirical data from different cases is observed, collected and analysed (Yin, 2003). Out of the first part of this research, literature review and explorative interviews, 7 circular urban area development factors were found and summarized. Next, these factors were validated and sharpened by conducting three case studies in Dutch practice. These cases are all located in the Randstad area and are being (re)developed in a mixed-use urban area and have a focus on circularity. Cases don't have to be similar to do comparative analysis, however the same framework needs to be used to analyse them to make comparison possible (Yin, 2003). Therefore, the same data collection model, consisting of two data collection formats, is used to analyse the cases. For every case analysis multiple methods are used to collect data, so that findings can be cross-checked (Bryman, 2012). The next techniques are used: project analysis, policy document review and stakeholder interviews.

For the project analysis, information about the case is gathered by reviewing documents about the urban area development. To get a first impression of the circular ambitions of the case, municipal policy documents on sustainability and circularity are analysed. Further, three stakeholders are interviewed per case. One of these interviewees must be employed by the municipality and the others can have another role, however this interviewee must have knowledge of circularity in relation to the project. Again, a semi-structured interview approach was chosen. These interviews consist of two parts: circular potentials of the urban area and the factors of circular urban area development. In the first part, the role of circularity in the project is openly discussed. In the second part, the framework consisting of the earlier found factors of circular urban area development were discussed in relation to the project. Every interviewed stakeholder could give his/her opinion on the

factors by adding, reshaping, renaming or removing factors, that were according to him/her, part of circular urban area development. The interview protocol can be found in appendix II. In table 3 an overview of the interviewees can be seen.

Table 3: Interviewee overview case studies (Own ill.).

Project	Name	Company	Role
Lincolnpark			Sustainability, circular economy & energy transition
			Construction specialist
			Sustainability consultant
Beurskwartier			Advisor sustainable urbanization
			Landscape architect
			Manager waste & resources
Kabeldistrict			Circular economy
			Project Developer
			Associate Partner & Architect

To provide validated data out of the case studies multiple cases were analysed. For this research the next cases are chosen: Lincolnpark in Haarlemmermeer, Beurskwartier in Utrecht and het Kabeldistrict in Delft.

Case I: Lincolnpark, Haarlemmermeer

Characteristics of Lincolnpark located in the municipality of Haarlemmermeer:

- Called “Circular urban area development” - needs to become the neighbourhood of the future.
- Located in the Metropolitan region of Amsterdam
- 8 hectares, part of the bigger urban area development “De Parken” (32 hectares)
- New built project, last plot that is owned by the municipality
- 850 new built residential of whom 200 social-housing, retail, education and sport facilities
- Public space consists of play-grounds, greenery and water
- Use of sustainable materials that can be re-used
- Smart use of energy, water, heating and air
- Ambition: Create closed loops of materials, water and energy to reduce the ecological footprint of the development
- Designed for flexibility and re-use
- Use of circular tendering processes
- Promotion of chain cooperation between the involved stakeholders (Gemeente Haarlemmermeer, 2017; Huijding, n.d.)

Case II: Beurskwartier, Utrecht

Characteristics of the Beurskwartier located in the municipality of Utrecht:

- Inner city transformation (redevelopment)

- Ambition to use circular strategies for the development of this area: “Circular Beurskwartier”
- 3.000 new dwellings 50.000 m2 workplaces, 10.000 m2 facilities > FSI of 4
- Building heights are 12, 25 or 45 meters, high rise varies between 70 and 90 meters
- Construction of 2 large public parks
- 4 circular strategies: living lab, landscape as a machine, the hybrid block and high streets
- Focus on flows of materials, energy, water and GTF waste

(Gemeente Utrecht, n.d.; Broekman & de Vries, 2017).

Case III: Het Kabeldistrict, Delft

Characteristics of het Kabeldistrict located in the municipality of Delft:

- Redevelopment of the old Dutch cable factory
- 12 hectares, part of the bigger urban area development “Schieoevers Noord”
- Redevelopment project, old structures of the cable factory still in use
- Adding of 300.000 - 380.000 m2 consisting of 3.000 - 4.000 dwellings, 60.000 m2 workplaces incl. manufacturing industry
- Use of the quality of the Schie, addition of a new small harbor, large public green area
- Smart use of the structures of the old cable factory
- Smart use of energy and the possibility to connect the area to a thermal heating system
- Inner part of the area needs to be car-free (only accessible by emergency vehicles and moving vans)
- Attracting and facilitating the manufacturing industry - chain cooperation between parties

(Personal communication, J. Versluijs, 25 Janruary).

2.2.4. Expert panel

An expert panel is organised to validate the found factors of circular urban area development and to define the managerial tools that can be used to steer and manage them in practice. In this focus group the external and internal validity of the found factors of this research are measured and discussed (Yin, 2003).

Out of the cross-case analysis several factors that contribute to the development of a circular urban area are found. These factors need to be validated by the expert panel. Furthermore, the applicability of these factors is tested and with the group the preconditions for circular urban area development process is summarized. The protocol for the expert meeting can be seen in appendix III. The use of a focus group makes it possible to interview more than one, usually more than 4 people at the same time. In this focus group special attention is drawn to the ways in which the individuals in this group discuss certain issues of the circular framework (Bryman, 2012). Within this focus group the emphasize lies on a particular topic, namely the applicability of the found circular urban area development factors in Dutch practice. The invited participants of this focus group are all individual experts who are experienced with steering and measuring tools used in real estate development. They are a public parties or consultants that accompany public parties in tendering processes. In total 6 people participated in the expert panel. In table 4, the participants of this expert panel can be seen.

Table 4: Participants expert panel

	Name	Organisation
1		Municipality of Utrecht
2		Brink
3		Copper8
4		Fakton
5		Alba Concepts
6		Arup

2.2.5. Research process

The objective of this research is to investigate the opportunities of circular urban area development by identifying the factors that contribute to circular urban area development and the managerial tools that are needed to steer on them in Dutch practice. Out of this, a set of factors and their managerial tools are established and summarized in a circular urban area development guideline.

To conduct this research several steps are taken: First, the findings of literature and explorative interviews are used to set-up the '*factors of circular urban area development*'. These factors are used to design a framework that can be used in the interview protocol for the case study interviews. This interview protocol is the same for every case, making comparison of the cases possible (Bryman, 2012). In these interviews the factors of circular urban area development will be validated and discussed in relation to the case projects. Out of this, conclusions about the relevant circular urban area development factors can be drawled. These case conclusions are used as input for the expert panel in which the factors are validated and sharpened one more time. Further, the applicability of these factors in Dutch practice is discussed and the preconditions to establish a circular urban area development are discussed. In conclusion, the factors and their management tools are summarized in a circular urban area development guideline.

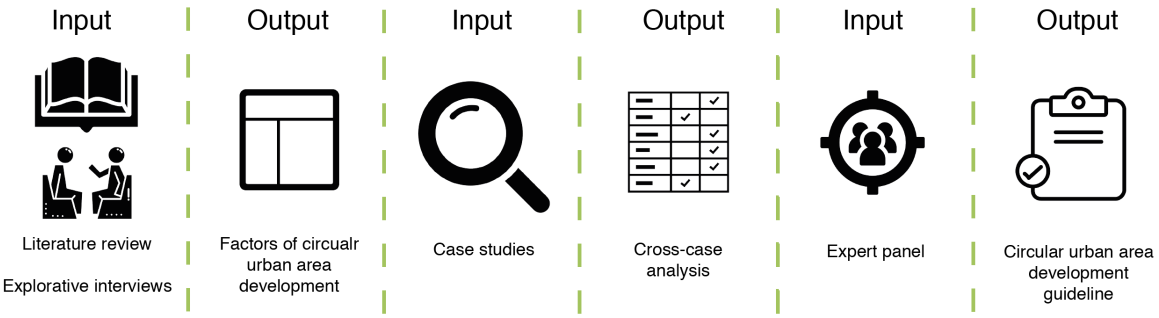


Fig. 3: Research process (Own ill.)

PART III: THEORIES

3. Theoretical framework

This section contains the theoretical framework of this research. Therefore, scientific and practical literature is being reviewed to answer the next sub-question: *"What are the characteristics of a circular economy and circularity?*" and "*What is a circular urban area development (according to literature)?" and "Which performance indicators, that could possibly be used in circular urban area development are available?".*

3.1. The concept of circularity

This section elaborates on the concept of circularity. First, the linear economy is compared with the thoughts of the circular economy. After, the differences between the circular economy and the concept of circularity in the built environment are explained. Finally, there is elaborated on the R-framework that is often used when talking about circularity. In this section the answer on the following sub-question is given: *"What are the characteristics of a circular economy and circularity?".*

3.1.1. Linear vs. circular economy

The world we're living in is facing many environmental challenges with global warming as a result. The construction industry can be held responsible for a large part of these environmental problems. Recent research has stated that a large part of the worldwide carbon emission comes from the construction of buildings (Radhi, as cited in Essays, 2013). In the Netherlands, 25% of the CO2 emission and 40% of the energy use is generated by the built environment. Furthermore, the construction of the built environment, both the buildings and the public space, is responsible for 60% of the global demand for materials (Hawken et al., 2013).

Despite all these warning numbers we're still using a linear approach regarding our energy and material use. This linear approach is based on the linear economy that is focussed on resource consumption and the production of raw materials. In this approach the emphasize is on take, make, use and waste, where demolition waste is the final step of the material lifecycle (Schokker, 2018; Sauvé, Bernard & Sloan, 2016). This linear economy approach is ignoring the life cycles of the planet: *"It is often illustrated as a line, with a beginning and an end - from extraction to disposal where the potential returns to the Earth are lost through pollution"* (Sauvé et al, 2016, p. 52). This is a strange. when you consider that 80% of the embodied energy in buildings comes from the production process of the building materials. This process consists of several steps that all consume a lot of energy and generate CO2 emission (Schokker, 2018; EMF, 2013).

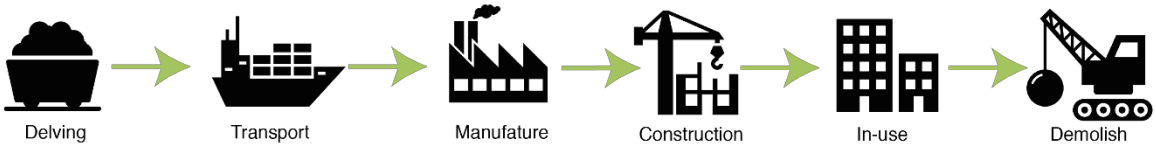


Fig. 4: Linear production process of building materials (Own ill.).

Furthermore, the primary materials that are used in the construction industry are derived from non-renewable resources that are being extracted from the Earth. Some of the reserves of these resources are limited, for example tin and zinc only have 50 years left meaning we're heading towards raw material scarcity (Habitat, 1993). Every year the Global Footprint Network calculates Earth Overshoot Day which means the day we consumed all the resources of our earth. in 1971 this day was on the 21st of December while today this day comes already in the end of July! This means that we consume every year 1.5 time our planet earth (DGB, 2017b). In this linear economy approach, all the energy and materials that are used in the building industry are becoming demolition waste in the end of the building lifecycle. This is a loss of energy, materials and an

increasing risk for the building sector (EMF, 2013). Therefore, a switch from the linear economy to the circular economy is needed. The concept of the circular economy is not new and emerged in the 70's (EMF, 2013). In the circular economy approach "*the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimized"* (EuropeanCommission, 2018, p.1). This results in closed loops of resources with the objective to optimizes the use of renewable resources and the reduction of waste and pollution (Sauvé et al. 2016). In this approach processes are characterized by reduce, reuse, repair and recycle (Schokker, 2018).

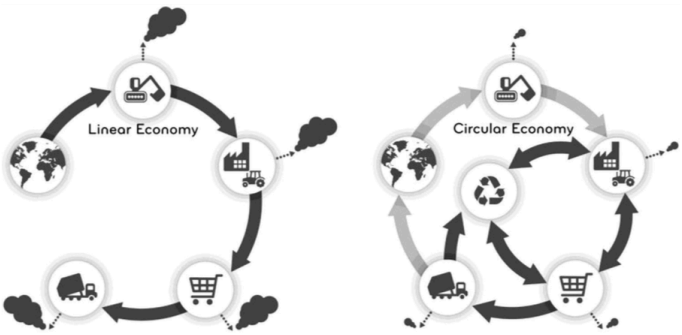


Fig. 5: Linear versus circular economy (Sauvé et al., 2016).

To the foundation of the circular economy lie several school of thoughts. Their founders and descriptions can be found in table 4:

Table 5: School of Thoughts as foundation for the circular economy (EMF, 2013).

Year	School of Thoughts	Founder	Description
1970	1. Regenerative Design	John T. Lyle	*"All systems could be orchestrated in a regenerative manner - Processes themselves renew or regenerate the energy and materials that they consume."*
1976	2. Performance Economy	Walter Stahel	*"Economy in loops with four main goals: product-life extension, long-life goods, reconditioning activities and waste prevention. Emphasize on selling services rather than products."*
2002	3. Cradle to Cradle	Michael Braungart & Bill McDonough	*"Safe and productive processes of nature's biological metabolism as a model for developing a technical metabolism flow of industrial materials, energy and water.* *Has 3 key principles:* *1. Waste equals food* *2. Use current solar income* *3. Celebrate diversity."*
1998	4. Industrial Ecology	Roland Clift	*"Study of material and energy flows through industrial systems. Aims at creating closed-loop processes in which waste serves as an input. This framework is referred to as the 'science of sustainability."*
2002	5. Biomimicry	Janine Benyus	*"Studies nature's best ideas and then imitates these processes to solve human problems. 'Innovation inspired by nature'.* *Has 3 key principles:* *1. Nature as model* *2. Nature as measure* 3. *Nature as mentor*

These five schools form the foundation of the circular economy in which the next principles can be summarized:

- Form closed systems: energy, water and material
- Economy in loops
- Service economy: selling services rather than products
- Inspired by nature: make use of nature's biological metabolism
- No waste: waste prevention and waste as input
- Make use of renewable resources

(EMF, 2013).

Thus, in the circular economy there is a closed loop in the whole economic system where products and materials retain the highest value at all time. This means that there is no loss in value, efficiency or the effectiveness of these products and no waste is generated (Geissdoerfer, Savaget, Bocken & Hultink, 2017). According to the European Commission (2018), the transition from a linear to a circular economy is needed to make our economy more sustainable and future proof. In 2050 the Dutch economy needs to be 100% circular, which means that no new raw-materials can be introduced in the economy and that CO2 emissions are reduced as much as possible. The building industry can contribute in the achievement of these goals (Rijksoverheid, 2016).

3.1.2. Circular economy vs. circularity

The concept of circularity is gaining momentum and is increasingly used in building projects and publications. However, there is no overall consensus about the definition of this concept. Kirchnerr et al. (2017) have researched the definition of circular economy and found 114 different definitions of this concept in literature. To capture the definition of circular economy Kirchnerr et al. (2017) set-up a coding framework to test whether an article was talking about circular economy. This framework consists of the core principles and aims of circular economy. This coding framework is summarized in table 5:

Table 6: Summary coding framework (Kircherr et al., 2017).

Circular economy	
Core principles	**Aims**
1. 4 R-framework	Sustainable development:
2. Waste hierarchy	1. Environmental quality
3. Systems perspective	2. Economic prosperity
	3. Social equity
	4. Future generations

In this coding framework, the main aim of the circular economy is sustainable development, which can be divided into four different sub-aims: Environmental quality, economic prosperity, social equity and future generations. The most mentioned aim is economic prosperity, followed by environmental quality what is mentioned in only 40% of the articles about circular economy. Social equity and future generations are barely mentioned (Kirchnerr, 2017; Bosch, 2017). This suggests that making profit with a feasible business case behind circular applications, is the biggest motive for using a circular economy approach. Besides, circular economy, the concept of circularity exists. The concept of circularity is derived from the concept of circular economy. In the circular economy, it is about the holistic economic system where making profit and staying economic feasible is the main goal (Bosch, 2017; Huijding, Gastkemper, Hoppe, Bloc & Faes, 2018). The main aim for the concept of circularity in the built environment, is gaining environmental quality by the high-quality reuse of materials, closing of product life cycles and reducing the environmental impact of these

materials. This means the environmental impact generated by the production processes of these building materials and resources that are therefore needed. From a circular perspective these resources are generated out of renewable energy and the materials can be re-used in the end (Bosch, 2017; Schokker, 2018).

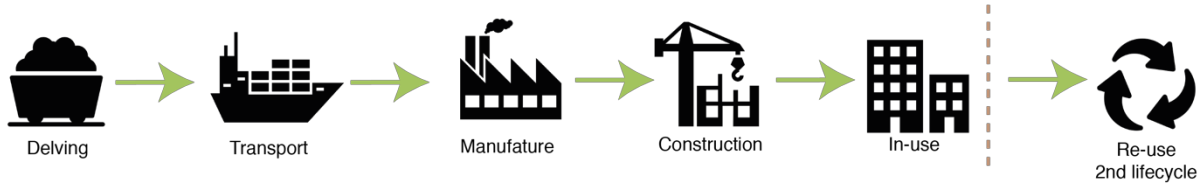


Fig. 6: Circular production process building materials (Own ill.).

One of the core principles of the circular economy consist of the system perspective in which three different scales are distinguished:

1. Micro-systems perspective: Component level - building
2. Meso-systems perspective: Regional level - urban area
3. Macro-systems perspective: Global and or national level - city

The micro level refers to the component level and the macro level to the city scale or higher. Most research on circular economy focusses on these two levels (Pomponi & Moncaster, 2017). The meso scale can refer to a neighbourhood or urban area level which is lacking sufficient literature from a circular economy perspective (Schokker, 2018). When looking at these three different scales and their description you can state that circular economy is mostly about the macro (city) scale while circularity is more about the micro (product) level. The meso (urban area) scale can be a combination of both.

Table 7: Circular economy (Own ill.)

Circular Economy	
Main focus:	Making profit
Main aim:	Economic prosperity
System perspective:	Meso Macro

Table 8: Circularity (Own ill.)

Circularity	
Main focus:	Closing of material cycles
Main aim:	Environmental quality
System perspective:	Micro Meso

3.1.3. The R-Framework

In the coding framework of Kirchnerr et al. (2017) one of the core principles of the circular economy is the 4 R-framework. These 4 R's stand for: Reduce, re-use, recycle and recover. The R that is mostly mentioned in literature is 'recycle' followed by 're-use'. Furthermore, recycle is the most promoted and mentioned R in policy documents and many times circularity is framed as the same as recycle (Kirchnerr et al., 2017; Allwood et al., 2011). In the Netherlands about 93% of the waste is used again and 79% of this is corresponding to the recycling of waste (Potting et al., 2017). In an example of the European Commission (2018) they showed that out of an input of 7.3 billion tonnes materials only 0.6 billion tonnes originate from recycled materials (around 10%). Besides these facts, most recycled materials experience a down-grade in quality and value and still many non-renewable resources are used to make these recycling processes possible (Potting et al., 2017; Allwood et al., 2011). Therefore, a division can be made between a recycling economy, still generating waste and a circular economy that is forming closed-loops without any form of waste (Rijksoverheid, n.d.)

Figure 6 shows the outline of the circular economy from the point of view of the Ellen MacArthur foundation (2018). The right side, the blue part, shows the different loops that materials and components can make: share/maintain/prolong, re-use/redistribute, refurbish/remanufacture and recycle. According to schokker (2018) recycle also needs to be subdivided in down-cycle and up-cycle. In this model the bigger the loop, the more energy is needed to make the operation possible. This means that recycling processes consume more energy than reusing a product. In the middle, in grey, the production process of products is visualized. At the top you can see the extraction of (renewable) resources. Further down these resources will be transported to the other chain partners to complete the production process. In this circular economy approach, all these chain partners are working with a lease construction and can take products or materials back after the first lifecycle (EMF, 2018). The blue loops of this diagram are part of the technosphere which is *"a human construct designed to support the conversion of raw materials for human consumption".* The right part, the green loops, are focussed on the biosphere which belongs to the concept of sustainability (U.S. Chamber of Commerce Foundation, n.d.).

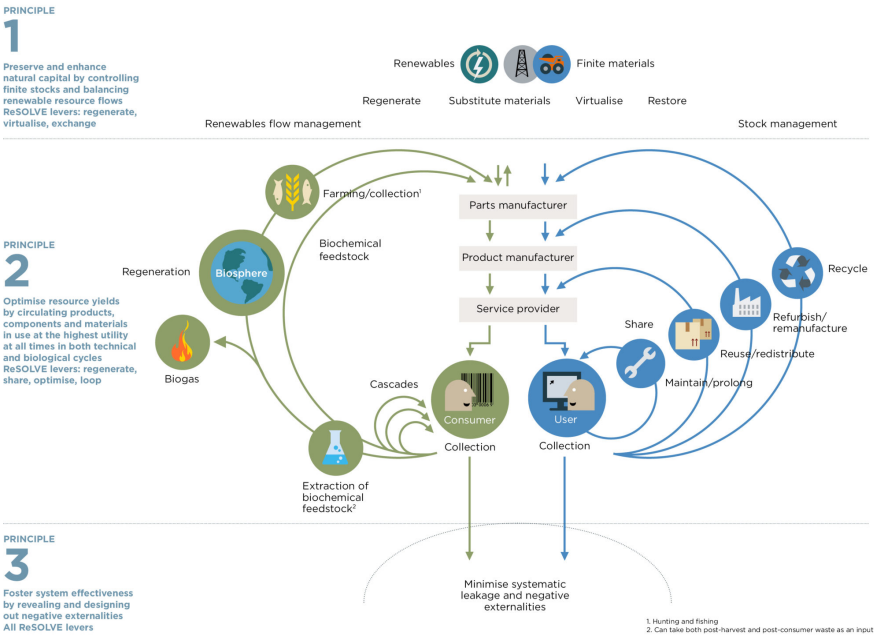


Fig. 7: The outline of a circular economy according to the Ellen MacArthur Foundation (EMF, 2018).

According to Kirchnerr et al. (2017) these loops can be extended to 10 loops, referred to as the 10 R-framework. This framework can be subdivided into 3 groups starting at the linear economy approach and going towards a more circular economy approach. This framework refers to possible actions that can be taken to make re-using of a product, after the first lifecycle, possible. This framework can be seen in figure 9. In this framework R8 refers to *'recycle'* which means: *"Process materials to obtain the same (high grade) or lower (downgrade) quality".* The aim is to maintain the quality, however a loss of quality, referred to as 'downcycling', is possible. When we than search for *'re-use'* we can find it at R3: *"Re-use by another consumer or discarded product which is still in good condition and fulfils its original function",* but still the 're-use' approach is not divided in the circular economy box. This circular economy box consists of three approaches: R2 Reduce, R1 Rethink and R0 Refuse. These three approaches described in the box: "smarter product use and manufacture", and state that we need to think different about the materials we use. For example, we can lease materials instead of buying them also referred to as the service economy or we can make use of natural resources, derived from plants, animals or trees to make our materials (Jones & Brischke, 2017; EMF, 2013).

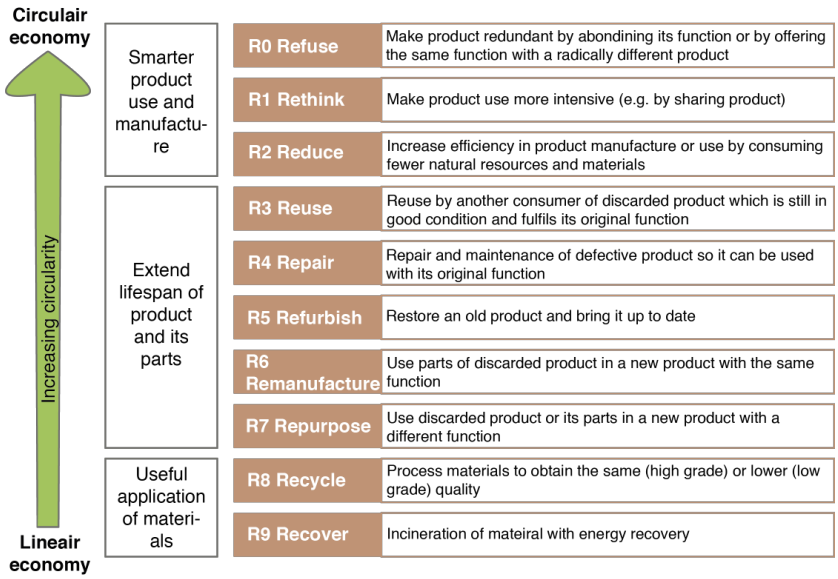


Fig. 8: 10 R-Framework (Own ill. adapted from Kirchnerr et al., 2017)

3.1.4. Conclusion

This section answers the research question: *"What are the characteristics of a circular economy and circularity?"*

The circular economy is the opposite of a linear economy, the economic approach that is used for over centuries. In the linear economy the emphasize is on take, make, use and waste as final step with the focus on resource consumption and production of raw materials (Sauvé et al., 2016). The opposite approach is the circular economy in which the value of products, materials and resources is maintained in the economy for as long as possible without losing value (EuropeanCommission, 2018). The foundation of the circular economy lies in several school of thoughts and can be characterized by the following:

- Form closed systems: energy, water and material
- Economy in loops
- Service economy: selling services rather than products
- Inspired by nature: make use of nature's biological metabolism
- No waste: waste prevention and waste as input
- Make use of renewable resources

(EMF, 2013).

While the concept of circular economy is gaining momentum, still no consensus about this concept exists and 114 definitions can be found in literature (Kirchnerr et al., 2017). However, the main aim of the holistic economic system of circular economy is clear: gaining economic prosperity. Next to circular economy exists the concept of circularity. These two concepts are closely related; however, they have a different focus. Circularity in the context of the built environment is about the high-quality reuse of materials and closing of product and resource life cycles. The aim of circularity is gaining a higher environmental quality by reducing the environmental impact over the total production process of the materials: delving, transport, manufacture, construction and in use (Schokker, 2018).

In between the linear and a circular economy lies the recycle economy. This economy is focussing on recycling; however, waste is still generated. Therefore, circularity cannot be seen as the same as recycling. In recycling processes materials and products experience a downcycle in quality and value and a lot of energy is still needed to make these processes possible (Potting et al., 2018). In the R-framework of Kirchnerr et al. (2017) R0 till R9 are approaches or actions that can be taken to give a product a second life. These approaches are ranked from circular to linear approach. Recycle can be found on place 8, refurbish on place 5 and reuse on place 3. The most circular approaches are R0 refuse, R1 rethink and R2 reduce and state that we need to think different about the way we use our materials, products and resources.

3.2. Circularity in the Built environment

This section elaborates on already existing circular principles in the built environment and several performance indicators, that can possibly be used to measure and manage circularity on an urban area scale. In the end the answer to the sub-questions of this section are given: *"What is a circular urban area development? And "Which performance indicators, that could possibly be used in circular urban area development are available?".*

3.2.1. Sustainable urban area development

The development of an urban area is a complex process that involves many stakeholders, what can take up to more than 10 years and has an impact on a large environment. An urban area development can be subdivided in between a real estate development and larger spatial plans. The first category,
real estate development is focussed on a single building and mostly privately executed while spatial plans are public led and focussed on regions and cities. The urban area is in between these two scales and is therefore a combination of a public and private initiative and needs an integrated development approach (Heurkens, 2018). This development process brings extensive changes in the area. First, in socio-economic perspective in the composition of the users and residents of the area. Second, the physical characters of the area will alter because of the demolition and construction of new buildings and roads (Franzen, Hobma, de Jonge & Wigmans, 2011).
These physical changes of an urban area development can be executed in three different ways: new build development, redevelopment and transformation.

In the last 10 years the importance of developing cities and urban areas in a sustainable way is brought to attention. A sustainable development is a comprehensive concept in which three development dimensions are combined: economic, environmental and social (World Economic Forum, 2018). In 2009 the nine planetary boundaries or Earth systems, which need to stay stable to prevent irreversible environmental effects are being established (Steffen et al., 2015). According to Hoornweg et al. (2016) cities can play an important role in sustaining these bio-physical Earth systems by creating sustainable urban areas. Besides these bio-physical themes, social-economic themes play a role in the development of a sustainable urban area such as creating safe and accessible places. Since, recent years the scarcity of resources is brought to attention and the circular economy emerged as a concept that can be used to tackle this problem (EMF, 2013). In this, the circular economy connects with the economic, environmental and social dimensions of a sustainable development (World Economic Forum, 2018). The concept of circularity is a derivative of the circular economy and is often seen as one of the conditions for a sustainable development (Geisdoerfer et al., 2017).

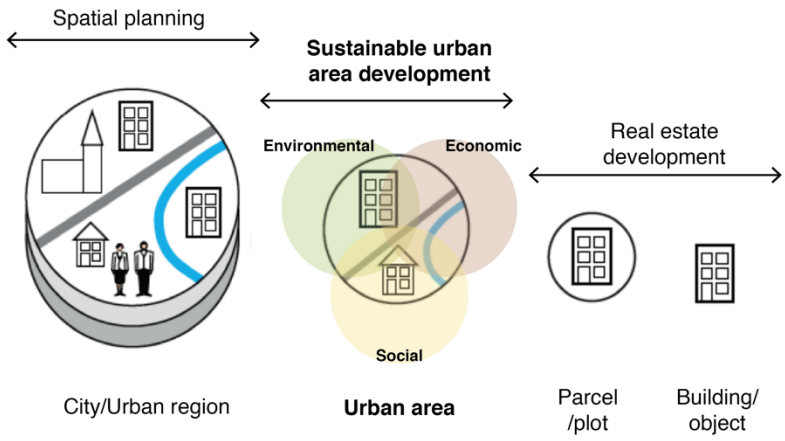


Fig. 9: Sustainable urban area development (Own ill. Based on Daamen, 2010)

3.2.2. Scales in the Built Environment

The built environment consists of different dimensions. These dimensions are called building scales and can be approached from different perspectives. These scales are distinguished to reduce complexity and mostly the lowest scale is the building (van Bueren, 2012). However, when looking at scales from a circular perspective the building can also be subdivided into smaller units. Furthermore, considered that the urban area is subdivided in between a real estate development and a city the next scales can be defined (van Bueren, 2018; Heurkens, 2018): Materials, component, product, building, urban area and a city. According to van Bueren (2012) the city is not the highest dimension. After the city there is the natural environment, a continent and the whole world. However, these larger scales are not applicable for this research and therefore not further researched. Because the focus is on urban area's one scale lower and higher is taken especially into account: The building and the city.

