Master Thesis

Reuse, Repair, Remanufacture and Recycle, Rethinking the Circular Economic Model.

A case study on business park Haskerveen, Heerenveen (The Netherlands).

N. Semplonius
S3114775
University of Groningen
Faculty of Spatial Sciences
Research Master Spatial Sciences
Specialization: Economic Geography
Supervisor: dr. A.E. Brouwer
Second assessor: prof. dr. D. Ballas

In collaboration with: Gemeente Heerenveen
Department: Spatial planning and economy
Internal supervisor: J. van der Laan

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Abstract

The need for sustainable development is widely acknowledged. In the case of production and consumption, this development should lead to the use of renewable resources and less waste. An element of the move towards sustainable development is the Circular Economy (CE), in which resources are recirculating. Sustainable development and the CE became more and more important in theory, after all, it remains difficult to translate it into practice. This qualitative research focuses on the unknown spatial scale in which the CE can best operate. A literature review, in-depth interviews in the case study area, and a geospatial network analysis based on the interviews are used. From the literature review, it becomes clear that many different components are required to create a successful CE. Moreover, contributions need to be made by both sides; companies and consumers. The case study area is already the location for some businesses that can contribute to a successful CE. Nonetheless, business park Haskerveen also shows that it is not achievable to have a complete CE on such a local scale. However, there is a possibility to close the loop for specific materials. For a CE in general, the regional scale will give the most successful results. To bring the CE to the highest success, it is important to have a clear focus and make use of the opportunities that are present or create new opportunities. More research into the practical application is recommended to increase the success of a CE.

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I. Introduction

Over the past decades, society has become more aware of the negative consequences of a growing population, their consumption, and technologies on the environment (Geissdoerfer et al., 2017). These human actions over time have led to an unstable world (Sillandpää & Ncibi, 2019). Alongside the environmental problems, also declining societal expectations and economic challenges lead to a need for action (Geissdoerfer et al., 2017). The current form of the linear economy, which involves the process of 'take-make-dispose' leads to