All these scales are related to each other; however, they have different characteristics. First, the larger the scale the more stakeholders are involved, what makes projects more complex. Second, the smaller scales are mostly private initiatives focused on products while larger scales are publicly led and more focussed on the process. An urban area is in the middle and is therefore a public-private initiative and focussed on both product and process. Last, the responsibilities of tasks differ per scale. For example, on the building scale the architect is responsible for the design while on the city scale urban planners are in charge (van Bueren, 2012). Despite all these differences these scales are all related and connected to each other. Decisions at a higher-level condition the lower scales. For example, a central heating system for a whole neighbourhood determines the heat systems of the individual homes. However, actions on a smaller scale have an impact on the higher scales as well. Non-renewable heating at individual homes contribute to emission on a global scale (van Bueren, 2012). Therefore, all the decisions on the different scales are interrelated to each other and cannot be seen separately. From a circular economy perspective some of these scales are lacking sufficient research. According to Pomponi & Moncaster (2017) the main focus of built environment research from a circular economy perspective is on the micro and macro level which means the component and the city scale. Furthermore Lotteau et al. (2015) has stated that our built environment is shaped in two operational scales: buildings and urban areas. While buildings are already lacking in literature from a circular perspective, almost none scientific research is conducted about circular urban area development.

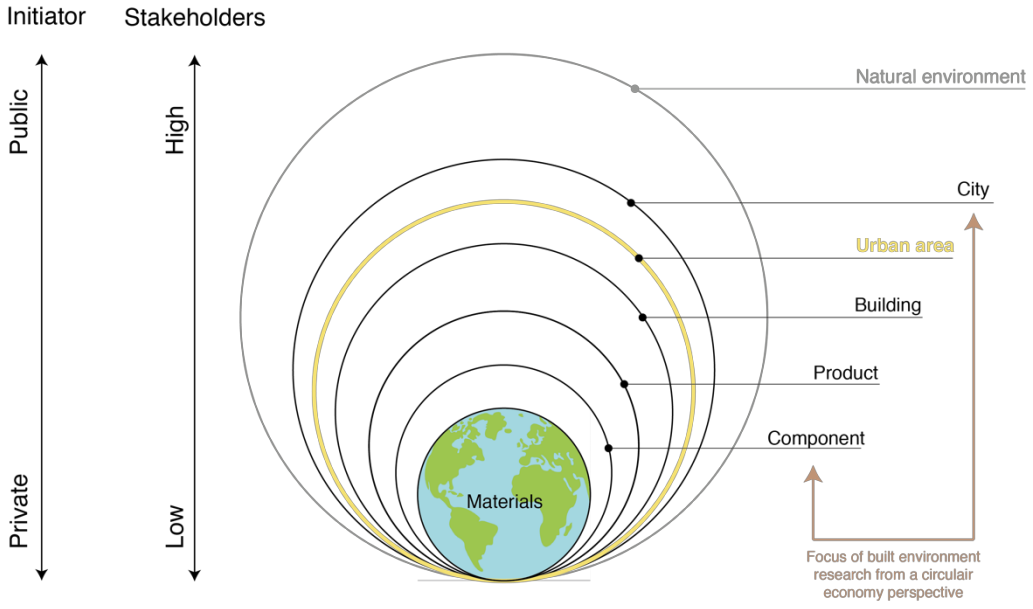


Fig. 10: Scales in the built environment from a circular perspective
(Own ill. Adapted from Van Bueren, 2018; Pomponi & Moncaster, 2017)

3.2.3. Circular principles

This part contains the explanation of already existing circular principles in the built environment. These circular ideas area derived from the circular economy school of thoughts. Because an urban area development is in between a building and a city, concepts for both scales are explained. Finally, already existing circular performance indicators from practice are explained.

3.2.3.1. Building scale: Adaptability and components

For over years architects and urban designers have tried to define flexibility in architecture as something that keeps the building functional for their users over time referred to as adaptability. According to Chaillou (2016, p.1) *"Flexibility" in architecture, refers to the ability of a building to continuously adapt its space layout and even its structure to evolving needs".* In this fast-changing world, including adaptability as a design principle beforehand is needed to match the building to the current and future demand of its users (Schmidt, Deamer & Austin, 2011). When not, the risk exists of an abandoned or even demolished building that reproduces demolishing waste. This way of thinking about adaptable buildings encourages multiple life cycles of buildings and components and minimises waste, what can contribute to a circular project development. Normally, every building project goes through four project phases: initiation, planning, execution and closure (Pinto, 1988). However, the life of a building does not necessarily have to end after the closure phase. Buildings can be designed in a way that they can easily adapt to their evolving needs.

As stated in the previous section, when looking at a building from a circular perspective, a building as an own entity doesn't exist. This line of thought already emerged in 1990 when Duffy stated that there is no such a thing as a building, because a building consists of several layers of building components. Brand (1994) adds to this his "Shearing Layers of Change", where every building component is isolated, which means that every layer has his own life cycle and characteristics. To intensify the flexibility of this system no relationship of interdependence between these layers can exist (Chaillou, 2016). The original scheme of Brand (1996) consist of 6 components that all have their own life cycle.

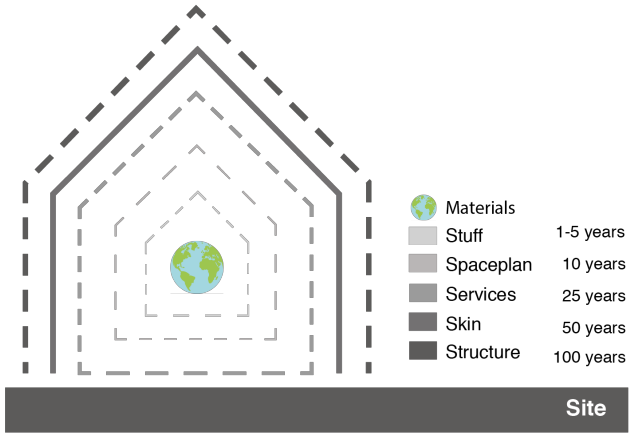


Fig. 11: The 6 S-model of the Shearing Layers of Change (Own ill. Adapted from Brand, 1994).

With this model of Brand (1994), designing adaptable buildings is possible. However, as stated in figure 11 in the previous section an urban area development is one scale larger than a building. This increase in scale entails more complexity (Franzen et al., 2011). However, an urban area development also needs to be designed in a flexible way to support circular development. Brand divided a building into components and the same can be done with urban areas. An urban area can be divided into the next components that also have their own lifecycle and design approach:

1. Buildings:
    - New built
    - Existing

2. Public space consisting of:
    - Streets/pavements
    - Street furniture
    - Green
3. Underground infrastructure

(Franzen et al., 2011: M. Schokker, 2018).

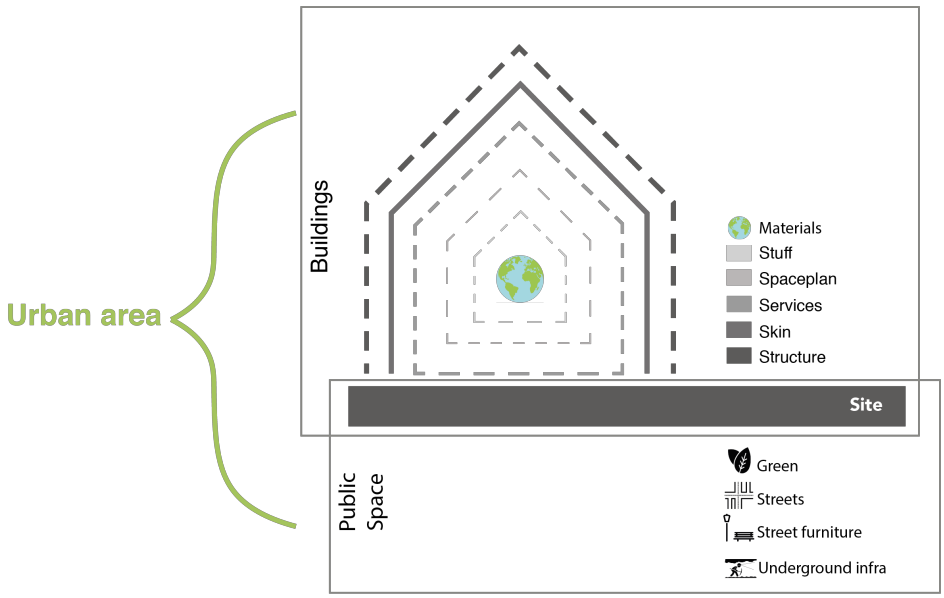


Fig. 12: Urban area components (Own ill.).

3.2.3.2. City scale: Systems and flows

In the foundation of the circular economy lie several thoughts of using nature's biological metabolism to form closed-loops of industrial flows: materials, energy and water (EMF, 2013). To better understand these systems in urban environment the ecosystem approach can be used. In this approach cities can be seen as a big open system consisting of several subsystems with determined system boundaries like for example the energy system. By distinguishing these different systems into smaller systems, it is easier to understand the smaller systems without losing the connection with the other (bigger) systems (van Bueren, 2012). In this system perspective processes in the built environment can be seen as flows focussed on input - throughput - output. In the built environment this input consists mostly the industrial flows which are water, energy and materials. Second, these flows all have a different timespan while being in the throughput. Finally, they come out as output that can differ in quality from the input. The challenge is to form closed-loops with these output resources and to maintain the quality of these resources for as long as possible (van Bueren, 2012).

As stated in section 3.2.2. the different building scales are all interrelated to each other. The Ecodevice model of Tjallingii (1996) in figure 14 is showing the relationship between these building scales and the different flows. This model states that input - throughput - output on different building scales are all interrelated and cannot be seen separated from each other (van Bueren, 2012). According to Vernay (2014) not only the buildings scales are related to each other, but interconnections between different flows should also be considered during a project development. Therefore, the aim needs to be to create circular urban systems where connections between subsystems are made. This approach of integrating energy, water and material systems, can increase the efficiency of the urban area and reduces waste.

Another approach that is focussed on interconnected closed-loops of energy, water and materials is the Cradle to Cradle (C2C) thought of McDonough and Braungart, written down in 2002 in their book 'Cradle to Cradle: Remaking the way we make things' (EMF, 2013; van den Dobbelsteen, 2008; DGB, 2017b). In this approach only, products and buildings consisting of re-usable components and without any form of inefficiency, spillage or waste can be produced with a fully closed system as a result (van Bueren, 2012). These systems are all related and connected to each other, which means that the principle of re-using flows in different system cycles is possible. Because of the use of multiple systems and loops this approach can be used in larger urban developments and therefore there are opportunities to use this
approach in urban area developments (van den Dobbelsteen, 2008).

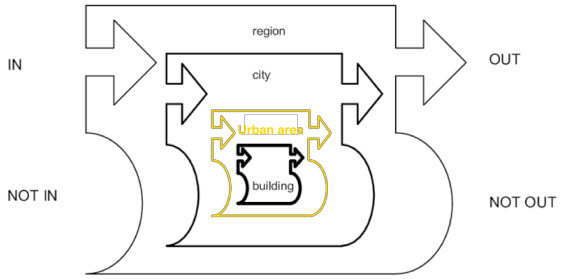


Fig. 13: Ecodevice model (Tjallingii, 1996)

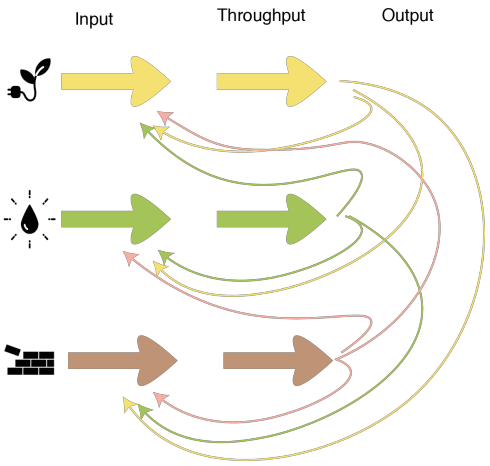


Fig. 14: Cradle-to-cradle approach with industrial flows (Own ill.).

3.2.4. Measuring circularity in the built environment

In the next section the existing performance indicators, that can be useful for measuring circularity in urban area development are distinguished and explained. The focus is on measurements that are used to measure the environmental impact of materials and tools that are applicable on the urban area scale.

Material performance: MPG

Since the 1st of January 2018 a minimum performance requirement is established to calculate the environmental impact of materials (DGB, 2017a). The MPG calculation (Milieuprestatieberekening Gebouw) is mandatory for every environmental permit application of new built residential and office buildings bigger than 100m2 BVO (RVO, n.d.). To calculate the MPG, first a Life Cycle Analysis (LCA) need to be conducted to calculate the environmental impact of the used products. The outcome of this analysis gives the shadow costs of a product per unit: S€/m2bvo. The shadow costs in this calculation mean the fictitious costs that should be made to undo the environmental effects of using this product (DGB, 2017a). Since 2018, the maximum allowed value is 1,0 (RVO, n.d.; DGB, 2017a). Choosing the right products like for example circular, recycled or bio-based materials, can positively influence the MPG value of the project (DGB, 2017a).

Integrated approach: DPG

Measuring the energy performance and material performance of a building can get contradictory results: *"The installation of solar panels or the addition of extra insulation to a building will result in a negative effect on the material performance because additional materials are needed, while on the other hand they improve the energy performance of the building"* (Alsema, E., Anink, D., Meijer,

A., Straub, A. & Donze, G., 2016, p.2). Therefore, an integrated approach, focussing on the evaluation of materials and energy performance, considering all the environmental impact of the whole building life cycle is useful (Alsema et al., 2016; W/E advisieurs, 2016). The combinations of these two performance indicators is called the DPG calculation (DuurzaamheidsPrestatie Gebouwen). The Life Cycle Analysis of the energy consumption of the building (EPG) is combined with the Life Cycle Analysis of the building materials (MPG) resulting in one number of the total environmental impact of a building over its entire life cycle (DPG) (Alsema et al., 2016).

Cradle-to-Cradle Certification

Since 2010 it is possible to get your products Cradle-to-Cradle certificated based on the thoughts of McDonough and Braungart. Together with the other chain parties an Assessment Summary Report is set-up that will be sent to the Product Innovation Institute for a check. As a result of this check the product will be Cradle-to-Cradle certificated and included in the Product Registry where all Cradle to Cradle-certificated products can be found. Each Cradle-to-Cradle certification is based on five criteria: Material health, material reutilization, renewable energy & carbon management, water stewardship, and social fairness. Each criterion is valued on its own. In the end a total certification level is determined on the basis of the lowest achieved value. The next appreciations can be achieved: Basic, Bronze, Silver, Gold and Platinum. This Cradle to Cradle certification approach is mostly focused on the product level. However, in 2016 a new movement was established that wants to make the translation of Cradle-to-Cradle certificated products to new innovations at building level leading to more circular buildings (DGB, 2017b).

BREEAM-NL Gebied

BREEAM is the first global instrument to measure the sustainability performance of projects in the built environment. BREEAM stands for 'Building Research Establishment Environment Assessment Method' and was established in 1990 in England. Since 2018, BREEAM-NL gebied (urban area) can be used in urban area (re)developments to measure the sustainability performance of the urban area. In the certification process the urban area is tested on six categories where several points per category can be earned. Each category has its own weighting on the total score. The next categories, scores and weightings can be distinguished:

Table 9: BREEAM NL-Gebied scores (Own ill. based on DGBC, 2018).

Category	Total score	Weighting on the total score	Weighting per point
Management	10	15%	1,5%
Synergy	18	16%	0,9%
Resources	52	20%	0,4%
Spatial planning	50	18%	0,4%
Welfare & prosperity	16	17%	1,1%
Urban area climate	30	14%	0,5%
Total	**176**	**100%**	

BREEAM-NL Gebied is focussed on sustainable urban area development. Using circular applications can contribute to the development of a sustainable urban area (Schokker, 2018b).

Table 10: Circular principles in BREEAM-NL gebied certification (Own ill. based on DGBC, 2018).

Category	Credit	Points	Weighting on total	Description
Synergie 3	Enable the area to adapt to changing conditions in use	3	2,7%	*(future)Changing market is taken into account, flexible policy frameworks, temporary use of buildings/locations*
Bronnen 3	Local generation of renewable energy	9	3,5%	*% of the energy demand that is generated within the urban area*
Bronnen 5	Reusability of products and raw materials in the public space	5	1,9%	*% of re-used material in the public space + % of circular materials*
Bronnen 6	Use of materials with a low environmental impact in the public space	5	1,9%	*% of the volume of the materials is based on comparison of LCA*
Bronnen 7	Use of materials with a responsible origin in the public space	4	1,5%	*Next to wood, % of the volume of the materials has a responsible origin*
Bronnen 10	Waste management to reduce waste (disposal) to minimize negative environmental effects	8	3,1%	*All (construction)waste streams recycled, waste generated in the area is re-used within the area or exchanged, reduce of waste flows out of the area*
Ruimtelijke Ordening 4	The efficient and optimal reuse of buildings and road	3	1,1%	*% of the existing works is re-used*
		37	**15,7%**	

Out of the 176 points that can be earned in the BREEAM-NL Gebied certification, 37 can be earned by applying circular interventions in the urban area development. These 37 points are responsible for 15,7% of the total score of 100% that can be earned. Based on the earned points and weightings the next five qualifications can be earned: Outstanding ≥ 85%, excellent ≥ 70%, very good ≥ 55%, good ≥45%, pass ≥ 30 and unclassified <30%. (DGBC, 2018).

GPR Stedenbouw

The GPR software is established by W/E advisors sustainable building. The GPR software is used to make sustainability of buildings and urban area developments more measurable. By using GPR the aim is to create the highest possible quality with the lowest possible environmental impact. Sustainability is measured by GPR by giving a rating on a scale of 1 to 10 for each of the five sustainability themes:

1. Energy is about the energy performance and the reduction of the energy demand (EPL)
2. Environment is about space and land-use, nature (green), water (blue) and buildings & infrastructure
3. Health is about sound and air quality, external security and nuisance & comfort
4. Quality of use is about mobility, functionality and experience value
5. Future value is about being future-oriented, flexible and utility value

(W/E adviseurs, n.d.).

3.2.5. Conclusion

In this section an answer is giving to the sub-questions: "*What is a circular urban area development?" and "Which performance indicators, that could possibly be used for circular urban area development are available?".*

An urban area can be seen as a physical scale in the built environment and is in between the scale of a building and a city. Therefore, the urban area scale has characteristics of both: public-private initiative and focussed on product and process. In the last 10 years the importance of developing cities in a sustainable way is brought to attention. Therefore, cities are aiming on developing sustainable urban areas in which three development dimensions are combined: economic prosperity, environmental quality and social equity. Since the growing scarcity of resources is brought to attention, the concept of circularity as derivative of the circular economy, is often used as condition for sustainable development in which the value of resources is maintained (Geisdoerfer et al, 2017; Hoornweg et al., 2016).

Despite, circular principles on the urban area scale are lacking, circular principles on the building and city scale exist. When looking at buildings from a circular perspective, the focus is on making adaptable buildings (Schmidt et al., 2011). Duffy (1990) and Brand (1994) stated that a building as an own entity doesn't exist and that a building consists of "shearing layers of change" which means that every building component has its own lifecycle. These components need to be flexible and can be replaced without demolishing other layers. Urban areas consist of the following components: buildings, publics space and underground infrastructure. When talking about circularity on a city scale, the ecosystem approach is often mentioned. In this approach a city can be seen as a big open system consisting of different subsystems, often referred to as the industrial flows which consist of the material, energy and water flow (EMF, 2013; van Bueren, 2012). From a circular perspective these flows all experience their own closed-loop of input - throughput - output. All these different flows can be interconnected. This means that the energy, water and material flows are all connected to one big integrated system where no waste is generalized.

A circular urban area development is a part of a sustainable urban area development in which the focus is on applying the principles of the circular economy (Hoornweg et al, 2016). Applying the thoughts of Brand (1994) on the urban area scale, combining it with the system approach of van Bueren (2012) the next summarizing figure can be drawled of the physical components of a circular urban area.

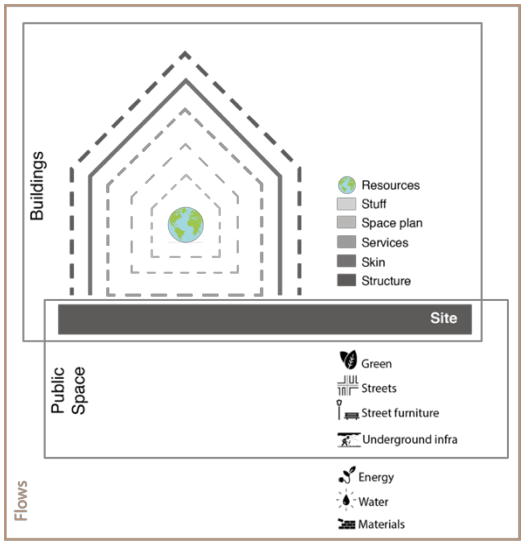


Fig. 15: Components of a circular urban area (Own ill.).

To measure the circular performance of a building or urban area there are several applications available (table 8). Circularity is about the environmental impact of the used materials and the resources that are needed to manufacture them. On a building level the environmental impact of building materials is measured by the MPG, a combination of the energy and materials performance can be measured with the DPG. Unfortunately, such a measurement is not available on the urban area scale. On the urban area scale, available performance indicators are focussed on measuring the sustainability performance in which circularity is one of the topics. An integrated sustainability performance indicator is the BREEAM-NL gebied certification. In this certification 37 points (15,7%) of the 176 points can be earned by the use of circular interventions. Second, the GPR software can also be used to measure the sustainability performance of urban areas. Scores are based on 5 themes and area rated from 1 to 10.

Table 11: Circular measurements for buildings and urban area's (Own ill).

Category	Building	Urban area
Material performance	MPG	-
	Cradle-to-Cradle	-
Integrated approach	DPG	-
Sustainability performance	BREEAM-NL Gebouw	BREEAM-NL Gebied
	GPR Gebouw	GPR Stedenbouw

PART IV: PRACTICE

4. Explorative interviews

In this section the findings of the explorative interviews are analysed and discussed. To get more clarification about the concept of circularity in general and in the context of an urban area 11 interviewees were questioned. First, the findings of these interviews are being summarized and explained. In the end, first conclusions are drawled to answer the research question: "*Which factors contribute to the development of a circular urban area"?.*

4.1. Findings

For this part of the research 11 explorative interviews are held with practitioners that are all employed in real estate. They have different backgrounds and hold positions with different focus points. These interviews were semi-structured and have the objective to define the concept of circular urban area development and factors that contribute to this. To conduct these interviews an expert interview protocol is made and can be seen in Appendix I. This interview protocol consists of four parts: (1) the term circularity, (2) circularity in the built environment, (3) circularity in urban area development and (4) the future perspective of circularity. An overview of the results can be found in the matrices in Appendix IV These matrices consist of the following:

- Matrix: The term circularity
- Matrix: Characteristics of a circular urban area development

Out of this, first results can be drawled. In the next section, the results of the interviews are explained. The answers are divided into three parts: Part A: The term circularity, B: Circularity in urban area development and C: Future perspective.

4.1.1 Part A: The term circularity

As discussed in previous sections there is no consensus about the definition of circularity. According to Kirchnerr et al. (2017) there are 114 different definitions found in literature. Therefore, every interview started with clarifying the concept of circularity and circular economy, so we talked about the same concept during the interview. Out of all the interviews the next consensus about the term circularity can be found.

Circularity:

- Is a part of sustainability
- Has a focus on closing resource-cycles
- Is about reusing building materials (R-model)
- Has a focus on the environmental impact of building materials and reducing their CO2 footprint / environmental impact
- Has a focus on the whole production process of building materials: Delving – Transport – Manufacture – in Use – 2nd lifecycle

Furthermore, the next definition of circular economy is found:

"The aim of the circular economy is to continue our economic growth and development without increasing the environmental impact and CO2 footprint of our actions. The circular economy comes with a business model that can be used to earn money, so that business and large production processes can change to a circular way of working."

4.1.2 Part B: Circularity in urban area development

Factors of a circular urban area development

The first question of the second part of the explorative interview was: *"What do you think circularity looks like in an urban area development and how does this work in practice?".* The answers on this question were broad and in further analysis the answers could be subdivided into 13 different subjects that are, according to the interviewees, part of a circular urban area development (see Appendix IV: Matrix characteristics of a circular urban area development). In the end, the most mentioned characteristics were summarized into 7 *'factors of circular urban area development'.* These 7 factors, that derive from these interviews are:

1. Integral water & energy system

(Integral) system where the cycles of water and energy can be closed. In this system, peak moments can be stored and used in time of scarcity. Both cycles can be linked to strengthen each other. Both cycles have some same characteristics and the same phases to go through These phases can be linked to each other too. These phases are:

   a. Generation
   b. Distribution
   c. Storage
   d. In use

The water-cycle has the opportunity to be closed on an urban area level. The energy-cycle can be closed on a bigger scale, for example the region scale, in which multiple urban areas can be connected and linked to each other to exchange peaks and declines.

2. Material flow between buildings and public space

Re-using the materials that are present in the urban area. This material flow can consist of building materials and materials from the public space that can be exchanged in a smart way (construction waste is considered as well). There are several opportunities to achieve this:

   a. Materials passport or urban area passport in which all used materials, buildings and public space, are documented and listed.
   b. Material hub that has enough space to store materials for a longer time. Therefore, materials need to be documented to make clear which materials are in the storage. Furthermore, a service provider can be hired to collect, store and deliver materials.

A material hub can serve a larger area than an urban area. However, the environmental profit of re-using materials may not be at the expense of the environmental impact of the transportation of these materials. Therefore, a radius of 10km around the hub is considered.

3. Re-using waste in use-phase

During the use-phase of the urban area companies and residents produce waste. Waste can be divided in 2 different categories with a different cycle:

   a. Waste with a technical cycle which means that the 'waste' can be recycled without losing quality:
      i. Construction waste see factor 2 'materials'.
      ii. Glass, textile, diapers, PMD (plastic, metal and cardboard).
   b. Waste with a biological cycle which means that after it is used it can be converted into nutrients for nature, humans or the ecosystem. This bio-waste or GFT waste can be collected and stored in a waste hub. After it can be used for:
      i. In the public space, gardens or roofgardens to grow local products such as vegetables.
      ii. The waste can be burned to make heat and energy out of it that can be re-used in the urban area.

4. Creating a community

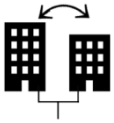
Creating a community (group of people/residents) that feels ownership and have an identification with the urban area. By creating a community social cohesion can be achieved which can result in a safer area. Furthermore, people are more likely to share with each other for example, spaces and attributes, when they feel ownership. To create this community the right target group should be attracted to the area by offering the right programme. Furthermore, meeting places (inside/outside) to stimulate interaction should be planned in the design phase of the urban area. During the use-phase a community manager can manage the meeting places and monitor the community feeling.

5. CO2 balance by creating green

Creating enough greenery in the urban area is of importance to absorb CO2 from the air. In this way it is possible to create a balance between the CO2 emission and absorption in the urban area. Reducing the amount of emissions creates a healthier and high-quality living environment which contributes to the overall healthiness of the residents and employees. Furthermore, adding green to the public space, roofs and facades stimulates biodiversity and contributes to the climate adaptivity of the urban area.

6. Stimulating the local economy

Stimulating the local economy of the urban area by creating a mixed-use urban area where people can live, work and recreate. This means that living, working and facilities are located close to each other and are good accessible for everyone. Furthermore, space can be created to produce local goods and services that can be used in the urban area.



7. Urban area as an adaptive system

The urban area functions as an adaptive system where buildings are flexible solids that can easily change their function. A smart and flexible grid, with flexible connecting points, connects all the buildings.

Initiator of a circular urban area development

The second question in this part was: *"Who needs to be the initiator of a circular urban area development?".* Is this a public or a private party? The next answer is found on this question:

"Creating a sustainable building project is not a scale but a process. The traditional building process is fragmentated and parties work in a chain cooperation. When we make the switch to a more circular building process, involved stakeholders need to work more closely together in the form of a consortium. A strong collaboration between governmental and market parties is therefore needed to achieve this goal."

Governmental parties need to steer and facilitate circularity by giving space for innovation and experiments. For example, being less strict about building regulations that make reusing materials difficult right now. Furthermore, governmental parties need to show their circular ambitions by asking for circularity in their projects. They need to ask for circular performance requirements instead of strict conditions.

Market parties need to act as pioneers that come up with new ideas and initiatives. An architect needs to take the availability of the building materials into account for the design, and demolishing companies need to be involved in this design process instead of being only involved in the

demolishing phase. The developer as client has the role as integrator to get all these parties together in the earliest possible stage.

Barriers of a circular urban area development

New phenomenon's come with barriers. The concept of circularity is new and the implementation of it in urban area developments is difficult to explain and define. The following barriers came out of the interviews:

- Which scale is the most suitable for the implementation of circularity? Is the scale of an urban area the right scale to focus on?
- There is a gap of knowledge of circularity on an urban area scale. This makes it difficult to value circularity and to ask for circular performance indicators.
- Stakeholders (public and private) involved in urban area developments are not aligned. A common consensus about circularity is missing in most projects which can lead to miscommunication between involved stakeholders.
- Implementing circularity in urban area development projects can lead to financial barriers. Using circular building methods can lead to higher building costs which are hard to earn back on a short term which makes it hard for a developer to implement circular building methods.
- The material flow is a ponderous system. Exchanging materials is reliable on some degree of chance which makes reusing materials hard.

4.1.3. Part C: Future perspective

Circularity in the coming years

The last part of the explorative interview were questions about the future perspective of the concept of circularity. The first question of this part was: *"Which direction will circularity take in the coming years?".*

A. The energy transition started 5-10 years ago. In the meantime, building energy neutral is becoming more standard. Since a few years circularity is becoming a more important topic in the building industry, resulting in more research and initiatives. Perhaps, over 10 years circularity is on the same level as energy is at this moment?
B. The circular economy is an economic system consisting of business models that are used to earn money. For this reason, it is possible for companies to develop circular business models in which circularity can get a financial value. In 2050 when the Netherlands is completely circular, circularity has to be a priority for every company to have a future perspective.
C. We need to be aware of the fact that the term circularity is not only used as marketing tool. When this happens, it can become a 'containerconcept' just as sustainability.
D. To make the switch from a linear to a circular economy we need a system change. Right now, we are in period A and we want to go to period B. This transition is a chaotic process in which we have a dichotomy in the economy.

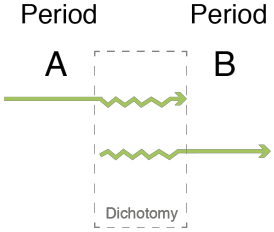


Fig. 16: Dichotomy in the city (Own ill. based on personal communication H. Jansen, 12 February 2019).

Changes and barriers of circular development.

The next question was about the opportunities and barriers of developing in a circular way:

Opportunities

- The business case of an urban area development is broader than the business case of one building. Therefore, it is easier to be creative with the costs. If building circular is more expensive, there is the possibility to save money on other posts. This is more difficult when developing one building.
- The shorter the life cycle of a product the more interesting the product is for the circular economy.
- The circular economy offers opportunities to create high quality living environments in dense urban areas.
- When we have the right business models, re-using a material will be cheaper than producing a new one.

Barriers

- Valuating circularity is difficult because a lot of knowledge on this subject is missing
- When organising material flows, there is a lot of uncertainty about roles, responsibilities and risks.
- Building costs for building circular are 14 – 20% more expensive than traditional building costs. The developer, who is taking the risk for the building cost, cannot see his investment back because the residual value is not included in the developer's business case.
- The building decree often does not allow it to re-use materials because they are not certified. Re-using materials in accordance with the building decree is difficult.
- At the moment buying new materials is less expensive than reusing old ones.
- Circularity goes beyond recycling bricks and concrete which is not circular at al.

Circular development can create value addition

Nowadays, developing with circular principles is more expensive than developing in the traditional way. However, circular development can create value addition in the following ways:

- Building circular can contribute to a high-quality living environment of an urban area, building or home. This added value can be the healthier living environment or lower maintenance costs. These qualities need to be validated and capitalized.
- Circular buildings can get a higher investment value like BREEAM certificated buildings.
- Use the "Sharing layers of change" of Brand (1994) to make the building components with a shorter lifecycle flexible. These components have the highest residual value that can be made transparent in the business case. In this model the initial investment costs are higher, but when looking at the total life cycle costs this can be cheaper.
- In 2050 when the whole Dutch economy is circular, all materials will have a different value. There will be more competition around materials increasing the value of it. Owning a material creates an economic value and financial value by leasing it. A building functions as a material bank.

Circular business models

The circular economy suggests that circularity can create an economic value. For the building industry, the practitioners thought about the following circular business models:

- The initial investment of a developer can be higher when the building they sell has a higher residual value. When the building is not depreciated till 0% but 10%, this 10% can be used to implement circular principles in the beginning of the development process.
- A developing investor who is involved in all phases of the project: design till exploitation is able to earn his initial investment back because he is involved for a long term.

- Building as a service in which all building components can be leased. The residual value of components with a short life cycle can be made visible in the business case cash flow.
- The business cases of municipalities and private parties are often not aligned. For example, the developer decides to build a closed water-system, meaning that the traditional sewer is not needed anymore. Normally, the municipality would pay for the sewer but in this case the money budgeted is not spend. Perhaps, this money can be spent on other circular principles in the development that are, in the normal business case, not feasible. Thus, municipality and developer need to communicate better about their costs and revenues.

4.2. Conclusion

In this section of the research the focus was on clarifying the definition of circularity and defining and explaining the factors that contribute to the development of a circular urban area. These findings are based on 11 explorative interviews held with practitioners, all working in real estate. With these interviews the next research question is answered: "*Which factors contribute to the development of a circular urban area?".* After analysing the interviews 7 factors of circular urban area development were found. The extensive explanation can be seen earlier in this chapter part B: "Factors of a circular urban area development". Below, a summary of these 7 factors can be seen:

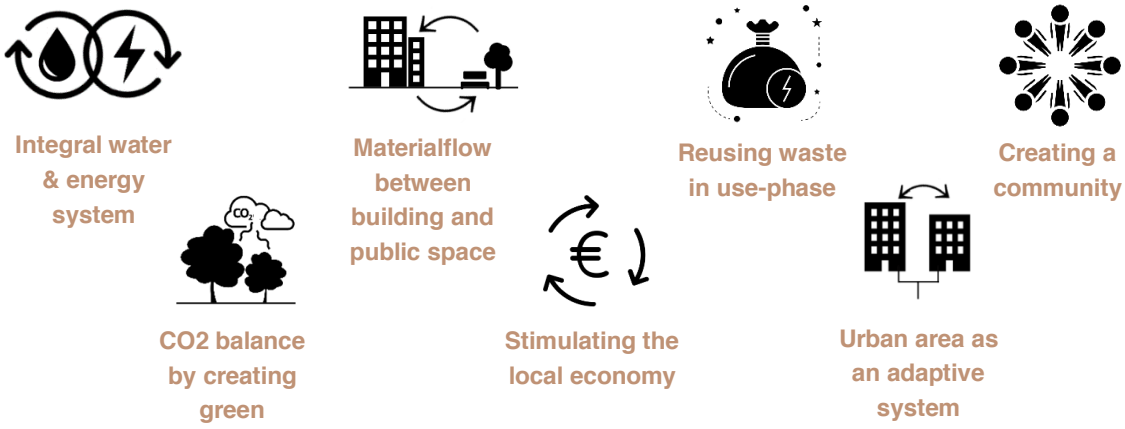


Fig. 17: Factors of circular urban area development found by explorative interviews (Own ill.).

These 7 factors are used in the case study analysis in the next chapter. In that chapter the 7 factors will be further analysed. In these case studies the factors will be validated by comparing them with real-life circular applications in Dutch urban area developments. Therefore, the definition of these characteristics can change in the next chapters.

5. Case Studies

In this part a multiple case study research is performed to gather empirical evidence about the used circular principles in urban area development in practice. The chapter starts with a description of the used case study research method. Second, three cases are researched: Lincolpark, Beurskwartier and Kabeldistrict. For every case a report is written in which a case description, project planning, stakeholder overview, municipal policy on circularity and the circular ambitions of the project are explained. Furthermore, three involved stakeholders per case are interviewed. Final, a cross case analysis is conducted, followed by the most important findings. The research question, where is further elaborated on in this section is: "*Which factors contribute to the development of a circular urban area development?"*

5.1. Case Study Research Method

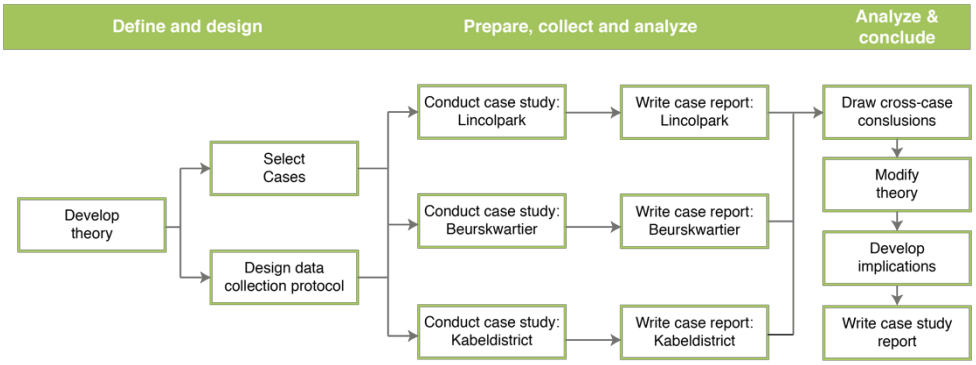


Fig. 18: Visualization of case study research method (Own ill. based on Yin, 2003)

In this chapter the *"factors of circular urban area development"* are validated and sharpened by conducting three case study analysis in these three case studies, documents are analyzed, and stakeholders interviewed. A case study research is used as a method to describe the presence of a phenomenon within its real-life context (Yin, 2003). In this case studies, the phenomenon of circularity in urban area development is researched and the real-life context consists of existing urban area developments in the Netherlands. The used method is the case study research method of Yin (2003) which consists of three steps. In the first step, which is called 'define and design', the research consisted of literature study and explorative interviews, to develop the theory that can be used for the case study analysis. Out of this, three Dutch cases were selected and the 'data collection protocol' is designed to conduct the case studies.
The second step is 'prepare, collect and analyze' and in this part the three case studies are conducted. For each case study several documents are analyzed and per case three stakeholders are interviewed. These findings are documented in individual case reports.
The last part is 'analyze and conclude'. In this part the individual cases are compared in a cross-case analysis by identifying the differences and similarities between the cases. Out of this, conclusions can be drawn on which factors belong to a circular urban area development.

5.1.1. Case study selection

For this part of the research three cases are chosen to make cross-case analysis possible. These three cases are not randomly chosen. The case selection is based on a defined set of criteria. The next criteria are defined:

- The area is being (re)developed into a mixed-use urban area
- The area is located in in the Randstad area in the Netherlands
- The development of the area is in the planning or execution phase

- The size of the development contains multiple urban area components: buildings, public space and infrastructure
- The ambition of the urban area development needs to have a focus on circularity

5.1.2. Design of data collection model

To do a cross-case analysis, multiple cases have to be conducted. To conduct every case in the same way a data collection model is designed (Yin, 2003). For this research three cases are researched in the Randstad area in the Netherlands: Lincolnpark in the municipality of Haarlemmermeer, Beurskwartier in the municipality of Utrecht and Kabeldistrict in the municipality of Delft. The mission for every case study is to understand which factors of this urban area development belong to the principles of the circular economy. The objectives are:

- Analyze each project by gathering information about the specifications and characteristics of the urban area (re)development project
- Get insight into the sustainability and circularity policy documents of the municipality
- Get insight into the sustainability and circularity objectives of the project
- Evaluate the significance of the 7 circular urban area development factors found in earlier research (literature study and explorative interviews)

The literature study and explorative interviews are used as starting point for the case study design. Every case is researched in the same way. The steps of each case study can be seen in the data collection model in figure 19. The data collection consists of a project analysis in which the case will be described. Second, policy documents and project documents are used to understand the circular ambitions of the municipality and the project. Finally, three stakeholders per case are interviewed to evaluate and identify the factors that contribute to the development of the circular urban area. The aim is to interview someone of the municipality and two public parties that were involved in the creation and elaboration of the circular ambitions of the project. All the subtracted information will be documented in a case study report.

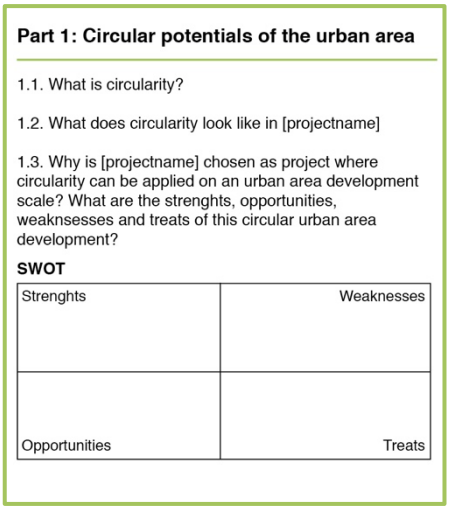
Fig. 19: Data collection model (Own ill.).

The information found in project analysis and policy documents is structured in the case study report in the following way:

- Case description including the project planning and most important stakeholders
- Municipal policy on sustainability and circularity
- Circular ambitions of the project
- Furthermore, three stakeholders will be interviewed per case. To structure these interviews a case study interview protocol is designed which can be seen in appendix II. This interview consists of two parts:
    1. The circular potentials of the urban area
    2. Evaluation and validation of the factors of circular urban area development in relation to the case study project

In the first part of the interview protocol the circular potentials of the project will be discussed openly. Furthermore, the strengths and opportunities for circularity in the project will be discussed and a SWOT analysis is conducted. The second part of the interview will focus on the factors of circular

urban area development in relation to the project. The 7 found *'factors'* will be discussed, and the interviewee is asked for his/her opinion on these factors and if they recognized them as being part of a circular urban area development. Furthermore, interviewees can add more factors or can remove them from the chart.



Part 1: Circular potentials of the urban area

1.1. What is circularity?

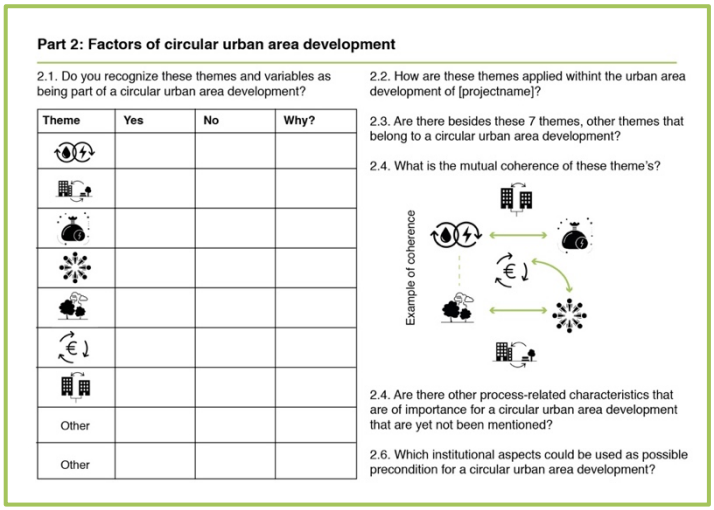
1.2. What does circularity look like in [projectname]

1.3. Why is [projectname] chosen as project where circularity can be applied on an urban area development scale? What are the strenghts, opportunities, weaknsesses and treats of this circular urban area development?

SWOT

Strenghts	Weaknesses
Opportunities	Treats

Fig. 20: Data collection format part 1 (Own ill.).



Part 2: Factors of circular urban area development

2.1. Do you recognize these themes and variables as being part of a circular urban area development?

Theme	Yes	No	Why?
Other			
Other			

2.2. How are these themes applied withint the urban area development of [projectname]?

2.3. Are there besides these 7 themes, other themes that belong to a circular urban area development?

2.4. What is the mutual coherence of these theme's?

2.4. Are there other process-related characteristics that are of importance for a circular urban area development that are yet not been mentioned?

2.6. Which institutional aspects could be used as possible precondition for a circular urban area development?

Fig. 21: Data collection format part 2 (Own ill.).

To conclude which factors, belong to circular urban area development according to the case study, conclusions are drawled by comparing the municipal policy, circular ambitions of the project and opinions of the three interviewees with each other. These three are listed and are valued by the next symbols:

- ✓ Factor of circular urban area development
- – Doubtable if a factor of circular urban area development
- ✕ Not a factor of circular urban area development

5.2. Case Study I: Lincolnpark, Haarlemmermeer

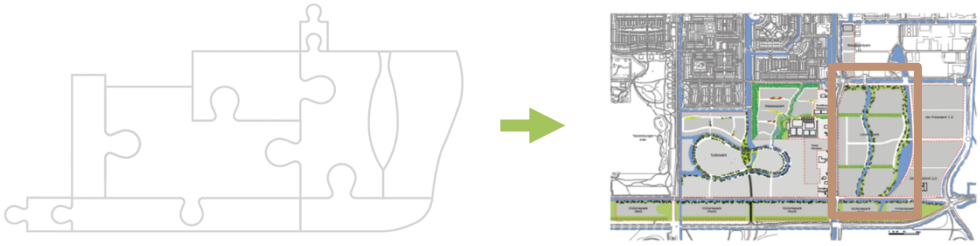


Fig. 22: de Parken & Lincolnpark (Gemeente Haarlemmermeer. 2017).

Lincolnpark, situated in Hoofddorp Zuid-Oost is part of a larger urban area development called 'De Parken'. This urban area development of 32 hectares is an initiative of the municipality Haarlemmermeer, that is part of the Metropolitan region Amsterdam. The Metropolitan region Amsterdam is assigned to build 50.000 new dwellings till 2025 and 250.000 till 2040. The municipality of Haarlemmermeer can contribute to this goal with their large-scale urban area development of 'De Parken'. In total 3.500 new dwellings are planned in this area of whom 500 are already under construction. The other 3.000 are planned for the coming 10 years (Gemeente Haarlemmermeer, 2017). The whole development 'De Parken' consist of 9 subarea's that are being developed in the upcoming years. In these area's supermarkets, retail and other public facilities are planned to support the new neighborhoods. In this vision, the area of Lincolnpark has been chosen as community center of 'De Parken'. The whole development needs to be executed in a sustainable way. However, in Lincolnpark the ambitions are set on applying the principles of the circular economy. Therefore, the development of Lincolnpark is called a 'circular urban area development' (Gemeente Haarlemmermeer, 2017). In Lincolnpark 850 dwellings are planned of whom 225 are social dwellings. Besides dwellings, retail, cafes, restaurants, a school and a small size care center will be realized. Furthermore, the public space is designed to simulate interaction, with greenery, water and playing areas (Gemeente Haarlemmermeer, 2017).

5.2.1. Planning

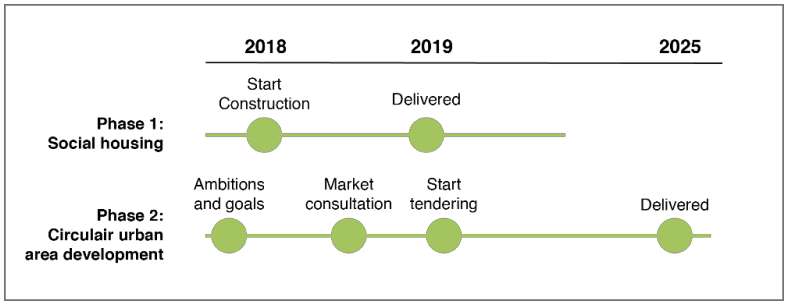


Fig. 23: Planning Lincolpark (Own ill.)

The first phase of Lincolpark is the construction of 225 social dwellings. These 225 social dwellings are built by housing corporation Eigen Haard. The construction of these dwellings started in 2018 and are planned to be delivered in 2019. These social dwellings are all gasless and solar panels are incorporated on the roofs (Gemeente Haarlemmermeer, 2018). The second phase consist of the circular urban area development. In 2018 the municipality of Haarlemmermeer established the direction and description of Lincolnpark, however a land-use plan for the area has yet not been established. Furthermore, a market consultation with over 100 different parties was organized where they talked about the direction of the circular urban area development (Gemeente Haarlemmermeer & Copper8, 2018). In the beginning of 2019, market parties could subscribe on

TenderNed. According to I. Groet (personal communication, 22 March, 2019) several parties subscribed and are now waiting for the tendering process to start which will held in an open dialogue between municipality and market party. In 2025 the whole plan for Lincolnpark should be delivered (Gemeente Haarlemmermeer, 2018).

5.2.2. Stakeholders

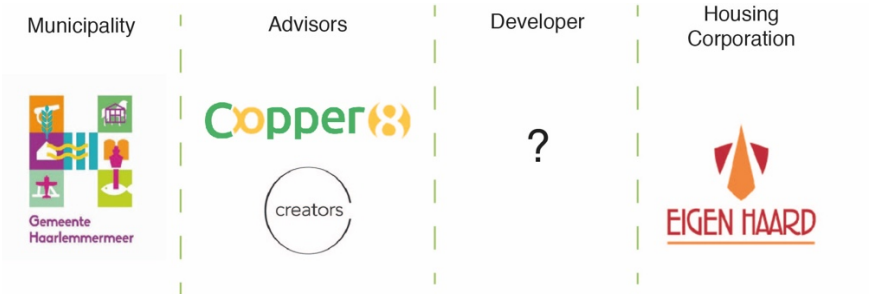


Fig. 24: Stakeholders Lincolpark (Own ill.)

5.2.3. Municipal policy on circularity

The municipality of Haarlemmermeer is located in the polder, and the average ground level height is 5 meters below sea level. Heavy rainfall and rising sea levels will have an immediate effect on their residents. Therefore, taking measures against the effects or climate change is needed. *"Sustainability is about the way we want to live, work, learn and live in the future. A sustainable future requires a substantially different way of acting by residents, companies, institutions, visitors and the municipality itself"* (Gemeente Haarlemmermeer, 2017, p.8). In their municipal sustainability program 2015-2018: "Haarlemmermeer towards a circular society", ambitions and goals are set on 4 different themes:

Water

The ambition is to develop a sustainable and climate proof water-system to avoid flooding. In this system surface, ground and wastewater are all connected. To achieve their ambitions several goals are set:

- Enough space for water
- Flexible water level management
- Improve the water quality and ecology
- Approach rainwater and wastewater differently
- Manage groundwater efficiently

Energy

The Metropolitan region Amsterdam has the ambition to be energy neutral in 2040. Every municipality within this metropolitan region has to contribute to this ambition. Therefore, the municipality of Haarlemmermeer has set the ambition: "Haarlemmermeer becomes energy-supplying":

- Reduce the energy consumption
- Increase the generation of renewable energy

Resources

One of the starting points of the circular society is to utilize the re-usability of products and raw materials and the healing power of natural resources to close resource cycles and minimize waste. Therefore, the ambition is to keep resources as long as possible in the cycle. This ambition will be achieved through 3 subthemes:

1. Reduction of waste stream: (1) Less residual waste, (2) more recycled products and (3) materials and lower waste tax

2. Optimum utilization of resources outside the scope of the waste policy (biomass, building materials and nutrients): (1) Reduce resource consumption, (2) re-use objects within municipal boundaries, (3) recover valuable components from waste streams, (4) sustainable management, (5) use of raw materials in chains, (6) more growth, application and processing of biomass and (7) the smartest application per material flow is selected (with the most value)
3. Strengthen the biodiversity and the ecological value with the objective to make the various ecosystems in Haarlemmermeer strong in quality and quantity so that it can easily adapt to changings circumstances.

Knowledge & innovation

This theme is the driving force behind the other theme's and contributes to the ambitions of all the other themes.

(Gemeente Haarlemmermeer, 2015).

5.2.4. Circular ambitions Lincolpark

The Municipality of Haarlemmermeer has set the goal to develop a circular urban area at the location of the new built area Lincolpark. This area needs to become a future proof, innovative and circular neighborhood where residents are involved and responsible (Gemeente Haarlemmermeer, 2017). The principles of the circular economy are incorporated in this sustainable urban area development:

- Urban area operates as a regenerating system which means that damaged parts of the area are fully restored.
- Use of raw materials and energy, generation of waste and emissions is prevented or minimized by closing material and energy cycles.

In the brochure: *"Lincolnpark Circulair: Sustainable neighborhood from and for the future. Join!"* published in 2018, the municipality has set project objectives that can be divided into 7 themes:

1. Landscape, urban design, water and greenery:
    a. Attractive identity
    b. Strengthen biodiversity
    c. Use ecosystem services: purify air, generate energy and filter water
    d. Climate proof: heavy rainfall does not lead to flooding
    e. Outdoor space and green-blue networks provide in multiple functions
    f. Water storage also has a landscape and use value

2. Buildings:
    a. Buildings are a resource depot and materials can be reused
    b. The environmental impact of buildings is as little as possible (materialization and energy consumption)
    c. The use of tap water is limited
    d. Buildings contribute to ecosystem services such as air purification, water storage and noise reduction
    e. Use of healthy materials
    f. Building have a healthy indoor climate

3. Renewable energy:
    a. An energy-supplying neighborhood with an energy and heat supply based on renewable energy
    b. Residents are "prosumers"; the income from energy generation is for the residents
    c. During the usage phase the energy consumption is monitored and optimized in a user-friendly way

4. Social sustainabiliy:
    a. Residents and users experience a high degree of “mental ownership” of their living environment
    b. The neighborhood is social and divers: suitable for people with different backgrounds and lifestyles
    c. The urban design of the neighborhood is safe, healthy and encourages people to meet
    d. The circular principles of Lincolpark are visible and can be used for educational purposes and behavioral change.
    e. Residents who are (temporarily) less self-sufficient feel at home
    f. Buildings, facilities and public space are accessible for everyone

5. Mobility and infrastructure:
    a. Sustainable mobility is stimulated, and fossil fuel consumption is avoided as much as possible, thereby contributing to a CO2-neutral mobility system
    b. Usage of bicycle and public transport is an attractive alternative for the (electric) car
    c. Parking facilities have multiple functions

6. Public space and raw material collection:
    a. The public space is a resource depot and materials can be reused
    b. Parts of the public space are removable and can be kept in the material cycle
    c. The environmental impact of the components of the public space is as little as possible
    d. The public space can be used in a multifunctional way
    e. The public space contributes to ecosystem services such as air purification, water storage and noise reduction
    f. Use of healthy materials
    g. They is no residual waste

7. Flexibility and adaptability:
    a. The neighborhood can easily adapt to short- and long-term changing circumstances and demands of the residents and users. This considers the entire life cycle of the neighborhood and its residents
    b. The urban design and green-blue structures are flexible and robust to accommodate future developments
    c. The energy system is flexible and adaptable in design and capacity
    d. Buildings are adaptable

5.2.5. In-case analysis Lincolnpark

For the in-case analysis of Lincolnpark, three involved stakeholders have been interviewed by using the proposed interview protocols. In these interviews participated someone from the municipality of Haarlemmermeer, one involved consultant who collaborated in the establishment of the sustainability themes and the consultant who supervised the market consultation. First, the circular potentials of Lincolnpark are explained. Second, the opinions of the interviewees on every factor are summarized and in the end, lessons learned from Lincolnpark are presented.

5.2.5.1. Circular potentials Lincolnpark

The urban area development of Lincolnpark is called ‘a circular urban area development’. The interviewees were all asked to give their definition of circularity and how this definition is translated into the plans of Lincolnpark. The question was asked: “What do you think circularity looks like in Lincolnpark?”. The next answer, agreed on by all interviewees, was given:

> *The aim of the development of Lincolnpark is to create “The neighborhood of the future” that must be able to adapt easily to the changings needs and demands of its residents and surroundings. The development itself can be seen as a sustainable urban area*

development in which the principles of the circular economy are being applied. In this, circularity is used as a principle to be able to act sustainable. Circularity is not the main aim but a means to achieve sustainability in the urban area development. When applying circular principles, the focus is on reducing the use of raw materials and closing resource cycles such as water, energy and materials (Personal communication, M. Korse, 25 March 2019 and I. Groet, 3 Aprll 2019).

The main reason why Lincolnpark is designated as an urban area where the principles of the circular economy can be applied is political driven. The plot of Lincolnpark is one of the last plots in the municipality of Haarlemmermeer that is owned by the municipality itself, meaning they can set the preconditions of the development. By using this approach, this circular development has several opportunities and weaknesses that can be seen in the next SWOT analysis:

Table 12: SWOT Analysis Lincolnpark

Strenghts	Weaknesses
- Municipality is owning the ground: can set up and manage the preconditions of the development - New built development: can be designed and constructed with flexible and circular design principles - Market consultation is held with over 100 participants to involve the market in preparation of the tender phase: entire construction chain was present	- Difficulties with setting the boundaries for circular tendering because circularity is 'new' and unknown - Business model not feasible - Social housing is constructed without circular principles - Unclarity about how to measure and manage circularity in this urban area
Opportunities	**Treats**
- Long term development with multiple phases: learn from previous phases and incorporate new innovations	- Noise pollution by Schiphol Airport and A4 highway - Multiple developers, difficult to close agreements - It is difficult to request a "crisis and recovery law" for extra-legal circular requirements - Housing shortage: Less time to do research on circular development - Municipal initiative: internal processes take a long time

5.2.5.2. Factors of circular urban area development in Lincolnpark

Below, the circular urban area development factors, according to the three interviewees, are explained for Lincolnpark.

Integral water & energy system

Despite water and energy are closely related to each other and have similar characteristics, they are two separate factors.

Energy

The factor energy can have different purposes. First, it can be the energy that is generated by movements in the area also seen as mobility. Second, the mostly used purpose for energy, is the daily-use energy, used for lightning or for the power of in-house machines. Despite, energy can be seen as a resource it is not part of the circular economy. For 10 years, the need for clean energy is being addressed, and building energy neutral has become the standard. Therefore, according to the interviewees, the factor energy belongs to the energy transition and is a means to achieve a climate neutral area which is part of a sustainable urban area

development but not part of circular urban area development.

Water

The factor water can also be divided into two different water flows. The first flow is the falling rainwater in the area. The second flow is water that is used for in-house purposes. Both water-cycles are connected to one waster-system in the sustainability program Haarlemmermeer (Gemeente Haarlemmermeer, 2015).

Because rainwater falls into the urban area a sufficient drainage system is needed. However, rainwater is not seen as a factor for circular urban area development but belongs to the subject climate adaptation which is part of the higher aim of creating a climate neutral area. On the other hand, use-water in-house for machines, showering and drinking can be seen as a resource that can be re-used on an urban area scale. This water system will be designed in the design-phase of the urban area development.

Material flow between buildings and public space

According to all interviewees, this factor is definitely part of a circular urban area development. In this material flow the focus is on building materials. Therefore, this factor can be called 'building material flow' instead of 'material flow'. In this cycle the emphasize is on the high-quality re-use of all physical component of an urban area such as building materials used in buildings and in the public space. In this, construction waste is also a part of the building material flow. Because products also have a functional value, besides the commodity value of the materials, it is best to re-use complete products over pulverized ones (See Ellen McArthur figure; smaller the cycle, the less the environmental impact of re-using). In the design-phase of the building-cycle, building materials are chosen by the developer and the architect. They already need to think about the second lifecycle of these materials and document them in an urban area passport. During the use-phase of the building-cycle, a building material hub is used to store released materials, and to make re-use possible.

Re-using waste in use-phase

Lincolnpark strives for a zero-waste neighborhood, because in an optimal circular economy there is no waste anymore (output = input). Therefore, the waste flow can perhaps be called 'material flow'. However, yet a total waste-free neighborhood is an illusion and how to deal with the waste of households is part of the development of this neighborhood. Waste is a flow that is generated in the 'use-phase' and consist of different 'material flows'. On an urban area scale, organic waste and biomass can be re-used for example as fertilizer for local food production. Other 'material flows' such as plastics or cardboard need to be recycled on higher scales.

Creating a community

When developing a new neighborhood, it is of importance to create a social safe and sustainable area which can be achieved by stimulating interaction amongst the residents. Despite, this social aspect is very important for the development of a sustainable urban area it is not a factor of circular urban area development because the social aspect belongs to the higher aim of creating a social sustainable area.

CO2 balance by creating green

The main aim of creating green in the area is not collecting CO2 emissions. However, there are many other reasons why creating enough green can be positive for the urban area. In this, green can be seen as a means for different purposes such as for climate adaptation, creating biodiversity, counteract heat stress, creating a healthy living environment and for noise protection. When designing green is it important to design it for the right purpose and not randomly add green to the

area. According to one of the interviewees, green as means for climate adaptation and heat stress is not part of a circular urban area development. However, according to another interviewee, green which is seen as a resource and strengthens the biodiversity can be a part of circularity.

Stimulating the local economy

Creating a local economy is a factor of a circular urban area development. The urban area will never have a total local economy, however certain goods and services can be traded locally such as growing and selling own crops. Furthermore, during the use-cycle of the urban area broken products can be repaired and re-used by having repair cafes and second-hand shops. This can create employment in the area, for example for people with a distance from the labor market. However, it is doubtable if creating employment is part of circularity or part of the higher goal of creating a social sustainable area.

Urban area as an adaptive system

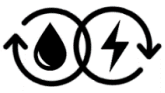
Creating adaptable buildings and functional flexible public spaces makes the urban area future proof and adaptable to changings circumstances. According to one interviewee, applying adaptable design principles is a strategy to create flexibility in the buildings and is therefore not a circular urban area development factor. However, according to the other interviewees creating adaptable buildings and flexible spaces is definitely a critical factor that contributes to the development of a circular urban area. There are three rules that apply for adaptable building design:

(1) Keep the Sharing Layers of Brand (1994) separated
(2) Create an overplus in the floor heights
(3) Make a uniform column structure with space for compartmentalization.

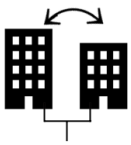
Mobility and accessibility

One of the interviewees added the factor ‘accessibility’. This means that the urban area needs to be good accessible by different modalities such as for bicycles, pedestrian and by public transport. It is accessible by car; however, people are stimulated to use the other modalities. By attracting people from outside to this area (public transport) it can stimulate the local economy of the urban area.

Table 13: Findings interviewees in-case analysis Case I: Lincolnpark

Factor	Municipality	Consultant 1	Consultant 2
 Integral water & energy system	- Energy and water are 2 separate factors - (Warm) water what is used in-house, is a resource - Rainwater is not a part of circularity - Use-energy is a part of the energy transition, not circular - Energy that is used for the heating of water can be considered as circular	- Energy and water are 2 separate factors - Water can be divided into: (1) Rainwater (2) Daily-use water - Energy can be divided into (1) Kinetic energy; everything that moves through the area and (2) Daily-use energy such as lightning - Energy can be exchanged between multiple areas - Water can be reused in the area itself	- Energy and water are 2 separate factors - Water can be divided into (1) Rainwater and (2) Daily-use water - Daily use water belongs to the ‘Use-cycle’ of the urban area = part of circularity - Daily use water system designed in the realisationphase - Rainwater is part of the subject ‘Climate’ - Energy is not part of circularity, belongs to the subject ‘Climate’
	- Material cycle is definitely part of circularity	- Take construction waste into account	- Belongs to the ‘Realisation-cycle’ of the urban area = the design

 Materialflow between buildings and public space	- Take construction waste into account - Use of materials without a high environmental impact - Try to reuse 'products' because they also have a functional value	- Call this factor: Building material flow - In this building material flow, try to reuse all the physical components of an urban area	and construction phase of the development - Part of circularity - High-quality reuse of materials
 Reusing waste in use-phase	- GFT: organic waste and biomass can be re-used on urban area scale as fertilizer for local food production - Other waste flows are being recycled on higher scales	- Call this factor: material flow, not waste because the CE strives for a zero-waste economy - This material flow is daily: household and industrial/commercial waste - GFT: organic waste and biomass can be re-used on urban area scale - Other waste flows are being recycled on higher scales	- Belongs to the 'Use-cycle' of the urban area - Part of circularity - This material flow is daily: household and industrial waste (less industrial waste in Lincolnpark)
 Creating a community	- Part of social sustainability - Aiming on creating social sustainability in the area - Creating meeting places and qualitative public spaces - Attracting the right target groups that want to share - Participation during the development process	- The social aspect is not part of circularity = part of social sustainability and something you also wants to achieve in the urban area	- Part of the subject 'Social sustainability', critical part of developing a sustainable urban area, however is not part of circularity
 CO2 balance by creating green	- CO2 collection not the main aim of implementing green - Green in the urban area makes the residents more healthy - Green can increase the value of properties - Climate adaptation: collecting rainwater and counteract heat stress - Green as resource refers to biodiversity and the ecological value	- Green be used for multiple reasons: counteract heat stress, water collection, air quality, nitrogen collection, noise protection to Schiphol - Make a choice for which to use the green, design for the use - Not randomly put green	- CO2 collection not the main aim of implementing green - Adding green is a means not a goal - Green can be used as means for different purposes: (1) Climate adaptation and (2) Biodiversity (both not part of circularity)
 Stimulating the local economy	- It will never have a total local economy, however certain components such as growing crops can - Include people with a distance from the labor market - Mixing functions stimulates the vibrancy of the area (- *Local economy is not included in Lincolnpark, however is part of a circular urban area)	- Definitely part of circular economy, maybe remove local - Creating employment in the area - Determine which product are usable for the local economy	- Repair broken items locally = High-quality reuse of products = Part of circularity - Part of the 'Use-cycle' of the urban area - Aim to create employment in the area belongs to the subject 'Social sustainability'

 Urban area as an adaptive system	- The measurements of buildings and the public space need to be functional flexible - Reserve space that you can use flexibly	- This factor is more a strategy that can be applied to create flexible buildings, not a circular urban area factor	- Developing adaptable buildings and public space is part of circularity - 3 rules for adaptable buildings: (1) Keep Layers of Brand separated (2) High floor height (3) Uniform column structure, space for compartmentalization - Aim is to be flexible with the measurements of the dwellings instead of having the capability to transform housing into offices
 Mobility and accessibility	**New factor** - Urban area is good accessible by multiple modalities: car, bicycle, pedestrian, public transport - Stimulates the local economy		

5.2.6. Lessons learned

First, despite all interviewees were asked the same questions about the same project, answers were different. The reason for this can be that no overall definition of circular urban area development is established in Lincolnpark. Despite, the project is called 'a circular urban area development' all stakeholders agreed on the fact that the aim of the development of Lincolnpark is to create a sustainable urban area in which the principles of circular economy are being applied. This suggests that besides circular principles, other not circular principles are used as well to develop this area. These, other principles can be mixed-up and used in the same context as the circular ones. This can also explain the differences in the answers of the interviewees.

In the next section the municipal policy, project ambitions and stakeholder opinions are compared and conclusions for Lincolnpark are summarized and explained.

Factor of circular urban area development

All interviewees divided the factor of circular urban area development between the building and use-cycle. With the building-cycle the design and realization phase of buildings and public space is meant. The use-cycle refers to the use-phase of the urban area when residents are producing waste and using resources such as energy and water. The found factors are also divided into these two cycles.

Building-cycle

Building material flow

- ✓ Municipal policy: keep resources as long as possible in the cycle without the creation of waste
- ✓ Ambitions project: Buildings & public space as resource depot, minimize environmental impact, use of healthy materials
- ✓ Stakeholders: 3 out 3 agreed being part of circularity

Re-using building materials and construction waste is definitely a factor of circular urban area development in which all physical urban area components can be re-used. In the policy and ambitions documents this is recognized and also all the 3 interviewees agreed upon this factor being part of circular urban area development. Circular building materials are selected in the realisation-phase (design phase) of the project and have a relation with the factor adaptive design principles.

Adaptive design principles

- ✕ Municipal policy: -
- ✓ Ambitions project: flexibility and adaptability in buildings and the public space, use of the public space in a multifunctional way
- ✓ Stakeholders: 2 out of 3 agreed being part of circularity

Using adaptive design principles is a factor of circular urban area development. Despite, adaptability is not included in the municipal policy, one of the themes of Lincolnpark is called 'flexibility and adaptability' and 2 out of 3 interviewees agreed on this factor. In this factor it is important to take the sharing layers of Brand (1994) into account so that buildings and public spaces can easily adapt to changings circumstances. In the design-phase of the building-cycle these adaptive design principles need to be implemented in the development process.

Use-cycle

Closed water-system (includes use-water and rainwater)

- ✓ Municipal policy: closed water system including surface, ground and wastewater
- ✓ Ambitions project: green-blue networks, climate proof, water storage, limited use of tap water
- ✓ Stakeholders: 2 out of 3 agreed on separating use and rainwater

In the municipal policy documents on circularity, water is mentioned as one of the four main focus points. In this document the municipality is aiming on creating a closed water system which includes and connects tapwater, rainwater and wastewater. 2 out of the 3 interviewees separated the use - and rain-water cycle. The use-water cycle was mentioned as a factor of circular urban area development, while rainwater belongs to the subject 'climate' and is not part of circularity. However, the reason for this can be that, right now, the law doesn't allow it to connect the use and rainwater to each other.

Use-water

- ✓ Municipal policy: closed water system including tap water and wastewater
- ✓ Ambitions project: limited use of tapwater, water storage
- ✓ Stakeholders: 3 out 3 agreed being part of circularity

Use-water can be seen as a factor of circular urban area development. Use-water refers to the tapwater what is used on a daily basis by the residents of Lincolnpark and the waste-water what is being produced by them. The use-water cycle needs to be designed in the design-phase of the project and is in working during the use-phase of the urban area. The factor use-water has a strong relation with the factor organic waste.

Re-using waste

- ✓ Municipal policy: reduction of waste stream, recover valuable components from waste streams
- ✓ Ambitions project: there is no residual waste
- ✓ Stakeholders: 3 out 3 agreed being part of circularity

In an optimal circular economy, there is no waste produced anymore. However, this can yet not be realised. Therefore, some waste streams can be re-used on the urban area scale: organic waste and biomass has the potential to be reused on this scale. Therefore, reusing organic waste and biomass can be seen as a factor of circular urban area development. Other waste streams are being re-used on other scales.

Stimulating the local economy

- ✓ Municipal policy: re-use objects within municipal boundaries, more recycled products
- ✕ Ambitions project: -
- ✓ Stakeholders: 3 out 3 agreed being part of circularity

According to one of the interviewees, stimulating the local economy is not included in the circular ambitions for Lincolnpark. Despite, this is not included the interviewee clarified that stimulating the local economy is definitely a factor of circular urban area development. The other two interviewees also agreed upon this. This factor is about, the repair and distribution of second-hand goods within the urban area and selling of local products. The circular economy is about high-quality reuse. Therefore, giving a product a second life is definitely circular.

Not clear if factor of circular urban area development

Green for biodiversity and ecological value

- ✓ Municipal policy: strengthen the biodiversity and the ecological value
- ✕ Ambitions project: strengthen biodiversity, green-blue networks, public space contributes to ecosystem services
- \- Stakeholders: 2 out of 3 (partly) agreed being part of circularity

It depends on the purpose of green if it can be a factor of circular urban area development. The interviewees didn't fully agree upon this. They definitely agreed on that green is important for the creation of a sustainable urban area, however this doesn't have to be circular. In the municipal sustainability program 'green' used as purpose for the strengthen of biodiversity and ecology value is part of the circular economy. Further, one of the interviewees said that green is part of circularity when green is seen as a resource. Another interviewee didn't agree on green for biodiversity being a factor of circular urban area development because biodiversity is a big overall theme which is a means to create a sustainable urban area. Therefore, it is doubtable if 'green' referred to as 'biodiversity' is a factor of circular urban area development.

Stimulating local employment

- ✕ Municipal policy: -
- ✕ Ambitions project: part of the theme social sustainability
- ✓ Stakeholders: 2 out of 3 agreed being part of circularity

One part of the local economy is about stimulating employment in the area. In the policy documents this factor is not mentioned and in the ambitions documents it is incorporated in social sustainability. However, 2 out of the 3 interviewees agreed that this factor belongs to circularity and is aprt of the

factor stimulating local economy. Therefore, it is doubtable if this factor must be incorporated in the local economy factor or divided under social sustainability.

Not a factor of circular urban area development

Rainwater

- ✓ Municipal policy: closed water system including ground and surface water
- ✕ Ambitions project: climate proof (heavy rainfall) part of sustainable urban area
- ✕ Stakeholders: 2 out of 3 agreed not being part of circularity

Despite the municipality included rainwater in their circular policy, 2 out of 3 stakeholders doesn't agree upon rainwater being a factor of circular urban area development. Rainwater management is part of the climate adaptability of the urban area which is one of the means of sustainable urban area development which is the main aim of the development of Lincolnpark.

Creating a community

- ✕ Municipal policy: -
- ✕ Ambitions project: social sustainability as own theme
- ✕ Stakeholders: 3 out of 3 agreed not being part of circularity

Creating a community in Lincolnpark is definitely important for the establishment of a safe and inclusive urban area. However, this factor is not part of circular urban area development but belongs to the overall theme of social sustainability which is one of the means for the creation of a sustainable urban area. In the municipal policy on circularity, community, is not mentioned. Further, all three interviewees agreed upon this factor not being part of a circular urban area development.

Green for climate adaptation and heat stress

- ✕ Municipal policy: -
- ✕ Ambitions project: climate proof, water storage in landscape
- ✕ Stakeholders: 3 out of 3 agreed not being part of circularity

According to the three interviewees, green used for the purpose of climate adaptation and biodiversity doesn't belong to the circular economy and therefore is not a factor of circular urban area development. Therefore, this factor is not included in the circular policy document. However, green used for climate adaptation is included in the sustainability program of Lincolnpark because is it an important factor for the development of a sustainable urban area.

Use-energy

- ✓ Municipal policy: energy supplying urban area
- ✕ Ambitions project: use of renewable energy
- ✕ Stakeholders: 2 out of 3 agreed not being part of circularity

Energy that is used on a daily basis by the residents of Lincolnpark is not seen as a factor of circular urban area development. According to 2 of the interviewees the factors energy belongs to the subject energy transition. This is important and indispensable for the development of a sustainable urban area; however, it is not seen as a factor of circular urban area development.

Mobility and accessibility

- ✕ Municipal policy: -

- ✕ Ambitions project: mobility and infrastructure as own theme
- ✕ Stakeholders: 2 out 3 didn't add this factor

Mobility & accessibility is added by one of the interviewees as being a factor of circular urban area development. This factor is about being good accessible for all forms of modality. In the circular policy document, no information is written on mobility and in the ambitions for Lincolnpark, mobility & infrastructure is used as one of the means to create a sustainable urban area. Therefore, this factor is not part of a circular urban area development.

Table 14: Conclusion 'factors' Lincolnpark

Factor of circular urban area development	Not clear	Not a factor of circular urban area development
Closed water system	Green: Biodiversity and ecological value	Rainwater: part of climate adaptation
Building material flow	Local economy: creating employment (part of circular economy or social sustainability)	Use-energy: part of energy transition
Re-using organic waste in use-cycle		Community: part of social sustainability
Stimulating local economy		Green: Climate adaptation, counteract heat stress, healthy environment
Adaptable building and functional flexible public spaces		Accessibility by multiple modalities

5.3. Case Study II: Beurskwartier, Utrecht

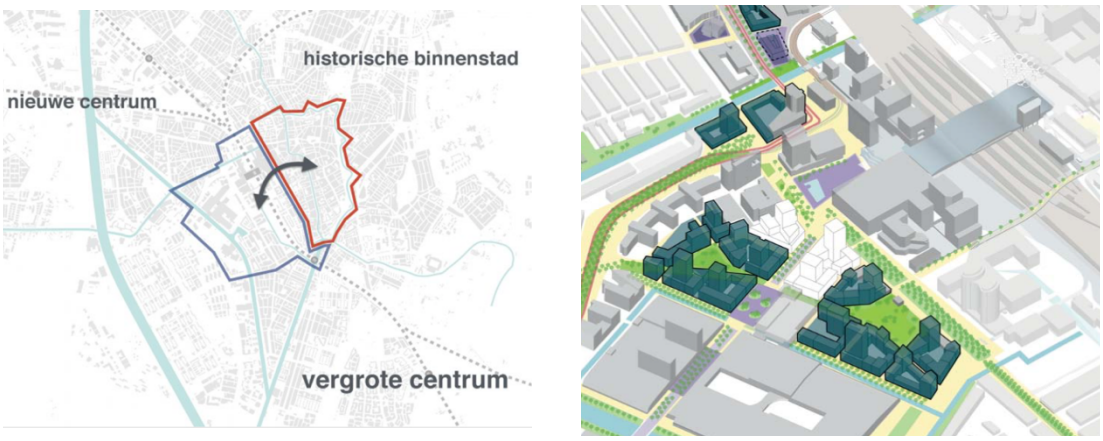


Fig. 25: Beurskwartier Utrecht (Gemeente Utrecht, 2017b).

The city of Utrecht is the 4th largest city of the Netherlands and is located in the Randstad area. Like the other G4 cities in the Netherlands Utrecht is growing due to urbanisation. In 2028 Utrecht will have 400.000 residents, which means an increase of 70.000 citizens (CU2030, n.d.). To facilitate all these people new neighbourhoods, have to build with affordable housing, sufficient facilities and workplaces. The area southwest of Utrecht central station, in between the Jaarbeurs and the Croeselaan is designated as a new inner-city district which will be densified in the upcoming years and function as a new centre of Utrecht. This inner-city urban area development is called 'Beurskwartier' and will become an example of a healthy and sustainable urban area (Gemeente Utrecht, 2017b). The area of Beurskwartier consist of 8 hectares and will be a dense area with an FSI (floor space index) of 4 with building heights of 12-25 meters and high rise of 45-70 meters. In this area around 3.000 new dwellings will be realised consisting of 200.000 m2 in total. Furthermore, 50.000m2 of workplaces will be realised and another 15.000m2 can be both: living or working. Because this area will attract many new people another 10.000m2 of facilities will be added to the plan and two public parks (Gemeente Utrecht, 2017a). For the development of Beurskwartier six focus points are established: (1) mixed and inclusive, (2) compact and vibrant, (3) network structure, (4) green and heathy, (5) smart mobility and (6) sustainable urban area.
One of their ambitions is to realise a sustainable future proof neighbourhood where energy and resources are used efficiently and are generated in a sustainable way. Furthermore, they want to establish a high degree of mental ownership among the residents so that they feel more connected and responsible for their neighbourhood (Gemeente Utrecht, 2017b).

5.3.1. Planning

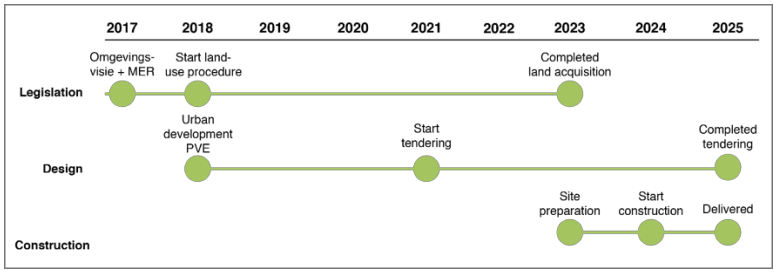


Fig. 26: Planning Beurskwartier (Own ill.)

The Beurskwartier area is at the moment a working area with industrial buildings and many parking places. In 2017 the municipality already collaborated with other parties to start the redevelopment process of this area. Several workshops with different stakeholders have taken place and in

December 2017 the “Omgevingsvisie Beurskwartier Lombokplein naar een groter centrum” was delivered. Many subjects such as mobility, placemaking and the circular economy were researched in living labs and are included in the vision. Despite this vision, the municipality of Utrecht will only acquire the land in 2023. The design process of the area has started in 2018 with composing the programme of requirements for the urban design. When these requirements are established the tender procedures can start. The municipality has the aim to divide the area in different building blocks and in different phases. When the municipality has acquired all the land the construction phase can start. They have planned to finish the whole Beurskwartier in 2025 (Gemeente Utrecht, 2017b).

5.3.2. Stakeholders

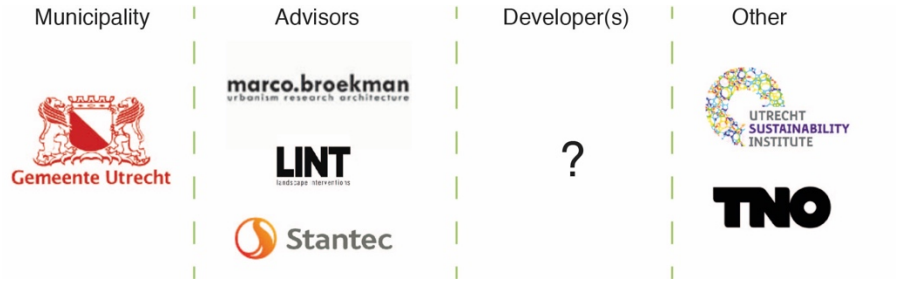


Fig. 27: Stakeholders Beurskwartier (Own ill).

5.3.3. Municipal policy on circularity

In 2015, 193 world leaders agreed to 17 goals for a better world by 2030. Utrecht as ‘Global Goals City’ has the responsibility to contribute to these goals. Therefore, the city of Utrecht focusses on Global Goal 11: Sustainable Cities and Communities, which means that cities and communities need to be inclusive, safe, resilient and sustainable (Gemeente Utrecht, 2017b). One of the focus points is the circular economy:

> *“In the circular economy, we see residual materials as an important resource, rather than as waste. Many discarded items can easily be re-used. Products must then be designed and made in such a way that they can easily be re-used. It is also important that they are made from non-toxic, renewable raw materials and that they are produced with respect for people and the environment. This requires companies to co-operate more closely with each other to be able to retain and share the raw materials in the chain” (Gemeente Utrecht, 2017b).*

In 2017 the municipality of Utrecht signed the “Grondstoffenakkoord” and is attached to the ambition of being 100% circular in 2050. In the “Raadsbrief circulaire economie van 15 december 2017” is written down how these ambition towards this circular transition will be achieved. In this, the municipality of Utrecht has set 3 priorities:

1. Circular purchasing:
    a. From sustainable to circular and socially responsible purchasing
    b. Experimenting: several tenders were circular
    c. Action plan MVI (maatschappelijk verantwoord inkopen)
    d. Learning together: sharing knowledge and experiences on regional and national level.
2. Collection: from waste to resource. In 2020, 50% of our resources such as plastic, glass and textile are collected separately from residual waste.
    a. Use of secondary raw materials in new products.
    b. Minimize the residual waste of companies and offices.
3. Built and disassemble circular (demolish circular): The “Motie Circulair Bouwen” has established that building circular has to be the standard in every building project.

a. Circularity will be a prominent subject in every urban area development and in every building project.
b. Gaining experience with circular building projects via experiments and collaboration.
c. Further development of the “Utrecht Circular” approach.

5.3.4. Circular ambitions Beurskwartier

As part of the “omgevingsvisie”, the opportunities of the circular economy are researched and published in the report “Circulair Beurskwartier” by Marco Broekman and LINT (now called FLUX). In the whole Cirkelregion Utrecht there are 10 important material flows. In Beurskwartier, 3 of them get special attention: These 3 flows are:

1. Building and demolishing waste needs to be circular
2. Making specific residual flows productive such as GFT waste (organic waste).
3. Offer small-scale space to high-quality collection and repair of electrical and electronic waste.

In this vision the prosumer (everyone who produces and consumes at the same time) has a big influence on the creation of waste. One of the goals of Circulair Beurskwartier is to make the prosumer aware of their influence on the generation of waste and material flows.

For the Beurskwartier area four strategies are established. The main goal of these strategies is to make the circular economy more visible in the daily life of the residents, employees and visitors to stimulate healthy and sustainable behavior in the Beurskwartier area.

1. Test Site Beurskwartier:
   The Beurskwartier area functions as a “learning city” where circular knowledge and data is collected and shared. Chosen locations in the city will be designed out of circular flows such as re-used building materials. On these locations several new technologies can be implemented, events can be organized, and waste separation can be encouraged. Furthermore, the Jaarbeurs building will function as resource “mine”, where building materials can be re-used in the test sites.

2. Landscape as a machine:
   Because of the FSI of 4 in the Beurskwartier greenery and nature has to be used in a smart way. Therefore, Beurskwartier will be designed out of intensive, vertical and hybrid shapes where buildings function as machines where flows can be collected, re-used and exchanged. These flows consist of: organic waste, coffee grits, water and clean air. To make these processes efficient a network of public spaces and greenhouses is designed:
   a. Restaurant greenhouse where organic waste can be reused, vegetables are cultivated, and rainwater reused.
   b. Water greenhouse where water from the Merwedekanaal is purified and where fish is farmed.
   c. Brewery greenhouse where hops grow on the facades and the roof is used as public space.
   d. Botanical greenhouse will be in the middle of one of the parks and will be where people meet and experiment.
   e. Green facades and roofs can collect rainwater, improve the air quality and seeds can grow on it. Furthermore, roofs can be designed as public space.
   f. Pocketparks are small oases full of shadow which contributes to cooling of the area.

3. The Hybrid Building Block:
   The plinth of the building blocks of the Beurskwartier can function as showroom for the circular economy where flows of the area are productive and visible. Examples of such places can be repair stores, sharing-economy stores and food production stores that can be used by the community. To achieve this goal, it is of importance to design the building blocks with enough space for flexible use and different program types. Ca 82 x 100m will be a sufficient measure.

4. High streets Utrecht:
   It is of importance to connect the Beurskwartier in a sufficient way to the high streets of Utrecht. By

doing so an urban network will be created where the circular economy and local employment will be stimulated. In these high streets circular stores can get a place. Seen from a larger scale, three types of circular working environments will originate:

a. Beurskwartier as Circular Business District where services, small test-sites, educational purposes and start-ups can be integrated.
b. Werkspoorkwartier as Circular Innovation district where larger-scale testing, recycling and higher environmental category functions are implemented.
c. High Streets as local working environments that have a community function and small-scale waste collection.

5.3.5. In-case analysis Beurskwartier

The interviewees of the Beurskwartier existed of someone of the municipality, the architect who worked on the report “circular Beurskwartier” and a waste expert who researched and elaborated on the possibilities of the (almost) zero waste ambition of the Beurskwartier area.

5.3.5.1. Circular potentials Beurskwartier

The Beurskwartier redevelopment area is located next to Utrecht central station. The area will be a high-dense urban area with a very low parking norm of 0.3. in 2017 the municipality of Utrecht started several ‘living lab’ studies to research the possibilities of the implementation of sustainability themes in the high-dense Beurskwartier area.

> *During the ‘living-labs’ many sustainability themes are being studied. The circular economy is one of these themes, however it is not the main aim of the development. The goal of the redevelopment of the Beurskwartier is to create “Healthy Urban Living” for all residents and employees (Personal communication, J. Hekhuis, 30 April 2019).*

In the municipality of Utrecht, they consider the definition of circular economy as being small. It is a part of sustainability, just as energy or climate adaptation is. The themes of waste and building materials are subjects that belong to the circular economy.

> *In the Beurskwartier, the circular economy is defined by the ambition of creating an (almost) zero waste neighborhood. This definition it is about closing the cycles of household and industrial waste with the focus on refuse, reduce and recycle in which four greenhouses are being designed to process waste into new products. In this, the circular economy is not the main aim. The circular economy is used as a tool to organize society in such a way that it is sustainable, future-proof and livable (Personal communication, G. de Zoeten, 9 April 2019; Personal communication, R. Kapel, 10 April 2019).*

Utrecht as one of the G4 cities has the task to build many new dwellings to reduce the housing shortage in the city. Beurskwartier is allocated as a place where 3.000 new dwellings will be built. This area, with such a high density, has to be developed in a sustainable way. Using the principles of the circular economy can have opportunities to reach this goal.

Table 15: SWOT Analysis Beurskwartier

Strenghts	Weaknesses
- Walking distance from Utrecht central station - Living labs to research the opportunities of sustainability themes, such as the circular economy	- Re-using waste flows into new products not adjusted to the users - Almost zero waste, because completely zero waste is not possible
Opportunities	**Treats**

- Circularity researched in early stage – municipality can steer, manage and set boundaries - Visibility and awareness: social component strongly integrated in design - Parking norm of 0.3: offers space for new initiatives regarding logistics and circularity	- Tendering per building block – multiple parties make implementing some circulars difficult - High density – achieving all ambitions is difficult - Who is paying for the BVO of the greenhouses? - Focused on the behavior of people: no waste separation = no circularity - Focus on waste, how many waste do we still have in 20/30 years in a circular economy?

5.3.5.2. Factors of circular urban area development in Beurskwartier

Below, the circular urban area development factors, according to the three interviewees, are explained for Beurskwartier.

Integral water & energy system

The integrated water & energy system is separated into two different factors by all interviewees.

Energy

The factor energy can be generated in different ways. It can be generated out of renewable resources such as solar or wind energy, or it can originate out of residual heat. Energy cycles can possibly be closed on higher levels than the urban area scale. Nevertheless, energy is by all the interviewees not seen as a factor of circular urban area development. According to them the factors belongs to energy transition and climate department.

Water

The factor water can be divided into different water cycles. One of these cycles is the use-water cycle which circulates on a daily basis through houses and building blocks. This watercycle needs to provide homes with clean drinking water. According to all interviewees the circulation of use-water is a factor of circular urban area development. The other water cycle is rainwater, which in the Beurskwartier, can be collected by vertical gardens and re-used in the restaurant greenhouse. In Beurskwartier they researched the possibilities of ‘new sanitation’. In this system there are three different water cycles that can be re-used. Black water, waste water of the toilets, can be re-used together with organic waste. Grey water, which is the remaining waste water, can re-used for heating, and blue water, which is rainwater, can be re-used for drinking water. However, the law needs to be changed to make this possible.

Circular building material cycle

In the ‘living-lab’ study about circular economy one of the flows with special attention in the Beurskwartier area was the flow of building materials and construction waste, that needs to be circular. All three interviewees agreed upon this being an important factor of circular urban area development. First, building materials out of existing buildings and public spaces can be re-used in the new development. After, there need to be steered on new built buildings that are developed with circular building principles. These circular building principles take the lifecycles of buildings components into account. One interviewee also suggested to make more use of bio-based buildings materials. Furthermore, material passport for buildings need to be required and even urban area passports can be considered to document all present materials in the urban area. Initiatives for materials hubs around Utrecht, are being supported by the municipality to make storage of building materials easier. An online platform that manages all these buildings materials would be a good addition.

Re-using waste in use-phase

Many researches is done into the possibilities of realizing an (almost) zero waste Beurskwartier. Waste is produced in the use-phase of the urban area by the many households and small companies that are located in the plinth of the building blocks. In the ambitions of (almost) zero waste Beurskwartier three focus points are established:

(1) Prevention of waste
(2) Closing waste chains
(3) Logistics are clean, quiet and safe solutions for the collection of waste.

Preventing waste is seen as the most circular. However, no waste is yet not realistic. Therefore, several waste flows will be separately collected which is, in this phase, seen as circular. Most flows will only be separately collected in the area and recycled outside the area. The only flow that has the potential to be re-used in the area itself is organic waste. This organic waste can for example be re-used in the restaurant and brewery greenhouse to grow mushrooms on.

Creating a community

In the development of a sustainable and lively urban area, the social aspect cannot be forgot. The behavior of people will have a strong influence on the success of waste separation. To encourage this circular behavior, people need to see what happens with their waste after usage. In Beurskwartier this is done by creating greenhouses were waste is being re-used. Creating a community feeling can possibly contribute in this behavior, however it is more a means to encourage such behavior instead of a factor of circular urban area development. According to all interviewees creating a community is a factor used to create a 'social sustainable' area and not part of the circular economy. One interviewee mentioned that the 'share-economy' can be a part of a circular urban area. Some products and tools can for example be shared among the residents of a building block (part of local economy). Be aware that too much sharing, such as living facilities, doesn't contribute to the livability of the area.

CO2 balance by creating green

Because of the planned high density of the Beurskwartier, creating pocket parks, vertical gardens and roof terraces is of importance to stimulate the livability of the area. The main reasons of adding green is not the collection of CO2 emissions, however green can be added for many other reasons:

(1) Climate adaptation
(2) Biodiversity and ecology
(3) Healthy urban living

All these purposes are of importance for the development of the Beurskwartier, however in this, the factor green is not seen as a factor of circular urban area development. Green serves other theme's and is a means to create a sustainable urban area.

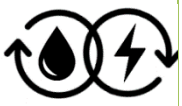
Stimulating the local economy

This factor, stimulating the local economy in the use-cycle, is the essence of what we want to achieve in the Beurskwartier area. To achieve this ambition space is reserved for repair cafes, second-hand shops and sharing-economy stores where high-quality collection and repair of electrical devices and other products can be realized. In the circular economy 'living-lab', these spaces are designed as part of the hybrid building block. Furthermore, the Beurskwartier area is designed as a mixed-use urban area where living, working and commercial facilities are within walking distance of each other and Utrecht central station, which reduces commuting. According to the interviewees this definitely stimulates the local economy. Growing local products in the public space or on roofs will not be possible due to the high-density, however the greenhouses can provide these services and are therefore also part of the local economy. All interviewees agreed upon this factor being part of a circular urban area development..

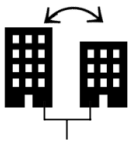
Urban area as an adaptive system

Make use of flexible dimensions in buildings and public space is a factor of circular urban area development, agreed upon by all interviewees. In the design of the buildings and the public space it is important to reserve space for flexibly use. This space can be used for multiple purposes and is referred to as 'shared space' by one interviewee. This shared space in the public space can be used by pedestrians, cyclists, emergency services and accidentally by car. When designing circular buildings, the different lifecycles of the building components need to be considered. The components with short lifecycles, under 50 years, can be removable, while components greater than 50 years need to be of such a quality that they remain for 50 years or more, such as the façade and the structure, don't necessarily have to be removable.

Table 16: Findings interviewees in-case analysis Case II: Beurskwartier

Factor	Municipality	Consultant	Architect
 Integral water & energy system	- Water and energy are 2 separate factors - Use-water is a factor of circularity: circulation of use-water (try to remove phosphate from the water) - Rainwater (mm/hour) is part of the theme Climate adaptation - Energy is part of the theme Energy transition	- Energy is part of the subject Climate - Several purposes for water: (1) Clean drinking water = waterquality (2) Economical use of drinking water = re-use water (3) Climate adaptive use of rainwater - New sanitation: blue, grey and black watercycles all separated (law change needed), has connection with waste	- Water and energy are 2 separate factors - Closing the water cycle has a chance on urban area scale - Rainwater re-used in Restaurant greenhouse - Water Merwede re-used in Watergreenhouse - Rainwater will be collected in vertical gardens - Closing the energy cycle on higher scale - Energy can have orginates from: (1) Solar -and windenergy: generating clean energy (2) Residual heat (connected with waste)
 Materialflow between buildings and public space	- Building material flow is part of circularity - About re-using building and construction waste - Building material passport need to be required for every (new) building - Urban area material passport is more difficult, but important! - Building material hub, serves larger area than only Beurskwartier (10km) - Online platform for re-using of building materials - Use of bio-based materials	- Call it: Circular building cycle - Part of circularity - During design and building phase steer and manage on using circular building principles, after building materials are stored for 25 years in buildings (during use-phase) - Material passports and material hubs are important	- Part of circularity - Important to think in scales: which scale is most suitable for re-using the building material? - Call this: building materials - About the lifecycles of building materials

 Reusing waste in use-phase	- (Almost) zero waste Beurskwartier - Separating waste & preventing it = circular - Organic waste can be re-used in the area - Other waste flows are not processed or recycled in the area, only separately collected - Space for greenhouses where waste can be collected - Make agreements with package suppliers that they ban cardboard or take it back	- Call it: Circular use-phase - (Almost) zero waste focusses on: (1) Prevention of waste (primary) (2) Closing chains (primary) (3) Logistically clean, quiet and safe solutions (secondary) - Designed through different scales: home, building, building block, hub, urban area - Organic waste re-used in building block - Recycling street (repair cafes) on urban area (part of local economy) - Separation for re-use: optimization at the level that yields the best returns - Return logistics!	- Produced in use-phase of the urban area - Produced by households and companies - Try to combine waste with other resource cycles to make new products: restaurant -and brewery-greenhouse - About closing cycles on small scales - Loss of value of daily use waste is faster than loss of value of building materials
 Creating a community	- Creating communities is not part of the circular economy - The sharing-economy can be part of circularity - Focus on car-sharing, however more part of theme mobility - Sharing is not always good, people still need privacy!	- The behavior of people is important for the success of waste separation - Always people who not participate, make is easy for them as well - Community can be a means to encourage circular behavior	- People need to see what happens with their waste to make them aware: mental condition - Do not force people to be part of a community - Creating communities is more part of social sustainability
 CO2 balance by creating green	- Green has multiple purposes, in Beurskwartier: (1) Climate adaptation (2) Biodiversity and ecology (3) Healthy urban living - Main purpose is healthy urban living - Not part of circularity	- CO2 collection by green is not main purpose of green - Green to stimulate the livability of the area = call this 'livability' - Green is a means to create a sustainable urban area - Green has multiple purposes: (1) Climate adaptation (2) Recreation	- Green is about the plants and animals, call this factor: Biodiversity - Climate adaptation is also a purpose of green: vertical gardens - Counteract heat stress by pocketparks
 Stimulating the local economy	- Repair cafes, 2nd hand shops, sharing-economy shops are part of circularity - Living, working and facilities within walking distance = circular - The greenhouses are part of the local economy = circular - Growing local products (probably) not possible because of the density	- Part of circularity - Recycling street with repair cafes, 2nd hand shops - Stimulate local initiatives because: (1) Community involvement (part of social sustainability) (2) Reduce commuting because of mixed-use area	- Stimulating the local economy by creating the 4 greenhouses and vertical gardens (landscape as a machine) - Essence of what we do in Beurskwartier

	- Creating more employment is an end in itself - Space for non-polluting and innovative companies		
 Urban area as an adaptive system	- Use of flexible dimensions is part of circularity - Spaces in buildings and the public space are multi-purpose = shared spaces - Shared spaces in public space can be used by: pedestrians, cyclist, emergency services, incidentally a car - Creating adaptable buildings and public spaces is part of circularity - Removable buildings components: Component with longer lifecycle than 50 years (Brand, 1994) not removable: facades, structure	- Part of circularity - Use flexible dimensions in buildings and the public space - Reserve space that you can use flexibly	- During design phase think in scenarios of what to do with the materials after their first life cycle - Part of circularity

5.3.6. Lessons learned

In 2017 the municipality of Utrecht started exploring several sustainability theme's, organized in living-labs, in relation to the development of the Beurskwartier area. The reason why the Beurskwartier is developed is to add 3.000 new dwellings to the city. Furthermore, the goal is set to develop a sustainable urban area with 'Healthy Urban Living' as main theme. In their sustainability program they have made a clear division between sustainability themes and factors that belong to each theme. In this, circularity is one of the means to develop a sustainable urban area. Therefore, clear direction is given about the factors that belong to the circularity subject, which is reflected in the answers of the interviewees. The used definition for circularity is small and refers to building materials and waste, however, this definition is still in evaluating because of the newness of this subject.

In the next section the municipal policy, project ambitions and stakeholder opinions are compared and conclusions for Beurskwartier are summarized and explained.

Factor of circular urban area development

Circular building material cycle

- ✓ Municipal policy: demolish circular 'motie circulair bouwen'
- ✓ Ambitions project: building and demolishing waste needs to be circular, re-using building materials
- ✓ Stakeholders: 3 out 3 agreed being part of circularity

The circular building material cycle is about the circular flow of building materials and construction waste. The development of Beurskwartier has two phases. Phase 1 is about re-using existing building materials. Phase 2 is about developing new buildings by using circular building principles

taken the lifecycles of building components into account. In this phase, building materials are being released from buildings, stored in hubs and re-used again. The municipal policy, the ambitions for this project and 3 out of 3 interviewees agreed upon this factor being part of a circular urban area development.

Adaptable buildings and shared public space

- ✓ Municipal policy: in every building project and urban area development circular building principles need to be used
- ✓ Ambitions project: Circular building principles, flexible building blocks
- ✓ Stakeholders: 3 out of 3 agreed being part of circularity

In the design-phase of the Beurskwartier buildings and public spaces need to be designed flexibly. For the design of adaptable buildings, the layers of Brand (1994) can be used. Components with a lifecycle under 50 years are removable. Public space can be designed for multiple purposes referred to as ‘shared space’. All interviewees agreed upon, using flexible design principles to create adaptable buildings and shared public spaces, is definitely a factor of circular urban area development.

Re-using organic waste and separate collection

- ✓ Municipal policy: collection from waste to resource, minimize waste of companies and offices
- ✓ Ambitions project: making specific residual flows productive, high streets: small-scale collection
- ✓ Stakeholders: 3 out 3 agreed being part of circularity

During the use-phase of the Beurskwartier waste is produced by households and companies. There is stated in the policy documents that minimizing the waste of companies and offices is part of circularity. Further, the aim for Beurskwartier is to create an (almost) zero waste urban area where waste is prevented, separately collected and the logistics are smartly arranged. The residual flow of organic waste can be made productive by re-using it in area itself, for example in the therefor designed greenhouses. 3 out of 3 interviewees agreed that re-using and separately collect waste is a factor of circular urban area development.

Stimulating the local economy

- ✕ Municipal policy: -
- ✓ Ambitions project: Offer space to high-quality collection and repair of products, growing own products and food production stores, hybrid building blocks, sharing-economy,
- ✓ Stakeholders: 3 out 3 agreed being part of circularity

In Beurskwartier the local economy is stimulated by creating a mixed-use vibrant area where products of residents and companies can get a second life by bringing them to repair cafes or second-hand shops. Also, the sharing-economy, in which people can share tools, can be part of the local economy. Creating space for these shops is realized in the design of the ‘hybrid building block’ and ‘high-streets’ where local employment is stimulated. Furthermore, the greenhouses are places were local products can grow, consumed and re-used. Despite, stimulating the local economy is not included in the policy document, it is a large subject in the ambition document and all interviewees agreed that this is definitely a factor of circular urban area development. Even one interviewee stated that this factor is the ‘essence’ of Beurskwartier.

Not clear if factor of circular urban area development

Closed water-system (includes use-water and rainwater)

- ✕ Municipal policy: -
- ✕ Ambitions project: -
- ✓ Stakeholders: 2 out of 3 agreed being part of circularity

In a closed water-system, rainwater and the water that is used by residents and companies, is connected to one water system that has the potential to be closed on the scale of an urban area. In the municipal policy documents about circularity this closed water-system is not mentioned and also in the ambitions document this factor is missing. However, 2 out of the 3 interviewees agreed that a closed water-system is part of a circular urban area development. However, at the moment the law does not allow it to connect use-water and rainwater into one system. One interviewee referred to new sanitation as a model to create a closed water-system.

Re-using rainwater

- ✕ Municipal policy: -
- ✓ Ambitions project: landscape as a machine: greenhouses, green roofs and facades to collect rainwater
- ✓ Stakeholders: 2 out of 3 agreed not being part of circularity

Rainwater needs to be collected in an efficient way in the Beurskwartier area. In the ambition document, rainwater is collected in the greenhouses and green facades and on the green roofs. Further, 1 of the interviewees said that rainwater is part of the bigger climate adaptation theme, which is a means for sustainable development. However, the other 2 interviewees divided rainwater under circular urban area development when rainwater can form a closed system with the other waterflows in the area.

Circulation of use-water

- ✕ Municipal policy: -
- ✕ Ambitions project: -
- ✓ Stakeholders: 3 out 3 agreed being part of circularity

3 out of 3 interviewees agreed that use-water, which is used in-house on a daily basis by residents and companies, is a factor of circular urban area development. According to them the aim, from a circular perspective, is to re-use this water in an economical way. However, in the policy and ambitions documents nothing is written about the circulation of use-water.

Concluded out of the analysis of the factor closed water-system, re-using rainwater and circulation of use-water, can be stated that creating a closed-water system which included rain -and use-water can be a factor of circular urban area development. However, at the moment the law is not allowing this closed-system due to the regulations regarding hygiene. This can explain why policy and ambitions documents are not including a closed water-system in their circularity program while, according to the interviewees, it is a factor of circular urban area development. Therefore, the water factors are all divided in the ‘doubtable’ box.

Not a factor of circular urban area development

Energy

- ✕ Municipal policy: -
- ✕ Ambitions project: -
- ✕ Stakeholders: 3 out of 3 agreed not being part of circularity

In the municipality of Utrecht, a whole team is working on the subject 'energy'. In this vision, energy is part of the subject energy transition. Therefore, energy is not included in the policy documents on circularity. Furthermore, nothing has been said about energy in the ambition documents and als all three interviewees agreed upon energy is not a factor of circular urban area development.

Creating a community

- ✕ Municipal policy: -
- ✕ Ambitions project: -
- ✕ Stakeholders: 3 out of 3 agreed not being part of circularity

Creating a community is part of social sustainability. It can contribute to the circular behavior of the people in the area, however it is more seen as a mean to encourage circular behavior by people instead being a factor of circular urban area development. The social part is not included in the policy and ambitions documents and also all three interviewees agreed that creating a community is part of the subject of social sustainability.

Green

- ✕ Municipal policy: -
- – Ambitions project: Pocket parks
- ✕ Stakeholders: 3 out of 3 agreed not being part of circularity

According to all interviewees adding green to the Beurskwartier is very important to create "Healthy urban living". Green can be used for many purposes such as for climate adaptation, counteracts heat stress or strengthen the biodiversity. However, none of these purposes is serving the circular economy according to all three stakeholders. Green in the form of 'pocket-parks' is realied in the Buerskwartier, because adding enough green is important for the development of a sustainable urban area. However, this is not a factor of circular urban area development.

Table 17: Conclusion 'factors' Beurskwartier

Factor of circular urban area development	Not clear	Not a factor of circular urban area development
Circular building material cycle	Closed water-system: incl. rain -and use-water	Energy: part of energy transition
Adaptable buildings and shared public space		Creating a community: part of social sustainability
Re-using organic waste and separate collection		Green: Climate adaptation, biodiversity and ecology, healthy urban living
Stimulating the local economy		

5.4. Case Study III: Kabeldistrict, Delft

Fig. 28: Location and impression of Kabeldistrict

The city of Delft is located in between the cities of Rotterdam and The Hague. As part of the Randstad area, Delft also has to contribute to the problem of housing shortage. Therefore, the municipality of Delft has stated that till 2030, 15.000 new dwellings have to be built. In Schieoevers Noord, one of the larger urban redevelopment locations in Delft, 10.000 of these dwellings are planned. At the moment this area is an industrial area where companies with high environmental categories are located. The whole redevelopment of the Schieoevers Noord is a process that will take 10-30 years (Gemeente Delft, 2017a). Despite this long-term perspective, the first plot of Schieoevers Noord is already in development. This first plot is the old Dutch cable factory, located in between the river the Schie, station Delft South (future Delft Campus) and the train track from Rotterdam to The Hague. This 12-hectare area, called Kabeldistrict, will be redeveloped in the upcoming years. In total 3.000. – 4.000 new dwellings will be built consisting of around 300.000m2. Furthermore, 60.000m2 of facilities will be added of whom a large part will be assigned to the high-tech manufacturing industry. Start-ups and scale-ups founded by students from the TU Delft get a change to grow in the Kabeldistrict. For the development of Kabeldistrict six focus points are established: (1) Mixed-use urban area for living and working, (2) high-dense urban area with internal cohesion, (3) connected and highly accessible with all modes of transport, (4) layered by remaining the old factory, (5) attention for the human dimension and (6) smart tech.

The whole Schieoevers Noord area needs to be a future proof and sustainable urban area. Therefore, the municipality of Delft wants to focus on the subjects: energy transition, climate adaptation, green environment, sustainable mobility and there are opportunities for the implementation of the circular economy (Blok, Streefland & Halsma, 2018). The Kabeldistrict area will start with these transitions by creating a car-free area where space is giving back to the pedestrians and cyclist. Furthermore, many materials stored in the old cable factory can be re-used in the new development (Personal communication J. Versluijs 15 March 2019).

5.4.1. Planning

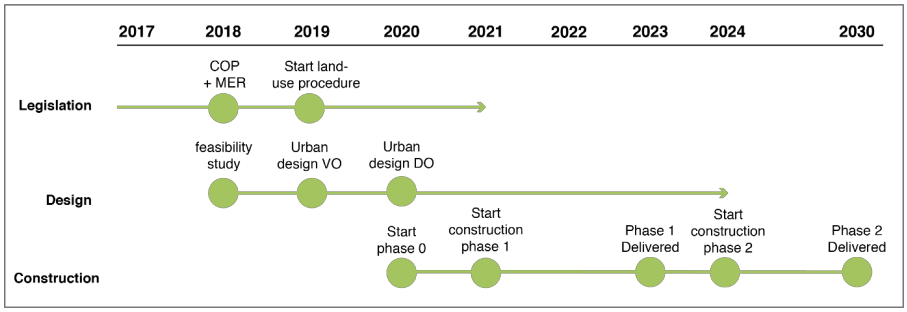


Fig. 29: Planning Kabeldistrict (Own ill).

The whole Schieoevers Noord area is in transition and the plot of the Kabeldistrict is the first to be developed. The land-use of the Schieovers is industrial which means that a land-use plan procedure to change the land-use is needed. To do so, the municipality has established an environmental impact assessment and the concept development plan is made to set the boundaries for the new development. At the same time the planteam consisting of the developers and architects is drawing feasibility studies and the urban design. According to the planning, the land-use plan needs to be changed by 2021 which means the construction works of the first phase of the development can start in that year. Because the area consists of 12 hectares the development is phased. The whole development of the Kabeldistrict needs to be finished in 2030 (Personal communication, J. Versluijs, 15 March 2019).

5.4.2. Stakeholders

Fig. 30: Stakeholders Kabeldistrict (Own ill).

5.4.3. Municipal policy on circularity

The municipality of Delft has the task to realize 15.000 new dwellings and corresponding workplaces and facilities. It is of importance to steer on sustainable neighborhoods that are prepared for the future and meet the current and future demand of its residents. To create a sustainable city, the municipality focusses on four sustainability subjects:

1. Green, blue & healthy: a pleasant living environment
2. Circular economy: cycle of resources
3. Climate adaptation: prepared for climate change
4. Energy neutral: renewable heat
   (Gemeente Delft, 2017b; Blok,Streefland & Halsma, 2018).

For every subject the municipality of Delft has described their ambition for 2040. They use the next definition for circular economy:

The circular economy is an economic system that maximizes the reusability of products and raw materials and minimizes value destruction. This is different from the (current) linear system, in which raw materials are seen as waste. The circular system has two cycles of materials: a biological cycle, in which residual materials safely flow back into nature after use, and a technical cycle, for which product (parts) or raw materials are designed and used in such a way that they can be re-used at a high-quality level (Gemeente Delft, 2017b, p.10).

Because of the complexity of the implantation of the circular economy, no policy documents on this subject are written yet. At the moment, one policy officer is working on the "Delft Vision and Implementation Agenda Circular" document of the municipality of Delft that needs to be finished by this year (Personal communication, M. van den Berg, 14 February 2019). Till this document is finished the goals of the government "Nederland circular 2050" are used which lead to the next objectives and measures:

Table 18: Objectives on circular eonomy by the municipality of Delft (Gemeente Delft, 2017b).

The term 'waste' no longer exists. Delft functions as a closed system for raw materials		
	Objective(s)	**Measure(s)**
2018		- Soil management established (soil flows based on the circular economy) - Delft Vision and Implementation Agenda circular
2020	- 75% of waste collected separately - 100 kg residual waste per resident	- Entrepreneurs in the city center dispose of their (joint) waste in a sustainable way - Waste in the public space is collected separately
2025	- 100% purchase of circular goods and services - The amount of residual waste per inhabitant (kg) is halved compared to 2017	
2030	- 50% less usage of raw materials (mineral, fossil and metals) - Delft is litter-free	
2040	- 100% re-use of waste - All entrepreneurs have a sustainable waste collection (zero waste) - Released streams in building processes can be re-used as resource on-site	
2050	- 100% circular	

5.4.4. Circular ambitions Kabeldistrict

In 2018 Metabolic researched the opportunities for the circular economy on the Schieoevers Noord. This area can be divided into three areas: Station Delft Zuid, the Kabeldistrict and the Eastside of the Schie. All the four sustainable subjects established by the municipality need to be considered for the development of a sustainable urban area on the Schieoevers. For the Kabeldistrict area these subjects are translated into the next objectives:

1. Green, blue & healthy: a high-quality living environment

   The Kabeldistrict area is almost completely paved without quality greenery. To create a healthy living environment for people and animals, it is of importance to introduce many new green structures. These green structures can be created on the ground floor as well on roofs and facades of buildings.

2. Circular economy: cycle of resources

There are several opportunities for the implementation of circular principles:

a. Urban mine: The materials stored in the existing industrial buildings can provide over 27% of the material demand for the new developments by preserving existing structures and reusing materials and components. Only when preserving or re-using is not possible, disassembly is possible.
b. State-of-the-art: in the new planned buildings new innovative circular building principles can be used. The design can be removable with flexible connections and reusable components. Furthermore, all buildings need to have a material passport where all used materials are documented.
c. Raw material hub: to match the supply and demand of 2nd hand building materials there needs to be a local storage for raw materials. By locating this storage on Schieoevers many CO2 emissions by transport movements can be prevented.
d. Circular manufacturing industry: residual waste such as plastic, textile and organic waste can be exchanged efficiently between this industry.

3. Climate adaptation: prepared for climate change

By 2050, Delft strives to overcome 99,5% of all-weather conditions without problems. This can be achieved by implementing climate adaptive measures in the design of the public space. This design takes blue (water) and green structures into account. Furthermore, paved surfaces must be prevented to reduce the flood sensitivity of the area.

4. Energy neutral: renewable heat.

The TU Delft campus is investigating the opportunities of geothermal heating. For the Kabeldistrict they are possibilities to connect to this same system. However, when this is not possible it is better to focus on WKO installations and strong isolation to reduce the heat demand. An independent energy advisor is now investigating the possibilities for the Kabeldistrict (Personal communication, J. Versluijs, 15 March 2019).

5. Sustainable mobility

Sustainable mobility is not seen as a main subject of the sustainability ambitions of the municipality of Delft. However, this subject has a strong influence on the livability of the area and it therefore mentioned**.** According to Daniel (as cited in Blok,Streefland & Halsma, 2018) pedestrians are able to walk around 400 meters to the public transport. The Kabeldistrict is located within this proximity. Therefore, the area can be car-free with a focus on the public transport, cyclist and pedestrians. Because, the area is well accessible there are opportunities for commercial facilities. **(**Blok,Streefland & Halsma, 2018).

5.4.5. In-case analysis Kabeldistrict

The development of the Kabeldistrict is in a further stage than the other two. Here, market parties are already involved in the planning and collaborate together with the municipality. The involved stakeholders that have been interviewed were the municipality, one of the developers and the involved architect.

5.4.5.1. Circular potentials Kabeldistrict

Het Kabeldistrict is part of the larger urban area development of the Schieoevers Noord. This old industrial area is designated as an urban area with the potential to apply circular building principles on a larger scale. At the moment of writing, no policy documents on circularity were written, however, research into the possibilities of applying circular principles is done.

Schieoevers Noord is designated as location where the principles of the circular economy can be applied on a large scale. The whole Schieoevers Noord is a large industrial area where, during redevelopment, many materials are released from existing structures that can be reused

in the new built buildings and public spaces. Furthermore, Schieoevers Noord needs to become a vibrant area where living and the manufacturing industry are mixed. This creates opportunities for the circular economy (M. van den Berg, Personal communication, 1 April 2019).

The redevelopment of the old cable factory is the first development of Schieoevers Noord. Principles of the circular economy need to be implemented and visible in this first development.

The old cable factory is a goldmine of material resources that can be upgraded and re-used in the new development. Besides re-using building materials, the circular economy is also about continuing the lifecycles of people and nature. Existing companies can perhaps be relocated in the new development. Furthermore, the water of the Schie and the greenery of the Kruithuis can get a second life. Circular economy in het Kabeldsitrict is about closing the lifecycles of materials, people and nature (M. van Loon, Personal communication 23 April 2019).

The city of Delft is a small municipality within in the Randstad area with an enormous task to build 15.000 new dwellings till 2030. The Schieoevers Noord is the last large redevelopment location of the city consisting of many old industrial buildings. Furthermore, Delft wants to be "The High-Tech Capital of the Netherlands" and therefore focusses on attracting manufacturing companies. Combining this industry with dwellings is something new in the Netherlands. Using the circular economy in this development is seen as an opportunity to develop this mixed-use urban area in a sustainable way.

Table 19: SWOT Analysis Kabeldistrict

Strenghts	Weaknesses
- Mixing living and the manufacturing industry: closing loops in the use-phase of the urban area - Using the qualities of the Schie and the Kruithuis	- No policy documents on circularity: difficult to steer and manage circular building principles if no boundaries are given
Opportunities	**Treats**
- Old industrial area where many materials can be reused – pilot for circular economy - Close to Delft Zuid (Campus) station: First energy neutral station of Holland - Close ties with the TU Delft, YESDelft, Dreamhall - Large and phased development: learn from previous phases and incorporate new innovations	- The whole Schieoevers Noord development is a long term development of 30-40 years - Some companies can still stay for over 10-20 years – stops the continuous of the development - Mixing living and the manufacturing industry: heavy industry with possible environmental impact that limited the possibilities for housing

5.4.5.2. Factors of circular urban area development in Kabeldistrict

Below, the circular urban area development factors, according to the three interviewees, are explained for Kabeldistrict.

Integral water & energy system

In Kabeldistrict two out of the three stakeholders separated water and energy into two different factors.

Energy

In this case the factor energy, is referred to as the electricity that is needed for the in-house usage of electrical devices. Creating a closed energy system on the scale of an urban area is an Utopia said one of the stakeholders. Nevertheless, there are opportunities to connect the

energy grid of multiple urban areas to exchange energy between areas. Despite, energy is an important factor for sustainable urban area development, this factor doesn't necessarily have to be a part of a circular urban area development. The subject 'energy' can be seen as self-contained subject which is part of the energy transition is.

Water

The factor water can have multiple purposes. When, being part of a circular urban area development, the factor water is about the water-cycles that are used in-house on a daily basis. This use-water, which is an essential resource, can form a closed system on the urban area scale. The other water-system, which is present in an urban area, is the rainwater. It is of importance to have a solid drainage system to deal with overflows of rainwater. However, this will not mean that this rainwater system can be connected with the use-water system, because due to regulations this is yet not possible. Therefore, this are two separate systems in which the rainwater system is not part of a circular urban area development.

Material flow between buildings and public space

Because, the Kabeldistrict is a redevelopment location, where the old cable factory is being transformed into a new neighborhood there are two phases of building material cycles. First, during the design-phase of the Kabeldistrict the existing materials of the old factory need to be analyzed and can possibly be re-used in the new development (re-use or recycle). The second phase is about re-using building materials after completion of the development, thus during the use-phase. In this phase, it is of importance to take the lifecycles of the different components into account. Some components will be re-used on a short term while other have lifecycles over 50-200 years (layers of Brand, 1994). The buildings materials with smaller lifecycles (<50 years) can, after their first lifecycle, be upcycled (re-used). When this is not possible, recycling or even downcycling is possible. However, always try to re-use products instead of pulverizing them to smaller parts. This because products have a functional value next to their commodity value. All interviewees agreed that the building material cycle of buildings and the public space is a factor of circular urban area development. Taking care of construction waste also belongs to this factor. According to the report of Metabolic, making use of a building material hub and material passports for buildings also belongs to the circular economy **(**Blok,Streefland & Halsma, 2018).

Re-using waste in use-phase

Waste is a flow that is produced on a daily basis during the use-phase of the urban area. In the Kabeldistirct, these waste flows will be produced by households, commercial facilities and the manufacturing industry. In the traditional approach household and industrial waste is collected separately, however in the high-dense Kabeldistrict area, the ambition is expressed to collect the waste in an integrated system with waste separation at source. According to one of the interviewees (waste expert) 2/3 of the daily basis household waste can be separately collected in the urban area. This consist of:

(1) Organic waste (GFT) that can be high-quality re-used in the urban area for compost
(2) Old paper and cardboard that can be recycled outside the urban area
(3) Plastic, metal and drink cartons that can be recycled outside the urban area

Other waste flows such as textile, small chemical waste (KCA) and diapers and incontinence material are collected and recycled on higher scales.

Creating a community

Facilitating spaces for interaction between the residents and employees of the Kabeldistrict is important to stimulate social cohesion in the area. By stimulating this, people are perhaps more eager to share spaces and facilities. However, creating a community is used as a means to

encourage circular behavior such as sharing, separating waste and re-using products, among residents and employees. Creating this community is part of the larger subject of creating a 'social sustainable' area and is therefore not a factor of circular urban area development. However, one interviewee said when talking about retaining current businesses (current community of old cable factory) in the new development it can be seen as a factor of circular urban area development: lifecycle op people.

CO2 balance by creating green

All three interviewees agreed upon green being extremely important for the development of a healthy, attractive and sustainable urban area, especially in the Kabeldistict area where the density will be enormous. Green can be placed on the ground level, roofs and facades and can be used for different purposes. One of the interviewees said that the main purpose of creating enough green is for climate adaptation and to counteract heat stress. In this case green has a strong connection with rainwater. Another interviewee said that climate adaptation and biodiversity are a result of creating a nature inclusive area. In this approach it starts with adding the right plants to attract the right insects and animals because you want to sustain their lifecycles for as long as possible in the Kabeldistrict referred to as *"long term circularity".* Because of the lifecycle approach of these plants and animals, green as nature inclusive, can be a factor of circular urban are development.

Stimulating the local economy

In the Kabeldistrict there will be space for living, commercial facilities and producing of the manufacturing industry. In the use-phase of the Kabeldistrict, resources and products can circulate between these functions. According to one interviewee *"living, working and producing in the same area is super circular!"* and also in the report of Metabolic the opportunities of a circular manufacturing industry are expressed (Blok,Streefland & Halsma, 2018). Furthermore, repair cafes and second-hand shops, possible combined with the technical entrepreneurs in the area, can expand the lifecycle of products. At the moment, there are already many companies located in the old cable factory. Some can be facilitated in the Kabeldistrict redevelopment. In this case, the lifecycle of these companies (people) is expanded, which is a factor of circular urban area development, according to one interviewee. Last, also growing local products in the area, such as vegetables, can be part of a circular urban area development.

Urban area as an adaptive system

All three interviewees agreed upon, adaptability of the urban area, being a factor of circular urban area development. One interviewee suggested to call this factor: "*Spatially adaptive",* because it is focused on the flexible design of the buildings and public spaces. By designing the buildings and public spaces it is important to create excess in some measurements and to reserve space that you can use flexibly. For the design of adaptable buildings, it is important to take the next design principles into account:

(1) Use a column structure instead of disk structure
(2) Reserve space for (extra) installations
(3) Reserve space for (extra) front doors
(4) In case of dwellings: Create flexible outdoor spaces

Furthermore, it is important to consider the lifecycle approach of Brand (1994) in the design of the buildings and the public space. However, not all urban area components need to be adaptable because some are built for 100-300 years, like for example building structures, facades and some parts of the underground infrastructure.

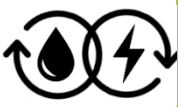
Mobility

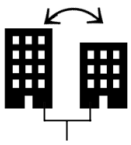
Two of the three interviewees added the factor 'mobility'. Mobility is about the movements (flows) of people and their goods in- and out of the area. To support this movements, the Kabeldistrict need to be good accessible by multiple modalities: car, bicycle, pedestrians and the public transport. Focus is on clean modalities and car-sharing, because the park norm is low (>0,6). Furthermore, because the area is mostly car-free, logistics such as moving vans, package delivery and waste collection need to be organized in a smart way. In the sustainability program of the municipality, sustainable mobility is not a main theme for the sustainability ambitions. Mobility is seen as a separate subject (Blok,Streefland & Halsma, 2018).

Smart

One of the interviewees added the factor 'smart'. However, 'smart' is more used as a tool to monitor the flows, and their supply and demand, that are moving through the Kabeldistrict. Adding 'smart' tools in the area can be useful, because the area can learn from the data and can develop further.

Table 20: Findings interviewees in-case analysis Case III: Kabeldistrict

Factor	Municipality	Developer	Architect
 Integral water & energy system	- This water is about in-house usage of water - In-house water cannot have a connection with rainwater - Phasing: add 'drain', from 'use' via 'drain' to 'generate', it is a loop	- Energy and water are 2 separate factors - Energy is the electricity for in-house usage, closed energy system on urban area scale is an Utopia - Water can be divided into (1) Rainwater (2) Daily-use water - Use-water can be a closed system on urban area scale - Rainwater not a closed system on urban area scale	- Energy and water are 2 separate factors - Energy belongs to the energy-transitions and is an own subject - Water can be seen as a resource that can have a cycle on an urban area scale
 Materialflow between buildings and public space	- Building material cycle is definitely a factor of circularity - Focus on construction waste (large batch on Schieoevers) - Building materials have different phases: (1) reuse of materials of old industries (2) reusing during use-phase of the urban area	- Better to reuse products as a whole (functional value) over pulverized materials - Building materials are log, can have long lifecycles of 50-200 years - Take construction waste into account	- Building material cycle is definitely a factor of circularity - Take construction waste into account - Start with analysis of which building materials are already in the area - First, try to upcycle (re-use) the material, then recycle, last downcycling
 Reusing waste in use-phase	- Biggest profit on urban area scale by focusing on 2/3 of all the household waste which consists of: (1) Organic waste (GFT): high quality re-use (2) Old paper and cardboard: recycle (3) PMD = plastic, metal and drink carton: recycle	- Every waste-flow has its own lifecycle on its own optimal scale - Organic waste can be re-used on the urban area scale	- Part of the use-phase of the urban area - This material flow is daily: household and industrial waste - Re-using organic waste as compost - Locally organized by residents of the area - Focus on separation at source

	- Focus on separation at source - Household, commercial and manufacturing waste need to be collected together (traditional it is separated)		- Other waste flows are being recycled on higher scales (responsibility of municipality)
 Creating a community	- Interaction need to be stimulated in the area - Don't force people to share! - Not sure if it is part of circularity	- Stimulating social cohesion can result in shared-economy - Separate and re-use organic waste for shared vegetable garden requires a community feeling - Community manager can also be an online platform	- Creating a community is a means to encourage circular behavior - This factor belongs to the subject 'Social sustainability' - Current companies can be facilitated in the next phase of the urban area is part of circularity (part of factor 'local economy')
 CO2 balance by creating green	- Call this factor: Climate Adaptation - Green used for climate adaptation and counteract heat stress has a relation with rainwater, not with use-water - Create green on the ground level, roofs and facades - Make agreements on public space management between municipality and developer	- The argument of reducing CO2 by creating enough green is a strong argument to add green as factor of circular urban area development!	- Call this factor: Nature inclusive = long term circularity - Nature inclusive is about adding the right greenery to attract the right insects and animals - Green needs to sustain the lifecycles of the plants, insects and animals for multiple generations - Climate adaptation and biodiversity are a result of creating a nature inclusive area
 Stimulating the local economy	- In-use phase resources can circulate between manufacturing companies - Create physical space for resource hub - Growing local products is part of the local economy which is a factor of circularity - Growing trees for timber construction is not possible	- Is about local amenities and local cash flows	- Part of the use-phase of the urban area - Expand the lifecycle of products by creating 2nd hand shops and repair cafes - Current companies can be facilitated in the next phase of the urban area (redevelopment) - Living, working and producing in the same area is super circular!
 Urban area as an adaptive system	- This is the 'innovation' side of the circular building principles - Focus on flexibility in buildings and the public space - Often flexible building principles require more building materials that traditional approaches	- Call this factor: spatially adaptive (and future proof) - Focus on flexible design in buildings and the public space - Create excess in building heights and public space - Not all components need to be flexible, some parts of an urban area are built for 100 - 300 years	- About the lifecycles of the buildings and public space (Brand, 1994) - Reserve space that you can use flexibly - (Adaptable) Design for the future: (1) Column structure (2) Space for installations (3) Space for front doors (4) Flexible outdoor space (in case of dwellings)

 Mobility	**New factor** - Logistics: supply of companies, moving vans, package delivery, waste collection - Transport movements in- and out of the area - Mobility is more than only car sharing	**New factor** - Flows of people that come and go by some sort of mobility - Urban area is good accessible by multiple modalities: car, bicycle, pedestrian, public transport - Mixing living and working reduces the transport movements	
 Smart		**New factor** - Can be used as a control tool to monitor all lifecycles and their demand and supply - ICT and sensors used to monitor, learn and develop	

5.4.6. Lessons learned

The potential for applying the principles of the circular economy in the redevelopment of Schieoevers Noord and the Kabeldistrict is expressed by the municipality. However, no concrete actions of 'how' to apply these principles are established. Currently, the municipality is writing their vision and ambitions on this subject which means, no boundaries for the development are set yet. This can conclude the differences in answers of the interviewees on which factors belong to this circular urban area development or not. In 2018 Metabolic has written the report 'Sustainable Schieoevers' in which 5 important spearpoints were mentioned for a sustainable redevelopment. These themes are being mixed-up with the factors of circular urban area development. One interviewee said the main aim of the development of the Kabeldistrict is to develop a sustainable urban area and circularity is one of the means to achieve this, suggesting keeping the concept circularity small to maintain focus.

In the next section the municipal policy, project ambitions and stakeholder opinions are compared and conclusions for Kabeldistrict are summarized and explained.

Factor of circular urban area development

Some interviewees talked about different phases in which the factors are used and executed. They made the division between the building-cycle and the use-phase (use-cycle). The building-cycle is characterized by building materials that are log. In the use-phase of the urban area, resources are used and produced by companies and residents. These resources have other lifecycles than building materials. Therefore, the factors are divided into these two cycles.

Building-cycle

Re-using building material flow

- ✓ Municipal policy: circular economy 'cycle of resources' > technical cycle. Delft functions as a closed system for raw-materials
- ✓ Ambitions project: re-using existing structures, raw material hub, material passports
- ✓ Stakeholders: 3 out 3 agreed being part of circularity

The plot of the Kabeldistrict area on which the old cable factory is currently located is full of materials that can possible be re-used in the redevelopment. Re-using materials and creating a building materials flow of both building materials and materials of the public space is a factor of circular urban area development according to all three interviewees, the municipal policy and ambition documents. To make re-using of building materials more efficient a material hub can be realized on the Schieoevers and material passports need to be required for every building project.

Urban area is spatially adaptive

- ✓ Municipal policy: circular economy 'cycle of resources'
- ✓ Ambitions project: Use of innovative circular building principles, removable design and flexible connections, re-usable components
- ✓ Stakeholders: 3 out of 3 agreed being part of circularity

This factor is about buildings and public space, that need to be designed in an adaptable way, taken the lifecycles op Brand (1994) into account. All interviewees agreed upon this factor being part of a circular urban area development. One interviewee suggested to call this factor *"spatially adaptive"* focused on the flexible design of buildings and the public space. This factor has a strong relation with the 'building material flow' factor.

Use-cycle

Re-using organic waste

- ✓ Municipal policy: 100% re-use of waste and the term waste no longer exists
- ✓ Ambitions project: circular manufacturing industry, residual waste can be exchanged efficiently, waste is separately collected
- ✓ Stakeholders: 3 out 3 agreed being part of circularity

In the use-cycle of the Kabeldistrict waste of households, commercial facilities and manufacturing companies are produced on a daily basis. The ambition of the municipality is to become 100% circular and therefore completely waste free in 2050. This it yet not the case and therefore, waste is divided under the circular economy. All interviewees agreed upon re-using waste being a factor of circular urban area development. One interviewee, who was a waste expert, explained that some flows can be re-used in the urban area while other have to be transported outside the area. Organic waste can be collected at source and re-used in the urban area itself and had a connection with use-water. The waste flow of old paper and cardboard and plastic, metal and drink cartons can also be separately collected in the Kabeldistrict area and recycled outside of the area.

Stimulating the local economy

- ✕ Municipal policy: -
- ✓ Ambitions project: Circular manufacturing industry
- ✓ Stakeholders: 3 out 3 agreed being part of circularity

All interviewees agreed upon stimulating the local economy being a factor of a circular urban area development. In the Kabeldistrict products can circulate between households, commercial facilities and the manufacturing industry. Furthermore, in repair cafes and 2nd hand shops, products can get a high-quality new life. The lifecycle of existing companies of the Kabelditrict can be expanded by facilitating them in the redevelopment, which according to one interviewee, belong to this factor of stimulating the local economy. In the municipal policy, this factor is not included, however in the ambition documents, the circular manufacturing industry is mentioned which refers to the potential

of circulating products between the different companies. Therefore, this factor belongs to circular urban area development.

Use-water

- ✓ Municipal policy: circular economy ‘cycle of resources’ > biological cycle
- ✕ Ambitions project: -
- ✓ Stakeholders: 3 out of 3 agreed being part of circularity

The use-water cycle that is flowing on a daily basis through the buildings belongs to the cycle of resources which is part of the circular economy in the policy documents of the municipality. Further, according to all interviewees, the use-water system can be closed on the scale of the Kabeldsitrict area. Therefore, use-water is a factor of circular urban area development.

Not clear if factor of circular urban area development

Green

- ✕ Municipal policy: climate adaptation, green, blue & health
- ✕ Ambitions project: green structures for climate adaptation
- ✓ Stakeholders: 2 out of 3 agreed being part of circularity

The factor ‘green’ is broad and can have multiple purposes. According to one interviewee, when approaching green with the lifecycle approach it is about sustaining the lifecycles of plants in the area. Certain plants will attract insects and animals which stimulates the biodiversity. In this case biodiversity is a result of creating a nature inclusive area. Approaching green with the lifecycle of plants, insects and animals for multiple generations can be a factor of circular urban area development. However, in the policy and ambitions documents green is part of the other sustainability themes: climate adaptation and green structures, which are not part of circularity. Therefore, this factor is doubtable.

Closed water-system (includes use-water and rainwater)

- – Municipal policy: part of green, blue, health: a pleasant living environment, (perhaps part of) cycle of resources
- ✕ Ambitions project:
- ✓ Stakeholders: 2 out of 3 agreed being part of circularity

The closed-water system, in which rainwater and use-waste (waste-water) are connected, is partly mentioned in the policy documents. However, it is not clear if this factor belongs to the subject of green, blue & health or the circular economy. Furthermore, one of the interviewees agreed that the water-cycle, including rain and use-water, is a resource and therefore belong to circularity. However, another interviewee said that these two water-flows can’t be connected. The reason for this is, that in the current regulations, connecting these flows is not possible regarding the hygiene. This could mean, that when regulations change, and these two flows can be connected, the factor ‘closed water-system’ can be a factor of circular urban area development. Therefore, this factor is divided under ‘doubtable’.

Not a factor of circular urban area development

Re-using rainwater

- ✕ Municipal policy: part of climate adaptation ‘prepared for climate change’
- ✕ Ambitions project: prevent flooding by heavy rainfall

- ✕ Stakeholders: 2 out of 3 agreed not being part of circularity

It is of importance to create a sufficient drainage system for rainwater that falls into the area. However, according to the municipal policy and 2 of the three stakeholders, this rainwater system is not a factor of circular urban area development and is closely related to climate adaptation. However, one interviewee suggested that rainwater can be a factor of circular urban area development when it is part of a closed water-system in which rain -and use-water are connected.

Use-energy

- ✕ Municipal policy: energy neutral 'renewable heat'
- ✕ Ambitions project: Geothermal heating
- ✕ Stakeholders: 3 out of 3 agreed not being part of circularity

Energy referred to as electricity that is used in-house is not a factor of circular urban area development. In the municipal policy, energy is part of the ambitions to become energy neutral and is a bigger sustainability theme. Further, all three stakeholders agreed that energy is not a factor of circular urban rea development and belongs to the topic about energy-transition.

Creating a community

- ✕ Municipal policy: -
- ✕ Ambitions project:
- ✕ Stakeholders: 3 out of 3 agreed not being part of circularity

Creating communities and enhancing social interaction can be used as a means to encourage circular behavior. However, this is not the main aim of creating communities which is creating a social sustainable urban area. Therefore, the social aspect is not included in the municipal policy documents about circularity and also all interviewees agreed upon 'creating communities' not being a factor of circular urban area development.

Mobility

- ✕ Municipal policy: sustainable mobility.
- ✕ Ambitions project: car-free area, public transport
- ✓ Stakeholders: 2 out of 3 agreed not being part of circularity

Mobility as a factor of circular urban area development was added by two interviewees. According to them this factor is about the transport movements (flows) of people and their goods in and out of the area. In this, logistic movements are also considered. According to the municipal policy, sustainable mobility is seen as a subject on its own, which is important for the development of a sustainable urban area. Therefore, mobility is not a factor of circular urban area development.

Smart

- ✕ Municipal policy: -
- ✕ Ambitions project: -
- ✕ Stakeholders: 1 out of 3 added this factor

One interviewee added the factor 'smart'. Smart tools can be used to monitor and measure circularity, however it is not a main factor of circular urban area development. Also in policy and ambitions documents this factor is not mentioned.

Table 21: Conclusion ‘factors’ Kabeldistrict

Factor of circular urban area development	Not clear	Not a factor of circular urban area development
Re-using building material flow (old factory, buildings and public space)	Green: climate adaptation and nature inclusive	Use-energy: part of energy transition
Urban area is spatially adaptive	Closed water-system incl. use -and rainwater	Rainwater: part of climate adaptation
Re-using organic waste, collect old paper, cardboard and PMD		Creating a community: part of social sustainability
Local economy: repair cafes, 2nd hand shops, local products, retaining companies		Mobility: movements (flows) of people and goods
Use-water: daily basis in-house usage		Smart: tool to measure circularity

5.5. Cross-case analysis

In this part of the research 'analyze and conclude' the data conducted out of the three cases studies are compared by identifying differences and similarities between the factors of circular urban area development (Yin, 2003). The outcome of this cross-case analysis is giving an answer to the research question: "*Which factors contribute to the development of a circular urban area?"*

5.5.1. Circular urban area development

As stated before, a circular urban area development is part of a sustainable urban area development. According to Hoornweg et al. (2016) urban areas play an important role in sustaining the bio-physical Earth systems, referred to as the 9 planetary boundaries. Further, cities consist of socio-economic factors which also need to be considered in the development of a sustainable urban area. Out of these bio-physical and socio-economic factors the next sustainable urban area development themes can be derived from Dutch practice: climate neutral, biodiversity, social sustainability, mobility and the circularity. In this, circularity can be used as one of the means to create a sustainable urban area. Focussing on circularity in urban area development can be called: ''circular urban area development".

According to the outcomes of the case studies all the urban areas are being developed with the aim of building new houses in the Randstad area, because of the housing shortage. These areas need to be developed in a sustainable way to reduce the environmental risks in the city. Using circular principles in these developments are seen as one of the means to create a sustainable urban area.

The factors that contribute to the development of a circular urban area development are further explained by giving the description and focus points of each factor. An overview of the results of the cases can be seen in table 20.

5.5.2. Factor of circular urban area development

Out of the cases can be concluded that a circular urban area development can be divided into two different cycles: building -and the use-cycle. First, In the building-cycle the emphasize is on the high-quality reuse of building materials. Building materials are log and have (often) long lifecycles. Second, the use-cycle is about the lifecycles of resources and products used on a daily-basis by the residents of the urban area. These resources and products, used on daily basis, are volatile and have short lifecycles. Because of the different characteristics of these cycles, the factors are divided between the building-cycle and use-cycle.

Building-cycle

1. Circular building material flow

This factor is about the high-quality re-use all building materials in the urban area, considering all physical components of buildings and the public space. Construction waste is also seen as a building material and can therefore be re-used. When high-quality re-use of building materials is not possible, remanufacturing or recycling can be applied (according to the cycles of the Ellen MacArthur foundation), however always try to re-use complete products over pulverized ones because they have a higher functional value. When the area is being redeveloped, try to re-use existing building materials and products in the new design. During the use-phase of the urban area, urban area components will be released according to the duration of their lifecycle, try to re-use these components or store them in a nearby material hub.

   - All materials are being documented in a material passport or an urban area passport

- Building materials can temporary be stored in material hubs
- Make use of bio-based materials

2. Spatially adaptive urban area

This factor is about the creation of adaptable buildings and flexible public spaces. For both, buildings and the public space flexible dimensions can be incorporated in the design by creating excess in some measurements. In this way, space is reserved for changing circumstances due to trends and innovations. For the design of the buildings and the public space make use of concept of the sharing layers of change from Brand (1994). The urban area components with short lifecycles below 50 years can be removable to make re-use possible. Components with lifecycles above 50 years, such as the facades and structures of buildings, can be designed with a long-term perspective in mind.

a. Rules for adaptable buildings:
    - Use a column structure
    - Reserve space for installations
    - Reserve space for front doors
    - Overplus floor heights
    - For housing: design flexible outdoor spaces
b. Rules for flexible public spaces
    - Create spaces for multi-prupose = shared spaces

Use-cycle

3. Circulation of use-water

When the circulation of water is mentioned in the circular economy, the use-water is meant. Use-water starts as tap-water, which is the fresh water that is used on a daily basis by residents and companies. The purpose of this water is for drinking, in-house machines, showering and flushing the toilet, after is becomes waste-water. On the scale of an urban area this use-water system has the potential to become a closed system where fresh water can be re-used in an economical way. For the implementation of such a closed tap-water system requires consideration during the design phase of the urban area. In the building blocks and in the underground infrastructure, space need to be reserved to make this possible. This water-system can have a strong relation with the flow of organic waste, which needs water to become re-usable.

According to the cases, use-water can be part of a larger water system in which use-water and rainwater are connected into one closed water-system. According to 6 of the 9 interviewees this closed water-system can be a factor of circular urban area development. Unfortunately, this is yet not possible because it is not allowed to connect these two water-systems due to hygiene regulations. When this law changes, the factor circulation of tap-water can possibly rename into closed water-system.

4. Re-use & separate collection of waste

During the use-phase of the urban area, household and companies produce waste on a daily-basis. An optimal circular economy strives for a zero-waste society; however, this is yet not been possible. Therefore, something has to be done to remove the waste flows out of the urban area. The total waste flow of households and companies consists of several different ‘waste components’ and 2/3 of this waste can be separately collected, preferably at the source (implemented in the design of the buildings):

- High-quality re-use of organic waste in the urban area as compost (connection with tap-water)
- Recycling of paper and cardboard outside the urban area
- Recycling of plastic, metal and drink carton outside the urban area

To reduce the inconveniences of daily-basis waste, the logistics of the waste out of the area need to be arranged safe and smart. An example of such a system is return logistics in which delivery vans drive in with packages and out with waste.

5. Stimulating the local economy

This factor is about the high-quality re-use of local products in the use-phase of the urban area. By creating a mixed-use urban area where living, working (and perhaps producing) are located within walking distance of each other, products can circulate between these functions. By creating places for repair-cafes, second-hand shops the lifecycles of products can be expanded and given a second life. Next to this, places for the sharing-economy can be realised where certain tools, that are not used on a daily basis by people, can be shared by the community. Furthermore, spaces in the public space or on roofs can be designed to grow local products such as vegetables that can be used in local restaurants or greenhouses in the area.

5.4.3. Not a factor of circular urban area development

Circularity is a part of the subject of sustainability. Because there is no consensus about the definition of circular economy and circularity and sufficient research into circular urban area development is lacking, some factors have been mixed-up by the interviewees. The next factors, that were mentioned in the explorative interviews as being part of a circular urban area development, are not a factor of circular urban area development anymore after the conducted case studies. Every factor and the reason for not being part of a circular urban area development, are shortly explained:

1. Use-energy system

When talking about energy, there is mostly referred to energy as electricity that is used in-house on a daily basis such as for lightning or the power of machines. For 10 years, the need for clean energy is being addressed, and building energy neutral has become the standard. Therefore, the factor energy belongs to the energy transition and is a means to achieve a climate neutral area which one of the means to create a sustainable urban area development.

2. Rainwater system

The Netherlands is a wet country with a lot of rainfall. Therefore, a sufficient drainage system is needed in a dense urban area to avoid flooding by heavy rainfall. Creating a sufficient drainage system is important for the climate adaptivity of the urban area. Therefore, rainwater is part of the theme climate neutral which is a part of sustainable urban area development. When it is allowed to connect rain -and use-water into one system, it is possible that rainwater becomes part of circular urban development.

3. Creating a community

Many social-economic factors play an important role in cities and urban areas. Therefore, the social aspect can never be forgotten when developing a sustainable urban area. However, creating communities is not part of a circular urban area development but an objective of creating social sustainable places. Emphasizing on creating communities in

the urban area can contribute to the circular behavior of people. However, it is not part of circularity.

4. Green for a climate adaptive urban area

The importance of creating enough green in the urban area has multiple purposes. Green created for climate adaptation is not a factor of circular urban area development because climate adaptation belongs to aim of creating a climate neutral urban area. Nevertheless, creating green places that absorb rainwater and counteract heat stress are indispensable for the development of a sustainable urban area. When green is created for the purpose of climate adaptation it has a strong connection with the rainwater system.

5. Green for a biodiverse urban area

One of the physical components of the public space and therefore also part of an urban area is green. Creating enough greenery in the form of green roofs, facades or in the public space is important for healthy urban living for all people that are living and working in the area. Further, it is important to create green for plants and animals to strengthen the biodiversity and ecological value of the area. However, this belongs to the aim to create rich biotopes which belongs to the subject of biodiversity which is one of the means to create a sustainable urban area.

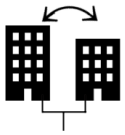
6. Mobility

The factor mobility is added by a few interviewees as being a factor of circular urban area development. Mobility is referred to the aim of creating an urban area that is good accessible by multiple (clean) modalities. According to Hoornweg, et al. (2016) 'mobility and connectivity' are part of the socio-economic boundaries and therefore belong to the social aspect of creating a sustainable urban area. Furthermore, two of the three interviewed municipalities see mobility as an important theme on its own.

Table 22: Findings cross-case analysis

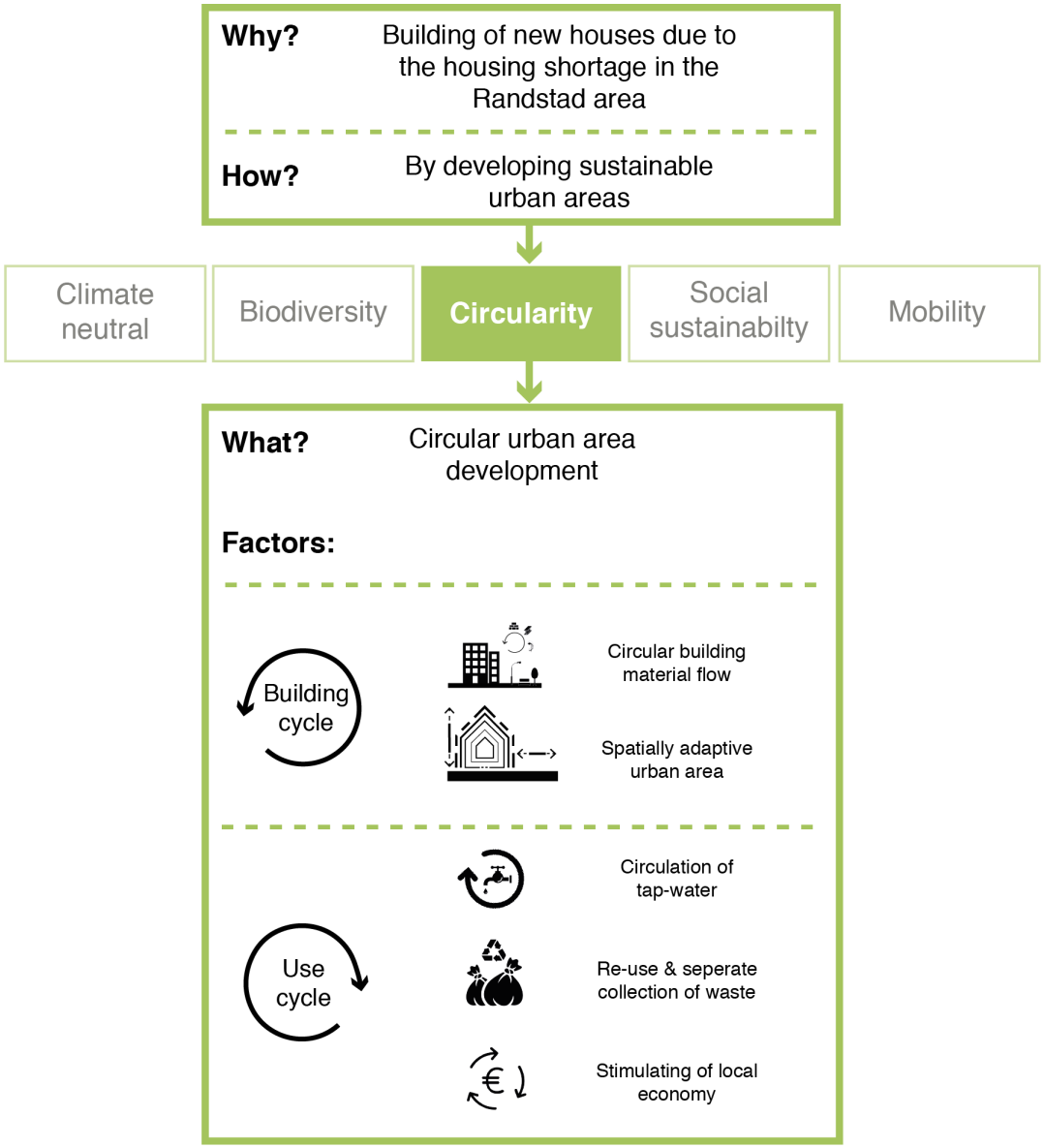
Factor	Lincolnpark	Beurskwartier	Kabeldistrict
Project description	- **Why**: housing shortage in the Metropolitan region Amsterdam - **Why circular:** last plot where municipality can set the boundaries - **How:** By developing a sustainable urban area in - **What:** Circular principles are being applied to develop in a sustainable way	- **Why**: housing shortage in G4 cities - **Why circular:** circularity is not the main aim for this urban area - **How:** focus on "healthy urban living" - **What:** circular principles such as (almost) zero waste ambition are being applied to develop the area in a sustainable way	- **Why**: housing shortage in Randstad area - **Why circular:** last large redevelopment location where many materials are stored - **How:** creating a mixed-use urban area - **What:** re-using existing materials, using circular design principles, implementation of the circular manufacturing industry
	Closed-water system ✓ Municipal policy ✓ Ambitions project ✓ Stakeholders: 2 out of 3 agreed being part of circularity Use-water ✓ Municipal policy ✓ Ambitions project	Closed-water system × Municipal policy × Ambitions project ✓ Stakeholders: 2 out of 3 agreed being part of circularity Circulation of use-water × Municipal policy × Ambitions project	Closed-water system - Municipal policy × Ambitions project: ✓ Stakeholders: 2 out of 3 agreed being part of circularity Use-water ✓ Municipal policy

 Integral water & energy system	✓ Stakeholders: 3 out 3 agreed being part of circularity Rainwater ✓ Municipal policy × Ambitions project: × Stakeholders: 2 out of 3 agreed not being part of circularity Energy ✓ Municipal policy × Ambitions project × Stakeholders: 2 out of 3 agreed not being part of circularity	✓ Stakeholders: 3 out 3 agreed being part of circularity Rainwater × Municipal policy ✓ Ambitions project ✓ Stakeholders: 2 out of 3 agreed not being part of circularity Energy × Municipal policy × Ambitions project × Stakeholders: 3 out of 3 agreed not being part of circularity	× Ambitions project ✓ Stakeholders: 3 out of 3 agreed being part of circularity Re-using rainwater × Municipal policy × Ambitions project × Stakeholders: 2 out of 3 agreed not being part of circularity Energy × Municipal policy × Ambitions project × Stakeholders: 3 out of 3 agreed not being part of circularity
 Materialflow between buildings and public space	Building material flow ✓ Municipal policy ✓ Ambitions project ✓ Stakeholders: 3 out 3 agreed being part of circularity	Circular building material cycle ✓ Municipal policy ✓ Ambitions project ✓ Stakeholders: 3 out 3 agreed being part of circularity	Re-using building material flow ✓ Municipal policy ✓ Ambitions project ✓ Stakeholders: 3 out 3 agreed being part of circularity
 Reusing waste in use-phase	Re-using waste ✓ Municipal policy ✓ Ambitions project ✓ Stakeholders: 3 out 3 agreed being part of circularity	Re-using organic waste and separate collection ✓ Municipal policy ✓ Ambitions project ✓ Stakeholders: 3 out 3 agreed being part of circularity	Re-using organic waste ✓ Municipal policy ✓ Ambitions project ✓ Stakeholders: 3 out 3 agreed being part of circularity
 Creating a community	Creating a community × Municipal policy × Ambitions project × Stakeholders: 3 out of 3 agreed not being part of circularity	Creating a community × Municipal policy × Ambitions project × Stakeholders: 3 out of 3 agreed not being part of circularity	Creating a community × Municipal policy × Ambitions project × Stakeholders: 3 out of 3 agreed not being part of circularity
 CO2 balance by creating green	Green: climate adaptation × Municipal policy × Ambitions project × Stakeholders: 3 out of 3 agreed not being part of circularity Green: biodiversity & ecological value ✓ Municipal policy × Ambitions project - 3 (partly) agreed being part of circularity	Green × Municipal policy – Ambitions project × Stakeholders: 3 out of 3 agreed not being part of circularity	Green × Municipal policy × Ambitions project ✓ Stakeholders: 2 out of 3 agreed being part of circularity -

 Stimulating the local economy	Stimulating the local economy ✓ Municipal policy ✕ Ambitions project ✓ Stakeholders: 3 out 3 agreed being part of circularity	Stimulating the local economy ✕ Municipal policy ✓ Ambitions project ✓ Stakeholders: 3 out 3 agreed being part of circularity	Stimulating local economy ✕ Municipal policy ✓ Ambitions projec ✓ Stakeholders: 3 out 3 agreed being part of circularity
 Urban area as an adaptive system	Adaptive design principles ✕ Municipal policy ✓ Ambitions project ✓ Stakeholders: 2 out of 3 agreed being part of circularity	Adaptable buildings and shared public space ✓ Municipal policy ✓ Ambitions project ✓ Stakeholders: 3 out of 3 agreed being part of circularity	Urban area is spatially adaptive ✓ Municipal policy ✓ Ambitions project ✓ Stakeholders: 3 out of 3 agreed being part of circularity
 Accessibility/ mobility	Mobility and accessibility ✕ Municipal policy ✕ Ambitions project ✕ Stakeholders: 2 out 3 didn't add this factor		Mobility ✕ Municipal policy ✕ Ambitions project ✓ Stakeholders: 2 out of 3 agreed not being part of circularity

5.6. Conclusion

Out of the case study analysis can be concluded that the reason for the development of these urban areas is the housing shortage in the Randstad area. In these developments all sustainability themes are used to create a sustainable urban area which is future proof. Every sustainability theme has its own subfactors. The next sustainability themes can be divided: climate neutral, biodiversity, circularity, social sustainability and mobility. In this, circularity is used as one of the means to create a sustainable urban area. When special focus is set on implementing circularity, the development can be called a circular urban area development which emphasizes on the next factors: circular building material flow, spatially adaptive urban area, circulation of tap-water, re-use & separate collection of waste and stimulating the local economy.



Fig, 31: Conclusion cross-case analysis

6. Expert panel

In this section an expert panel was organized, to get a comprehensive overview of the process steps that should be taken to make a circular urban area development possible and the applicability of the factors in practice. The last sub-question, that will be answered by this expert panel is: "*Which instruments can be used to manage these factors of circular urban area development in Dutch practice?*

6.1. Selection of members

The invited participants of this focus group are all individual experts. They have all sufficient knowledge on the subject of circularity and are familiar with urban area development processes and instruments used in practice to steer on sustainability.

Table 23: Participants expert panel

	Name	Organisation
1		Municipality of Utrecht
2		Brink
3		Copper8
4		Fakton
5		Alba Concepts
6		Arup

6.2. Content expert panel

In preparation of the meeting, all the expert members got a document sent in which gave an explanation of the found factors of circular urban area development The aim of the expert panel was to find answers to the questions which actors, and preconditions are needed to make circular urban area development possible in practice. Furthermore, every 'factor' will be discussed in relation to possible instruments that can manage them in practice. These instruments can consist of legal, financial, organizational instruments or new design tools that need to be developed. The complete questionnaire can be seen in appendix IV.

6.3. Outcomes expert panel

Part I: Circular urban area development factors

1: In front of you, you can see the factors that contribute to the development of a circular urban area. Are you missing factors?

The expert meeting started with a discussion about the definition of circular urban area development. Again, no consensus about this concept could be reached by the group. Some agreed that circular urban area development is a sustainable urban area development with a focus on circularity, while others used a broader definition where all flows are connected to each other on different scale levels. Nevertheless, all agreed upon the approach of circular urban area development being the same as the approach of a sustainable urban area development, however the circular approach gives more direction to what kind of solutions you can think of. Therefore, circularity is more concrete than sustainability, and has the aim to create value retention. Furthermore, they said that in the circular economy, the three dimensions for sustainable

development; economic, ecological and social are combined. In this way it can become an economy in which all these dimensions work together and where value isn't lost.

Thus, circularity is a way to achieve sustainability by focusing on value retention. In this, circularity is not the goal, but a means to create value retention.

The five factors that were found in earlier stages of this research were explained and discussed during the panel. Some adjustments were made and one factor was added by the experts`. They all agreed on making the division between the building -and use-cycle.

Building-cycle

Circular building material flow

They all agreed on this factor being a factor of circular urban area development. Material hubs can facilitate areas that are larger than an urban area, however the space usage for these hubs don't have to be enormous.

Spatially adaptive urban area

They all agreed on this factor being a factor of circular urban area development. Creating excess and space for adjustments in the future can create value.

Use-cycle

Collection & logistics of waste

Despite, in an ideal circular economy waste is seen as input, they all agreed on this factor being important for the development of a circular urban area. They suggested to add logistics to this factor. Therefore, this factor is called 'collection & logistics of waste'.

Stimulating the local economy

This factor can be organized on different levels and is about the local production and usage of products. The sharing economy is also part of this factor. On every scale level different attributes can be shared. On the building level tools can be shared and on the building block or urban area scale mobility can be shared. This factor is also part of the social dimension of circular urban area development.

Closed water-system

The whole group didn't' agreed upon the division between tap-water and rainwater. According to them the water-system in the circular economy consist of both waterflows: tap -and rainwater. Therefore, this factor is called closed water-system in which both systems are integrated.

Efficient energy system

The factor energy was added by the expert panel. They stated that all industrial flows (energy, water and materials) play an important role on the scale of an urban area. One of the industrial flows is energy, which is an important factor for the circular urban area

development and has a strong relation with the orientation of efficient space usage of buildings and the public space.

Part II: Applicability of the factors in practice

The second part of the expert panel consisted of the applicability of these factors in Dutch practice. This is explained by answering four sub-questions. For every sub-question the discussion between the experts is explained and a possible consensus is stated.

2a: Which disciplines are needed to make circular area development (by means of these factors) possible?

Instead of answering the question about disciplines, the expert panel changed 'disciplines' unconsciously to 'actors: "*Which actors are needed to make circular urban area development possible?".*

As stated before, urban area development is a public-private initiative. Therefore, the group suggested that for every urban area development a 'project team' need to be established between local authorities and the private developers. During this establishment it is important to map everybody's roles and responsibilities. In this model the local authorities need to stimulate private parties by requesting the implementation of circular principles. Furthermore, local authorities are mostly responsible for the public space and therefore can steer on circularity in its layout. An important mind-shift on the private side is that private parties can remain responsible after the execution making them responsible for the quality of the components of the urban area after the execution. According to the group this is a behavior shift that belongs to the circular economy and contributes to the development of a circular urban area. Second, they agreed that the whole building chain needs to cooperate. This is a challenge because the construction industry is conservative, and the building chain is split up between many different parties. The building industry can be innovative; however, the circular economy is also about a behavior change in the whole building chain.

> *"I think the construction industry is very different from other sectors. The building chain is very long, and very split. For example: If apple wants to make a sustainable iPhone, then they can turn all the buttons and it will be sustainable. In the construction industry, we must sit down with 50 parties and work together to become sustainable".*

2b: What preconditions for urban area development must be set to make a circular urban area development possible?

For every development preconditions have to be set. During the expert panel several preconditions were discussed that are needed to develop an urban area in a circular way. In the next section, every precondition is explained.

Define the boundaries of the circular urban area

The experts all agreed that the traditional approach of defining the boundaries of an urban area development is not sufficient for a circular urban area development. In the traditional approach a line is drawled on the city map that indicates the plot. However, when developing a circular urban area, we need to look beyond these lines because in a circular urban area development flows (energy, water, materials, waste) are going in and out of the

area. Therefore, it is important to conduct a flow analysis to plot the different flows against the different scale levels (home, building, urban area, city), resulting in the next outcomes:

- Per scale level all the existing flows
- Per flow how it works through the different scale levels

By doing so a relation can be established between the scale levels and the flows, and the most efficient scale for each flow can be used which creates value and minimized waste.

Public space is key

There was concluded by all experts that the 'role' of the public space is key in the development of a circular urban area and that several circular solutions can be found in the public space: *"Look beyond the boundaries of the buildings to implement circular principles".* In most urban area developments, the local authorities are defining the conditions for the public space and are, after the development, responsible for the maintenance of it. Therefore, local authorities are for a large part responsible for the implementation of circular boundaries for the public space in circular urban area development and therefore need to set these boundaries at the start of the project.

Long-term perspective

During the expert panel the ideal business model for a circular urban area development was discussed. The group stated that there are two different perspectives that involved parties can have during a development: short -and long-term perspective. Normally, a traditional developer has a short-term perspective which means that they are involved during the design phase, and after the execution of the project they step out of the process. Making the implementation of circular principles feasible requires a long-term perspective. Therefore, to develop a circular urban area, stakeholders with long-term perspectives and corresponding long-term business models need to be involved in the whole process of the project: from design till exploitation. This mind shift, of stakeholders that stay involved and responsible for their products, after execution is part of the circular economy. At this moment, there are a few parties with such interests such as developing investors and housing corporations. Therefore, it is important to involve such parties in the development of a circular urban area.

Consensus is key

Urban area development is characterized by a partnership between public and private parties, mostly between the municipality and the developer. For a circular urban area development, it is important to define the value of the project principles in the beginning of the project, together with the project team. In this it is important to get consensus about the definition of circularity and how this will be implemented in the circular urban area development: *"It works, when we all speak the same language".* Further, agreements can be made on which quantitative and qualitative measurements are used to value the circular principles in the development.

Create value in the design

The group talked about possible design principles that are needed to design a circular urban area. First, they stated that the creation of excess in the dimensions of buildings and public space is needed to make the urban area flexible over time, which means that this space can be used in an adaptable way. Second, because the main aim of circularity is value retention it is important to ask the next questions in the beginning of the development:

- Which existing valuables do I want to keep?
- What value can I create in this area?

2c: Which steering instruments / management tools are needed to effectively manage these "factors"?

After the question: *"How circularity could be efficiently managed in practice"* a new discussion emerged.

First, according to two of the experts, the current measurement methods are too much focused on quantitative analysis. Urban areas as complex systems will have more benefit from qualitative measurements. Therefore, there was suggested by these two experts to give conditions instead of hard requirements. On the other hand, the other four experts stated that the market must be stimulated, and quantitative measuring instruments can be used as incentive for the market. For example, when a developer invests in circular principles, this overvalue needs to be reflected in the price of the buildings. Therefore, quantitative numbers are needed to convince the buyer. Furthermore, using quantitative numbers makes it easier to speak the same language and avoid discussions about the definition of circularity.

Second, the group concluded that the circular economy is about the efficient usage of building materials and resources. However, in current developments it is hard to measure the (in)efficiency of building materials and resources. Therefore, they all agreed that using smart data tools can give circularity in urban area development an enormous boost. By using smart data tools, for example, the demand and supply of the flows that are going in and out of the area, can more easily be managed which can support decision making. As result can be concluded that smart data can have a positive influence on the management of circular urban area development.

Management tools

Focusing on the found factors of circular urban area development four possible management tools were suggested by the experts, that can be used to manage these factors in Dutch practice.

1. Legal instruments
2. Financial incentives
3. Organizational instruments
4. Design tools

Per factor the management tools are explained:

Circular building material flow

Instruments:

- **Legal:** material passports need to be required for every building to document all building materials.
- **Design tool:** A smart data tool that can be used to match the supply (demolishing) and demand (new built) side of building materials. The BAG-viewer (basis administratie gebouwen), which is an online database consisting of all cadastral information of every building in the Netherlands, can for example be expanded by adding the demolishing date and information of the building materials in these buildings. With smart data tools a match between the building materials in old and new buildings can be made.

Spatially adaptive urban area

Instruments:

- **Design tool:** For buildings you can use the Building Circularity Index, developed by Alba Concepts, as design tool. In this tool the flexibility, type of

connections and other factors that influence the adaptability of a building are considered in the design.

- **Design tool:** In the public space the term 'redundancy' can be used. A redundancy tool can help in optimizing the public space through the factor time. This tool needs to be developed.

Efficient energy system

Instruments:

- **Legal**: for buildings the EPC (energieprestatie) which measures the energy use of the whole building. From 2020 the BENG (bijna energieneutrale gebouwen) will be used which focusses on the buildings energy requirement in KWh/m2, primary use of fossil energy in KwH/m2 per year and share of renewable energy in %.
- **Legal:** for urban areas the EMG (energiemaatregelen op gebiedsniveau) can be used. This instrument can make use of collective energy measures outside the building parcel. With this calculation it is possible to make use of the following larger energy systems: heat network for external heat supply, hot water circulation system of external heat supply, collective cooling network of external cooling and collective electricity generation.
- **Design tool:** A smart flow-analysis can be developed, which measures the energy usage and generation of the urban area. According to the outcome of this analysis a smart energy system can be designed.

Closed water-system

Instruments:

- **Legal:** To create closed water systems in which tap water, waste water and rainwater are combined, the laws & regulations regarding hygiene need to be changed (hygiëne code drinkwater). At the moment, there is defined that waste water needs to be removed and cannot be connected to the tap water system, because it is not identified as a resource. The Municipality is responsible for the collection and transport of wastewater according to article 10.33 Wm (wet milieu en beheer). At the moment, the only possibility to create a closed water system is by the crisis and recovery law (crisis en herstelwet).
- **Financial**: To stimulate closed water-systems, taxes can be paid over flushing waste water into the sewer. Taxes will be paid over the amount of waste water, referred to as the sewerage tax. The municipality remains the responsible body for instituting the sewerage tax as referred to in the proposed Article 228a of the Municipalities Act.

Collection & logistics of waste

Instruments:

- **Organizational:** Facilitate separate collection of waste; glass, plastics, organic, paper, cardboard. Make this (partly) visible in the area to affect the circular behavior of people.
- **Legal:** The municipality is responsible for the collection of residential waste (10.21 - 10.29 Wm (wet milieu en beheer); however, the municipality is not required to collect company waste. The company itself is responsible for their waste disposala and collection established in article 10.36 – 10.55 Wm. Changes should be made

in chapter 10 of Wet milieu beheer to make the joint collection of residential and company waste possible
- **Organizational:** The municipality can set-up a VVE structure among companies in the urban area, to support them organize their waste disposal together, instead of every company on its own. This can reduce transport movements in the urban area.

Stimulating the local economy

Instruments:

- **Financial**: Stimulating the use of local products by less taxation on products that are produced locally. On products that have a high environmental impact, such as meat -and milk products or products that are transported over a large distance more taxes are paid.
- **Financial:** Other way around; the environmental impact and pollution factor are calculated through in the prices of the products which means that products with a high environmental impact are more expensive than local products.

2d: What are currently the most important bottlenecks (for preconditions and instruments) for making circular area development possible?

The last question that was discussed during the expert panel was the question about the current bottlenecks that hinder circular urban area development. The next barriers were established:

- Local authorities want to set qualitative conditions for circular urban area development while market parties need quantitative measurements to value their circular interventions. The public side needs to encourage market parties to use circular strategies in their development. Therefore, local authorities must dare to take the step to use circular tender procedures.

- The whole building chain, who is involved in the development of a circular urban area, need to switch to a circular way of working to make circular urban area development possible. However, this chain can consist of more than 50 parties, which can make it a difficult process.

PART V: CONCLUSIONS

7. Conclusion

The aim of this research was to gain more insight into the factors that contribute to the development of a circular urban area and how these factors can be managed in Dutch practice. For this research, the next goals were formulated:

1. To get a comprehensive definition of the circular economy and circularity in the built environment
2. To get a comprehensive definition of circular urban area development
3. To get an overview of the factors that contribute to the development of a circular urban area
4. To get insight into the instruments and tools that can be used in practice to steer on the factors of circular urban area development

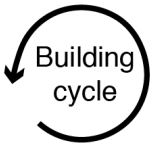
First, a literature study was done to understand the concept of circular economy and circularity in the built environment. Second, explorative interviews were held with practitioners to get a first impression on which factors could contribute the development of a circular urban area. Third, these circular urban area development 'factors' were validated and sharpened through case study analysis. Last, the applicability of these 'factors' in practice is analyzed by an expert panel, resulting in a guideline that can be used in Dutch practice by public of private parties who are involved in urban area development and wants to steer on the development of a circular urban area.
The main research question, that is be answered by this research, is:

"What are the factors that contribute to the development of a circular urban area and how can these factors be managed in practice?

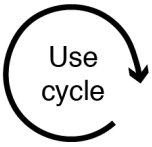
The research questions can be divided in two questions: *"what are the factors that contribute to the development of a circular urban area*?" and "*How can these factors be managed in practice?".* First, the questions will be answered separately. After, the answers are combined into the final output of this research: The circular urban area development guideline.

Part 1: "What are the factors that contribute to the development of a circular urban area?"

Circular urban area development and sustainable urban area development are closely linked. According to the outcomes of this research, most urban areas are being developed with the aim of building new houses in the Randstad area, because of the increasing housing shortage. These areas need to be developed in a sustainable way to reduce the environmental risks in these high dense urban areas. Using the concept of circularity is seen as a one of the means and used as a condition for these sustainable developments. These circular principles consist of several factors that contribute to the development of a circular urban area. These factors can be divided into two different cycles: building -and the use-cycle. This division is made because they differ in characteristics:



In the building-cycle the emphasize is on the high-quality re-use of building materials. In this building-cycle, the focus is on the lifecycles of buildings components and building materials that are log and mostly have long lifecycles.



The use-cycle is about the lifecycles of resources and products used on a daily-basis by the residents and employees in the urban area. Resources and products used on daily basis in the use-cycle are volatile and have short lifecycles.

First, the two factors that are part of the building-cycle are explained. After, the four factors belonging to the use-cycle are discussed.

Building-cycle

1. Circular building material flow

This factor Is about the high-quality re-use of all physical components of an urban area (fig. 9) and can be applied in the design and use-phase of the project. First, when the urban area development is a redevelopment or transformation project, existing building materials and structures can be incorporated in the new design of the urban area. Second, during the use-phase of the urban area, components will be released according to the duration of their lifecycle (according to Brand, 1994), try to re-use these components or store them in a nearby material hub. When re-using building materials always try to re-use them in the most environmentally friendly way according to the 10 R-framework of Kirchnerr et al. (2017) (see fig. 9 on p. 37).

2. Spatially adaptive urban area

This factor Is about the creation of adaptable buildings and flexible public spaces that can easily respond to changing circumstances due to trends and innovations. For the design of adaptable buildings, the concept of Brand (1994) can be used. Components with lifecycles below 50 years can be removable to make re-use possible. Components with lifecycles above 50 years (facades and structures) are designed for the long-term and can be robust.

- Rules for adaptable buildings: use a column structure, reserve space for installations, reserve space for front doors, overplus floor heights, design flexible outdoor space (for housing)
- Rules for flexible public spaces: Create spaces for multi-purpose = shared spaces

Use-cycle

3. Efficient energy-system

This factor is about the energy that is used in the urban area by residents and companies on a daily-basis. This energy can be used as electricity for lighting or for the heating of water. The energy demand of the urban area can be measures, to select the most efficient and environmentally friendly energy system. Energy generation and consumption has a strong relation with the orientation of buildings and public spaces. Furthermore, the energy system is not likely to be closed on the urban area scale and therefore can be linked by multiple areas.

4. Closed water-system

Water has the potential to become a closed system on the scale of an urban area. In this water-system tap-water, waste water and rainwater are combined to one closed system which can be re-used in an economical way. This water-system has a strong relation with the flow of organic waste, which needs water to become re-usable.

5. Re-use, collection and logistics of waste

During the use-phase of the urban area, households and companies produce waste on a daily-basic. The total waste flow of households and companies consists of several different 'waste components' and 2/3 of this waste can be separately collected, preferably at the source:

- High-quality re-use of organic waste in the urban area as compost (connection with water)
- Recycling of paper and cardboard outside the urban area
- Recycling of plastic, metal and drink carton outside the urban area

To reduce the inconveniences of daily-basis waste, the logistics of the waste out of the area plays an important role in the quality assurance of the urban area and therefore needs to be organized in an efficient way.

6. Stimulating the local economy

This factor is about the high-quality re-use of local products. By creating a mixed-use urban area where living, working (and perhaps producing) are located within walking distance of each other, products can circulate between these functions. By creating places for repair-cafes, second-hand shops and the sharing-economy products can efficiently be re-used. Furthermore, spaces in the public space or on roofs can be designed to grow local products such as vegetables that can be used in local restaurants or shops in the neighborhood. This factor has also a strong relation with the social dimension of circular development.

Part 2: "How can these factors be managed in practice?"

The second part of this research was about the managerial tools that can be used to steer on the factors in Dutch practice. Every factor of circular urban area development was discussed in relation to possible instruments that can be used to make the applicability of these factors in circular urban area development practice possible. These instruments consist of:

- Legal instruments
- Organizational instruments
- € Financial incentives
- Design tools

Notable it that the factors in the building-cycle are often management with design tools because these factors are mostly executed in the design-phase of the urban area. Further, the next conclusions can be drawled:

Legal instruments

For some factors, existing legal instruments can be used to steer on them. For other factors existing laws and regulations need to change to make implementation possible.

- Material passports are required for every new built building
- The EPC (energieprestatie), BENG (bijna energie neutral gebouwen) can be used to measure the energy performance of buildings
- The EMG (energiemaatregelen op gebiedsniveau) can be used to measure the energy performance of the urban area
- Laws & regulation regarding hygiene referred to as 'hygiene code drinkwater' don't allow it to connect waste water to the drinkwater system. In article 10.33 Wm (wet milieu and beheer) is stated that the municipality is responsible for the collection of this waste water. When this law allows is to connect these systems, a closed

system can be realized. As result, the municipality is no longer responsible for the collection of the waste water out of the urban area.
- At the moment, the crisis and recovery law can be used to make an exception on the hygiene code drinkwater and article 10.33 Wm to create a closed water system.
- Laws & regulation regarding the collection of company and residential waste need to change. In chapter 10 of Wet 'Milieu en beheer' is stated that companies are responsible for the collection of their own waste (article 10.36 – 10.55 Wm). The municipality is responsible for the collection of residential waste (article 10.21 – 10.29 Wm). Joint collection of company and residential waste needs to be possible to reduce transport movements and make the collection more efficient.

Organizational instruments

For the collection of waste, the municipality or developer can set up an organizational structure to make the implementation of this factor possible.

- Different garbage bins that are suitable for different waste flows can be placed in the public space of the urban area. Facilitating this separate waste collection, makes the residents aware of waste separation.
- Every company is responsible for its own waste disposal (article 10.36 – 10.55 Wm) generating a lot of transport movements to collect all this waste separately. Together with the companies in the urban area a VVE structure can be set-up, that can organize their waste disposal together.

Financial incentive

The use of financial incentives can make certain products or applications financially more attractive.

- Normally, waste water flushes into the sewer. When taxes are paid over the amount of waste water that is flushed into the sewer, it will be more feasible to have a closed water system in which the waste water is re-used efficiently. This incentive can stimulate the design of a closed water-system.
- When local products are less expensive than products that are imported, because less taxes are paid over these products, the demand for these products can grow.
- Other way around; the environmental impact and pollution factor are calculated through in the prices of the used products. This means that products with a high environmental impact, that for example are produced in an environmental unfriendly way or transported from far away, are more expensive than local products.

Design tools

Design tools can be used in the design-phase of the urban area development to implement circular design principles.

- The BAG-viewer (basis administratie gebouwen), which is an online database consisting of all cadastral information of all buildings in the Netherlands, can be expanded by adding the demolishing date of a building and material passports into this tool. This makes it easier to make a match between the supply (demolishing) and demand (new built) of building materials.
- For the design of adaptable building, the 'Building Circularity Index' developed by Alba Concepts can be used.
- For the design of flexible public spaces, a 'Redundancy tool' need to be developed which can contribute in the optimizing of the public space.

Guideline

Circular urban area development

	Factors		Measures
Building cycle		**Circular building material flow** High-quality re-use of building materials in the most environmentally friendly way. In redevelopment projects existing structures can be re-used for the new design or can be stored in a nearby material hub.	→	Material passports for all buildings Material passports for all materials in the public space Use online data tool to find existing materials to re-use in own developent
		**Spatially adaptive urban area** Creation of adaptable buildings and flexible public spaces. The concept of Brand (1994) can be used to define which urban area components need to be robust and which need to be flexible.	→	Use the Building Circularity Index of Alba Concepts to design adaptable buildings Use the term redundancy to optimize the design of the public space
Use cycle		**Efficient energy system** An efficient and environmentally energy system can be selected based on the energy demand of the urban area. Energy generation and consumtion is influenced by the orientation of buildings and public spaces.	→	Use EPC or BENG to measure the energy perfomance of buildings Use EMG to measure the energy perfomance of the urban area Apply a smart flow analysis to design a smart energy system
		**Closed water-system** A closed water-system can be realised on the scale of an urban area. In this closed system, drinking-water, waste-water and the rainwater flow can be combined and connected. This watersystem has a strong relation with the flow of organic waste.	→	Change the 'hygiene code drinking water' to connect waste and drinking water Use crisis and recoveray law Introduce paying taxes over the amount of waste-water that is flushed into the sewer
		**Re-use, collection and logistics of waste** Households and companies producte waste on a daily-basis. Organic waste can be re-used in the urban area. Other waste flows, such as paper and plastics, need to be seperately collected in the urban area and can be recycled out of the area on a higher scale. The logistics of waste need to be organized in an efficient way.	→	Facilitate seperate waste collection is in the public space Change the law in Chapter 10 of Wet Milieu en beheer to make joint collection of residential and company waste possibble Set-up a VVE structure among the companies in the urban area to organize their waste disposal together
		**Stimulating the local economy** High-quality re-use of local products. In a mixed-use urban area places are created for repair cafes and the sharing-economy. Further, (roof) gardens can be designed to grow local products on that can be sold to local restaurants and shops.	→	Introduce less taxation over local products Calculate the environmental impact and pollution factor through the prices of products

Fig. 32: Circular urban area development guideline

8. Discussion

In the section the outcomes of this research are discussed. First, the results are compared with theory, second compared to practice and last the relation between the outcomes and the limitation and generatability of the results are discussed.

8.1. Discussion on theory

In the literature review of this research, three research themes were covered: (1) Circular economy and circularity, (2) Circularity in the built environment and (3) Circular urban area development. The outcomes of this research are compared and discussed in relation to the used literature.

Circular economy and circularity literature

The past few years many articles and publications are written about the circular economy and the concept of circularity. One of the difficulties of this subject is that many different definitions are used in literature and in practice, which lead to miscommunications. In 2017, Kirchnerr et al, concluded that out of 148 different publications, 114 different definitions of the circular economy could be found. In the paper “Conceptualizing the circular economy: An analysis of 114 definitions”, the definition of circular economy and circularity is conceptualized in different frameworks. The coding framework which summarizes the core principles and aims of the circular economy, states that the main aim of the circular economy is for sustainable development. This matches with the findings of this research, however practice is not still not aware of this. Further, Kirchnerr et al. (2017) expands the figure ‘outline of a circular economy’ of the Ellen MacArthur foundation to the 10 R-framework. According to the 10 R-framework the three approaches ‘reduce’, ‘rethink’ and ‘refuse’ are part of the circular economy. However, according to the findings of this research, these three approaches are not often used in practice, and are not reflected in the found factors, which are more focused on ‘reuse’, ‘refurbish’ and ‘recycle’. The reason for this is that we’re still using a linear economy approach consisting of linear standards.

Circularity in the built environment literature

In literature and in practice the term ‘circular economy’, ‘circularity’, ‘and ‘sustainable development’ are used next to each other and in the same context, without giving a comprehensive overview of their differences and similarities. Therefore, many miscommunications and misinterpretations occur in literature and in practice which has been proved by the 114 different definitions of Kirchnerr et al. (2017). To establish a comprehensive overview of these different terms the articles of Hoornweg et al. (2016), Steffen et al. (2015) and Geisdoerfer et al. (2017) were used. Out of these literature sources a certain hierarchy between the terms ‘circular economy’, ‘circularity’ and ‘sustainable development’ could be established. According to these literature sources, both concepts of the circular economy and circularity are used in the context of sustainable development. The main aim of the circular economy is gaining economic prosperity and is therefore an economic system. The concept of circularity is a derivative of the circular economy, has a focus on the environmental impact of building materials and resources and is seen as condition and used as a means for sustainable development.

The outcome of this research gives an overview of the terms ‘circular economy’, ‘circularity’ and ‘sustainable development’. This can be used in practice to reach consensus about these terms in project teams, which is according to the expert panel an important precondition for the development of a circular urban area.

Circular urban area development literature

Because literature sources about circular urban area development are scarce, literature about circular buildings and cities are used and combined to establish the components of a circular urban

area development. On the building scale the shearing layers of Brand (1994) are used, and on the city scale the ecosystem approach of van Bueren (2012). Brand (1994) states that buildings consist of several building components that all have their own lifecycle. This adaptable building concept has been found useful for the development of a circular urban area and is reflected in the found factor: spatially adaptive urban area. The ecosystem approach of van Bueren (2012) is partly useful. In this approach the three industrial flows: energy, water and materials are all connected to each other to minimize waste. However, in practice it is not possible to connect the material flow to the energy or water flow because they have to different characteristics which makes it impracticable. These three flows are all reflected in the factors of circular urban area development, however making interconnections between all of them is not possible. Further, the two factors 'waste collection' and 'stimulating the local economy' have not been found in studied literature. In the ideal circular economy, waste is seen as input, which clarifies why this factor has not been found in literature.

8.2. Discussion on practice

In this research several empirical methods are used: explorative interviews, case study analysis and an expert panel. The added value of each of these methods is discussed in this section.

Explorative interviews

During the explorative interviews, 11 different people with different backgrounds, municipality, developers and consultants, were interviewed to get an understanding of circularity throughout the whole real estate sector. The answers of the interviewees were varied. Some experts stated that the definition of circular urban area development was broad including social aspects while others narrowed the definition down to only building materials. Because the circular economy and circularity are new phenomenon's, people are biased by what they have experienced in practice or have read in papers. Because circular urban area development is a completely new phenomenon, no consensus about this subject could be established out of the explorative interviews. Nevertheless, this step of the research was indispensable to get a first feeling by the concept of circular urban area development and to draw a framework out of it that could be used for the interview protocol for the case study analysis.

Case studies

The three studied cases are all urban area developments that are in the initiation or design phase. In only one case, Kabeldistrict, a public-private collaboration was established between local authorities and developers which made it possible to research the public and private side of circular urban area development and to compare them. The other two cases are in the initiation phase, so only the point of view of the public side (including advisors) has been researched meaning that the factors have not been tested in practice.

Case I: Lincolnpark, Haarlemmermeer

When searching on the internet for 'circular urban area development', one of the first projects that come-up is Lincolnpark, located in the municipality of Haarlemmermeer. Despite, they have far reaching circular ambitions, all interviewed stakeholders agreed that the development itself was a sustainable urban area development instead of a circular urban area development. Out of this can be concluded that the term 'circular urban area development' for marketing and political purposes.

Case II: Beurskwartier, Utrecht

The municipality of Utrecht has a strict division in their sustainability themes. In their developments, circularity is used as one of the means to create a sustainable development. The development of the Beurskwartier area, can therefore not be called a circular urban area development. Nevertheless, interventions are planned in this area that are part of circularity such as the collection and logistics of waste and the stimulation of the local economy. Because both factors have not been found in studied literature, an explanation of these factors was found in the Beurskwartier case, which is more focused on pragmatic circular interventions than studied literature.

Case IIi: Kabeldistrict, Delft

This is the only case in which a collaboration between public (local authorities) and private actors (developers, architects) is established. At time of interviewing, the municipality of Delft had yet not composed a municipal policy on circularity. This makes it more difficult for the private side to establish concrete circular focus points for their development. This is reflected in the results of this case study in which the private side used a broad definition of circularity.

Expert panel

The last part of this research consisted of the expert panel. In preparation of this meeting a document was send which gave them an overview of the findings from practice so far. Directly, after I presented these findings a discussion (again) emerged about the definition of circular urban area development. There was no consensus among the group. Some used a broad definition which contained many sustainability themes while others used a smaller approach. One of the experts stated that a circular urban area development is a development where all flows are connected to each other. However, when an other expert asked the question “how this looks like?”, no answer was given. Despite, all experts agreed that ‘consensus is key’ for the development of a circular urban areas, no consensus could be established among the experts.

Further, the question was asked *“which disciplines are needed to make circular urban area development possible?”.* The question was misunderstood by the group who started talking about possible *‘actors*’. Out of this can be concluded that their scope is limited to public and private actors, instead of cooperating with disciplines outside the real estate sector.

Last, the experts stated that one of the preconditions for circular urban area development is to ‘create value in the design’. However, they were not able the define ‘why’, ‘what’ and ‘how’ of this value creation. Out of this can be concluded that the implementation of circularity is difficult and, still not always tangible.

Mismatch in practice

The three conducted case studies were part of the few larger urban area developments in which there is an emphasize on implementing circular principles. Although, many market parties are currently talking about the implementation of circular principles in their urban area developments, the actual execution of circular urban area development is not taken place. The most value created with these projects is the marketing and branding value for the organization itself. Mismatches in practice make is difficult to implement circular principles and to develop urban areas in a circular way. Out of this research the next mismatches in practice can be distinguished:

Quantitative vs. qualitative

First, there is no consensus about the measuring method that can be used to steer on circularity in practice. The public side wants to focus on qualitative measurements, without hard numbers, to value circularity. However, private actors such as developers and architects want to use quantitative instruments to delimitate their circular development. Further, with quantitative measures it is easier for the private side to justify their circular expenses and to include them in their business models.

Scientific vs. practice

Second, researchers of scientific papers and articles are using a broad definition of circular urban area development in which all existing flows are connected to each other and re-used in an efficient way. However, 'how' to implement this though in practice is unknown and unfortunately not do-able for practice. Stakeholders who are involved in circular urban area development in practice want to have a clear scope and definition of circular urban area development instead of a vague and not tangible definition.

Linear vs. circular

Third, the found factors are derived from urban area developments that are being developed according to the current linear norms and standards of urban area development. Because, a shift is needed in the whole economic system towards a circular approach, norms and standards will probably change. Therefore, the found factors are still based upon the linear economy, which is the 'old truth'.

8.3. Limitations, validity and generalizability of the results

First, for this research three cases in Dutch context were researched. Because the concept of circular urban area development is new and urban areas developments are long term processes none of them are completed yet. Therefore, it is difficult to test whether the factors are successfully implemented in practice. The derived factors from practice are all based on development plans that are established in the initiation or design phase of the project, therefore these factors are only tested on paper and not in real life. Therefore, the results are valid to a certain extent. More cases should be researched that are further in the development process (execution and exploitation) to validate the found factors.

Second, because of the lack of sufficient literature on circular urban area development most data is derived from empirical findings from practice. The data is conducted from explorative interviews with people working in real estate. Because of the use of a semi-structured approach, new topics could emerge during the interview and there was room for their own interpretations leading to biased answers. Therefore, the external validity of the found factors is enhanced by (1) conducting a cross-case analysis in Dutch practice and (2) incorporating outsides in the expert panel. Except one expert, these 'outsides' were not involved during the explorative interviews or case study research.

Subsequently, the three cases are located in the Randstad area. Development projects are location bound, therefore the context of the case has a large influence on the project outcomes which makes it difficult to generalize the results of these cases. Further, the cases are selected based on the use of circular principles in the project. Despite, circularity was an important theme in all of the three cases, more sustainability themes were used. Again, these themes were mixed in project documents and by involved stakeholders which makes it difficult to draw valid conclusions. However, certain factors and themes were used in multiple cases which makes it possible to draw some general conclusions that can be useful for further theoretical and empirical research into circular urban area development.

8.4. Added value of this research

Despite, circular urban area development is a new phenomenon, still consisting of many unanswered questions, this research contributes to theory and practice. This research provides an overview of the differences and similarities of the definitions of circular economy, circularity and sustainable development and their mutual relationship when these terms are used in the built environment. Further, this research gives a comprehensive overview of what circular urban area development could look like in practice. It provides guidance for developing a circular urban area in Dutch practice considering current norms. This guideline makes the development of a circular urban area more tangible for practice.

The shift towards a circular economy is a slow and complex process in which small steps forward need to be taken. Despite, this research is based upon empirical evidence found in urban area developments that are executed in a linear way, it helps in establishing the truth about where we currently are in Dutch practice and can be used as a starting point for the development of circular urban areas.

8.5. Recommendations

This section presents the further recommendations on the topic of circular urban area development, which is so new that many gaps in literature and practice could be filled by doing more research into this subject:

- Because the concept of circular urban area development is new, no circular urban area developments are completed yet. This makes it hard to test whether the found 'factors' can really be implemented in practice. Therefore, it would be interesting to conduct this research again when the projects are completed or in a further stage of development. The organizational, financial and legal barriers for the implementation of the factors can be researched more in-depth. As a result, advice can be given to change laws and regulations, establish new partnerships or create new business models to make the implementation of these factors possible.
- According to literature and several experts circularity, in the built environment is about flows such as water, energy, materials and waste, that are flowing in -and -out of the urban area through different scale levels. To close every flow in the most efficient way, it can be interesting to research which scale level is the most suitable for which circular flow. An outcome can be that for some flows, generic principles can be used. More research into the relation between flows and scale levels can be interesting to make circular urban area development more efficient.
- During the expert panel there was stated that the 'public space is key' for the development of a circular urban area. Local authorities are defining the boundaries for the public space and are responsible for the maintenance. Therefore, they play an important role in the implementation of circular principles in the public space. Many research is done into circular buildings, however circular public spaces is a less researched topic which is also less mentioned in the empirical findings of this research. Therefore, more research into this topic can be conducted.
- One of the findings of the expert panel was that the use of smart data can play an important role in the development of a circular urban area. Smart data tools can support the project team in making decisions. The relation between existing smart data tools and circular development can be interesting for further research. In this way, it can be easier to manage circularity and to measure the effectiveness of circular interventions.

9. Reflection

The final part of this thesis is a reflection on the graduation research and process. First, the position of this research within graduation laboratory is reflected. Second, the used research methods and process is discussed.

9.1. Position of research within graduation laboratory

This research was conducted in the graduation laboratory of 'sustainable area transformation' which is focused on sustainable urban area development. The 'sustainable' part is captured by the extensive research into the concept of circularity, that can be used to develop sustainable areas. Furthermore, urban areas are characterized by public-private collaboration focused on products and processes. in this research both sides are captured by defining the 'factors' of circular urban area development, the applicability of these factors in practice and the legal and organizational instruments, financial incentives and design tools that can be used to manage them.

9.2. Reflection on research methods

In this part the methods that are used to conduct this research are discussed.

Literature study

This research started with a literature study into the concept of circular urban area development. Because of the newness of this subject, almost none scientific research can be found. Therefore, it sometimes was a jigsaw to find and combine the right sources to lay out the theoretical framework. Fortunately, scientific literature can be found on circular buildings and cities. By combining these sources, a framework for circular urban area development could be established that was used in further research.

Explorative interviews

The experts that were interviewed during the explorative interviews all had different backgrounds. This was done, to address people that are active in all the facets of real estate and to make the outcomes more generalizable. However, not all interviewees were experts in the field of circularity and their answers were derived from personal opinions, resulting in broad outcomes. These explorative interviews were held in the beginning of this research. At this moment, the concept was new for both experts and I, resulting sometimes in less critical questions and results.

Case study

In the case study analysis, it was the first time that theoretical concepts felt into place and some consensus about the use of circularity in urban area development in practice could be established. Unfortunately, all researched projects were in the beginning of the development process, which makes it difficult to find real evidence. Furthermore, data derived from these cases was based on norms and standards that are currently used in traditional urban area development which are developed using a linear approach. When the principles of the circular economy are used, norms and standards will probably change. However, at the moment we're not that far.

Expert panel

Findings out of the case studies were discussed during the expert panel which resulted in an intensive discussion about the definition of circular urban area development. In this research the definition of circular urban area development is narrowed to get more focus. However, some experts of the panel used a broader scope, which made is difficult to criticize the found factors.

9.3. Reflection on research process

This last part reflects on the research process which started in September 2018. This part is written from a personal point of view.

In September 2018, when this graduation research started, the decision to conduct a research in the field of sustainable area transformation was quickly made. Based on my own interest in sustainable development, I started to explore the concept of circularity in relation to urban area development. After searching the internet, the lack of knowledge on the subject of circular urban area development became clear, and the topic for my graduation research was established.
The period before the P1 consisted mostly out of literature study and the reading of articles to get in touch with the subject. It became clear that no consensus of the definition of circular urban area development exists and that the concepts of circular economy, circularity and sustainable development are used in the same context and often mixed-up. Because, of the lack of literature on circular urban area development, practice was needed to find the possible definition of circular urban area development. The period between P1 and P2 was all about conducting explorative interviews to narrow the definition of this concept.

After all the explorative interviews were conducted, the findings could be tested and validated in Dutch practice by doing a multiple case study analysis. Three cases were selected; however, these cases were all in the beginning of its process. The factors of circular urban area development were only drawled on paper which makes it hard to find real evidence. However, during the cross-case analysis a pattern could be found in the development of these cases and the concept of circular urban area development became clearer. This was also the moment when things started to fell in place.

Finally, in the expert panel it became once again clear that no consensus of circular urban rea development is established. However, some clear directions and preconditions of circular urban area development were stated that can be used in practice and for further research.

In the beginning of this research I wanted to develop a circular urban area development scorecard that could be used in project teams of urban area development to make the implementation of circularity easier. However, this is yet not been possible because the concept is too new to make scoring possible. Although, the final results differ from the proposed outcome, this research has established some interesting findings on the factors of circular urban area development, possible instruments that can be used to manage them and a guideline that can be used in Dutch practice to develop a circular urban area.

Something that I will therefore take into practice myself it the awareness of the environmental risks that we're created in our linear system. During this research I became more aware of my linear behavior and I changed some of my behavior patterns: separating waste, only necessary showering, not using the dryer anymore, driving electrical and eating less meat. Further, I will definitely implement and share my knowledge on sustainable development and circularity in my next job.

Heleen Luijt
June 2019

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Appendices

I: Interview protocol explorative interviews

Experts interview; circulariteit in gebiedsontwikkeling

Interviewer: Heleen Luijt
Geïnterviewde: Naam + organisatie

1. **Introductie**
   - Introductie scriptie onderwerp; de toepassing van circulariteit in gebiedsontwikkeling

2. **Het begrip circulariteit**
   - Wat betekent circulariteit voor u/uw organisatie?
     - Wat doet uw organisatie precies met circulariteit: product maken, advies geven etc.
   - Wat is volgens u het verschil tussen circulariteit en een circulaire economie?

3. **Circulariteit in de gebouwde omgeving**
   - Op wat voor manier wordt circulariteit toegepast in de gebouwde omgeving (binnen uw organisatie)?q
   - Op welk schaalniveau gebeurt dit: materiaal, componenten, producten, gebouwen, gebieden, stad, regio's of misschien nog iets anders?
     - Kunt u hier voorbeelden van geven?

4. **Circulariteit in gebiedsontwikkeling (schaal groter dan het gebouw, schaal kleiner dan de stad)**
   - Hoe ziet volgens u circulariteit in een gebiedsontwikkeling eruit en hoe werkt dit?
   - Waar ligt de focus op:
     - Water, energie, materialen, zelfvoorzienend vermogen van het gebied, allemaal bij elkaar of misschien nog iets anders?
     - Product of het proces of allebei?
   - Kunt u voorbeelden geven uit de praktijk?
   - Is uw eigen organisatie bezig met het toepassen van circulariteit in een gebiedsontwikkeling?
     - Ja —> Welke voorbeelden kunt u geven?
     - Nee —> Waarom niet? Wat zijn de belemmeringen?
   - Wie moet circulariteit in gebiedsontwikkeling initiëren?
     - Publieke of private partij?
   - Wat zijn de belemmeringen voor een circulaire gebiedsontwikkeling?

5. **Toekomst perspectief**
   - Welke richting denkt u dat circulariteit de komende jaren opgaat?
     - Wordt het het nieuwe status quo of is het alleen maar een marketing term?
   - Wat zijn nu de drijfveren om circulair te ontwikkelen (kansen/obstakels)?
   - Waar verwacht men dat waardetoevoeging kan ontstaan door circulair te ontwikkelen?
   - Welke business en verdienmodellen kunnen hiervoor gebruikt worden?

6. **Afronding**
   1. Toevoegingen/aanvullingen/opmerkingen
      1. Cases
      2. Mensen die ik moet spreken

II: Interview protocol case studies
Casestudies interview

Deel 1: Potentie circulariteit gebied

1.1. Wat is circulariteit volgens u?

1.2. Hoe ziet volgens u circulariteit eruit in [projectnaam]?

1.3. Waarom is [projectnaam] gekozen als gebied waar circulariteit op deze gebiedsschaal toegepast kan worden? Wat zijn de kansen en potenties van dit gebied en waar zitten de moeilijkheden? (locatie/doelgroepen/schaal/programma/samenwerking/etc)

SWOT

Strenghts	Weaknesses
Opportunities	Treats

Deel 2: Thema's circulaire gebiedsontwikkeling

Op basis van voorgaand onderzoek heb ik 7 thema's en variabelen geselecteerd die passen binnen een circulaire gebiedsontwikkeling. Deze thema's kunnen circulaire ambities binnen een gebied versterken en concreter maken. Deze 7 thema's zijn:

1. (Integraal) systeem waarbij de kringlopen van water en energie gesloten worden en waar pieken opgeslagen kunnen worden om dalen op een ander tijdstip op te vangen: Smart grid. Beide kringlopen kennen verschillende fases.
    a. Water vormt een gesloten systeem op gebiedsniveau
    b. Energie heeft uitwisseling met andere gebieden (regioschaal) Fasering
        i. Opwekking
        ii. Distributie
        iii. Opslag
        iv. Gebruik

2. Materialenstroom: Hier is een uitwisseling van materialen tussen gebied en openbare ruimte mogelijk. Hiervoor is nodig:
    a. Materialenpaspoort/gebiedspaspoort waar alle materialen van zowel de gebouwen als de openbare ruimte gedocumenteerd staan.
    b. Materialen hub die een gebied kan bedienen groter dan alleen het plangebied. +/- 10km straal omdat transport kosten niet de winst van het hergebruiken van materialen mag overstijgen. In deze hub:
        i. Ruimte om de materialen op te slaan

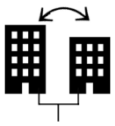
ii. Service provider die de materialen ophaalt, opslaat en weer wegbrengt

3. Afval: Wordt geproduceerd in de gebruiksfase. Er zijn 2 verschillende afvalstromen:
    a. Niet zuiver: plastic, glas, textiel, bouwafval zoals beton
    b. Biomassa en GFT afval: dit afval verzamelen (scheiden) in een afvalhub:
        i. Gebruiken in openbare ruimte en daken voor verbouwen lokale producten
        ii. Verbranden om er warmte en energie van te maken die weer ingezet kan worden in het gebied.

4. Gemeenschap/community: groep mensen die eigenaarschap voor een gebied voelen en zich identificeren met het gebied.
    a. Sociale controle en verantwoordelijkheid voor het gebied
    b. Deeleconomie: functies, ruimtes en attributen delen met elkaar
    c. Communitymanager
    d. Stimuleren van interactie en ontmoeten

5. Groen in het gebied. Groen kan CO2 opnemen waardoor er een balans tussen de vrijkomende CO2 en het opnemen van CO2 kan komen.
    a. Voorkomen/opnemen van emissies is goed voor de luchtkwaliteit en de gezondheid
    b. Klimaatadaptatie en biodiversiteit stimuleren

6. Lokale economie: stimuleren van een lokale economie door lokale producten en voorwaarden te gebruiken.
    a. Werkgelegenheid creëren
    b. Wonen, werken en voorzieningen op loopafstand – gemengd gebied
    c. Lokale producten laten groeien en gebruiken: bomen laten groeien voor houtbouw



7. Adaptief gebied: gebouwen als solids die makkelijk van functie kunnen wisselen en die op elk systeem/grid aangesloten kunnen worden.

2.1. Herkent u deze thema's en variabelen als zijnde onderdeel van een circulaire gebiedsontwikkeling?

- Thema's wel:
- Thema's niet: onder welk onderdeel schakelt u ze dan (energie/gezondheid/etc)?

Thema	**Wel**	**Niet**	**Waarom wel/niet?**
(Integraal) energie en water systeem			
Materialenkringloop – gebouw en openbare ruimte			
Afvalstromen – biologische kringloop en technische kringloop			
Gemeenschap/community			
Groen en CO2			
Lokale economie			
Gebied als adaptief systeem			

2.2. Op welke manier worden deze thema's en variabelen toegepast binnen de gebiedsontwikkeling van [projectnaam]?

2.3. Zijn er naast deze 7 thema's nog andere thema's die volgens u bij een circulaire gebiedsontwikkeling horen (die in [projectnaam] onder circulariteit geschakeld zijn)?

2.4. Op wat voor manier hangen deze thema's met elkaar samen/wat is de onderlinge samenhang van deze thema's? Welke thema's horen misschien bij elkaar en/of moeten samengevoegd worden?

2.5. Deze 7 thema's zijn vooral gefocust op (fysieke) productkenmerken, zijn er nog andere procesmatige kenmerken van belang/essentieel bij het doorlopen van een circulaire gebiedsontwikkeling die nog niet genoemd zijn?

III: Interview protocol expert panel

Expertmeeting circulaire gebiedsontwikkeling – Vragen

Scriptie onderzoek Heleen Luijt, TU Delft

Hoofdvraag onderzoek:

Welke factoren dragen bij aan de ontwikkeling van een circulair gebied en hoe kan er op deze factoren gestuurd worden in de praktijk?

Vragen expertmeeting:

1. Voor u, ziet u de factoren die bijdrage aan de ontwikkeling van een circulair gebied. Missen er in uw ogen nog factoren?

2. Hoe kunnen deze 'factoren' in de praktijk worden toegepast?

    a. Welke **actoren** zijn er nodig om circulaire gebiedsontwikkeling (d.m.v. deze factoren) mogelijk te maken?

    b. Welke **randvoorwaarden** voor gebiedsontwikkeling moeten er gesteld worden om een circulaire gebiedsontwikkeling mogelijk te maken?

    c. Welke **sturingsinstrumenten/-middele**n zijn er nodig om effectief te kunnen sturen op deze 'factoren'? (Bestaande juridische, financiële, organisatorische instrumenten, of nieuwe te ontwikkelen instrumenten. Denk hierbij aan bouwbesluit normen, financiële incentives, tendering etc.)
        i. Welke bestaande middelen kunnen we al toepassen (combinatie van meerdere middelen mogelijk)?
        ii. Voor welke factoren moeten we nog middelen bedenken? Hoe zien die middelen er dan uit? Combinatie van bestaande of nieuw te bedenken instrumenten?

    d. Wat zijn op dit moment nog de belangrijkste **knelpunten** (voor randvoorwaarden en instrumenten) voor het mogelijk maken van circulaire gebiedsontwikkeling?

3. Hoe realistisch is het, gezien de druk op de bouw (huizenvraag, bouwkosten), dat we de komende jaren in gaan zetten op circulaire gebiedsontwikkeling?

IV: Matrix – explorative interviews: circularity

Focus op materialen hergebruiken (min mogelijk afval)	**Milieu impact en het verkleinen van de CO2 footprint**	**Onderdeel van duurzaamheid**	**Focus op het productieproces van materialen**	**Sluiten van kringlopen**	**Anders**
Circulariteit: materialen hergebruiken.	Circulair bouwen gaat over de milieu impact van materialen over het hele productieproces	Circulair is 1 van de 4 hoofdonderwerpen binnen duurzame gebiedsontwikkeling: - Klimaatadaptatie - Luchtkwaliteit - Energie - Circulariteit	Die milieu impact is heel breed en gaat over de hele keten van delven van dat materiaal, tot transport, naar verwerking, vervolgens zit het 50 jaar in een gebouw en dan heeft het nog een bepaald afvalscenario.	Sluiten van kringlopen met zo min mogelijk afval - Energie - Water - Materialen	1. Dierbaarheid 2. Gezondheid/well 3. Dynamiek en flexibiliteit 4. Tec/Interactie:
Circulair bouwen gaat over de milieu impact van materialen en over het afvalscenario van deze materialen	Zo laag mogelijke milieu impact	Circulariteit is een thema onder de paraplu duurzaamheid	Bij het produceren van materialen zijn alle thema's integraal betrokken.	Kringlopen sluiten: - Water - Energie	Werken aan nieuwe proposities: hogere restwaarde andere voorinvestering (=financieel)
Reduce, reuse, recycle	Het gaat over het verminderen van je CO2 footprint:	Circulariteit is een thema onder duurzaamheid.	Op gebouwniveau beschouwen we bij circulariteit puur het materiaal. We nemen hierbij het hele productieproces mee maar kijken vooral naar of het materiaal 'virgin' is en de potentie om het aan het eind weer terug te winnen		4 problemen in de wereld die we moeten oplossen: 1. Vervuiling 2. Grondstoffenuitputting 3. Klimaatverandering 4. Ineenstorten van biodiversiteit. Deze 4 thema's horen allemaal onder circulair want ze gaan allemaal over de lokale economie en samenleving.
Wat kun je hergebruiken? Hoe ga je met je materialen om?	Bouwen met een lagere milieu impact en om de CO2 footprint te verkleinen	Circulariteit is een onderdeel van duurzaamheid.	Focus op productieproces van materialen en het hergebruiken hiervan		
Focus op het hergebruiken van materialen		Circulariteit is voor mij niks anders dan duurzaam bouwen. Duurzaamheid en circulariteit zijn integrale concepten die je niet kunt opdelen.			
Circulariteit heeft vooral betrekking op materialen					
Circulariteit gaat erover dat je nadenkt wat je aan het eind van de levensduur met de elementen/materialen gaat doen					
Op gebouwniveau beschouwen we bij circulariteit puur het materiaal. We nemen hierbij het hele productieproces mee maar kijken vooral naar of het materiaal					

IV: Matrix – explorative interviews: factors of circular urban area development

Integraal systeem: uitwisselen, koppelen en sluiten	Materialenkringloop (bouwhub)	Waterkringloop	Energiekringloop	Afval	Groen (+CO2)	Sociale component: Gemeenschap/community (deeleconomie)	Zelfvoorzienend/lokale economie	Adaptief bouwen (flexibiliteit)	Leasen-economie	Lokaal geproduceerde producten: Bio-based/natuurlijke materialen	Projectfase	Fysieke componenten gebied – lage MPG Kwaliteit gebied
Ontwerpfase: Sluiten en koppelen van de kringlopen water, energie en materialen tot een integraal systeem.	Bouwhub/materialenhub waarbij de vervoersbewegingen x de afstand niet vervuilender mag zijn dan de milieu winst die je maakt bij het hergebruiken van de materialen: +/- 10 km.	Gebied breed definieert kun je het ook hebben over energie en waterstromen.	Gebied breed definieert kun je het ook hebben over energie en waterstromen.	Gebruiksfase: Ouput van de een kan input zijn voor de ander. Wonen – werken met bijv. GFT afval.	Gezondheid: voorkomen van emissies en kwaliteit van de lucht. > Toevoegen van groen	Tec/interactie: Communitymanager is de interactie. Kan 1 iemand of meerdere partijen zijn die ervoor zorgt dat er gemeenschappen gevormd worden en in stand gehouden.	Iets maken wat logisch is voor de plek om de werkgelegenheid te creëren om de lokale economie op gang te helpen	Dynamiek: solids die oneindig van functie kunnen wisselen. Gebouwen hier als solids die je op elk systeem kunt aansluiten (energie, water). Actieve plint. Community manager die alles regelt.	Lease systeem op alle lagen van een gebiedsontwikkeling = kwalitatieve producten	Gebiedsontwikkeling is vaak een lang proces. Plot voor de bouw al inzetten om natuurlijke materialen op te laten groeien (bio-based).	Exploitatiefase/gebruikersfase: Kijk naar het programma. Ouput van de een kan input zijn voor de ander. Wonen – werken met bijv. GFT afval.	Zo laag mogelijke milieu impact (MPG) van de fysieke componenten van een gebied: - Bestaande gebouwen - Nieuwe gebouwen - Ondergrondse infrastructuur - Openbare ruimte (Verdiend niet perse een gebiedsaanpak)
Circulariteit: grondstoffen = materialen opnieuw inzetten uit gebied of nabije omgeving. Ook energie en waterkringlopen sluiten. Deze kringlopen bestaan uit: a. Opwekking b. Distributie c. Opslag d. (Gebruik)	Hergebruiken van producten en materialen (materialenstroom).: uitwisseling tussen gebouwen en openbare ruimte. Meer hergebruik mogelijkheden in een groot gebied (Meer R'en)	Kringlopen: Welke stroom voor welke schaal? a. Water = gebied	Energie = regioschaal	Afval: begint bij gebruikers. In een gebied kan 1 gebouw een afvalverwerkingsfabriek zijn (afvalhub).	Groen is belangrijk in je gebied (klimaatadaptatie en biodiversiteit) om CO2 op te nemen. Balans tussen CO2 uitstoot en opname.	Sociale component: bewust maken bijv. van je afval.	Zelfvoorzienend zijn door zelf energie op te wekken (energie)	Gebouwen die zo flexibel zijn dat je ze op elk systeem/net kunt aansluiten. Makkelijk van kleur kunnen veranderen: wonen – werken.		Lokaal geproduceerde producten: bomen laten groeien, materialen uit de buurt (kleine transportafstand).	Ontwerpfase: Sluiten en koppelen van de kringlopen water, energie en materialen tot een integraal systeem.	Kwaliteit en identiteit maken in het gebied waardoor de fysieke componenten langer mee gaan
Netwerk van stromen die logisch met elkaar uitgewisseld worden: materialen, energie, water en afval.	Materialen databank/hub en materialenpaspoorten met een meldpunt waar je je materialen kunt aangeven. Provider haalt ze op, slaat ze op en brengt ze naar de volgende (min mogelijk vervoersbewegingen). Dit kan met materialen met kleine levenscyclus: lantaarnpaal, straatmeubilair (=materialen hergebruiken).			Uitwisseling genereren met GFT en snoeiafval a. GFT + snoei scheiden > eigen groentes verbouwen b. GFT + snoei > energie > openbare verlichting	Mobiliteit anders inrichten: deelconcepten en minder CO2 uitstoot.	Gemeenschap/community: groep mensen die ergens eigenaarschap voor voelt. Fysieke ruimte bieden om een gemeenschap te vormen d.m.v. gedeelde functies/voorzieningen in een gebied	Buurtleven: 5.000 – 15.000 mensen. Alles op loopafstand, geen auto. Lokale voorwaarden en een lokale economie. Uitwisseling tussen buurten mogelijk.			Gebied heeft de schaal om bio-based materialen te laten groeien	Afval: begint bij gebruikers. In een gebied kan 1 gebouw een afvalverwerkingsfabriek zijn (afvalhub).	
Sluiten van kringlopen: energie, water en afval	Materialen, bouwhub = uitwisseling tussen meerdere gebieden			Groen afval hergebruiken. Afval van bewoners opslaan in een hub en er energie van maken (vervoersbewegingen minimaliseren)		Gebied vormt een gemeenschap/community die zich identificeert met het gebied (participatie en sociale samenleving)	Wonen en werken mengen met voorzieningen naast de deur. De auto en snelwegen zijn dan niet meer vanzelfsprekend.			Gebied al inzetten door bomen te laten groeien > inzetten voor langere tijd dus voor houtbouw (50 jaar) en niet verbranding	Ontwerpen vanuit de aarde. In ontwerpfase circulaire principes meenemen.	
Smart grid voor je energie, water en afval. Slimme uitwisseling met naastgelegen gebieden mogelijk om pieken en dalen op te vangen.	Bouwhub/2de hands Praktis waar je materialen tussen gebouwen kunt uitwisselen (tussen gebieden mits transport niet te ver is)			Biomassa afval wordt gefilterd door het gebied > afvalverwerker > warmte > terug naar het gebied.		Mobiliteit anders inrichten: deelconcepten en minder CO2 uitstoot.						
	Circulariteit: grondstoffen = materialen opnieuw inzetten uit gebied of nabije omgeving.			Biomassa afval = gebied. Hoogwaardig hergebruik op daken Afval (glas, plastic etc) = regioschaal								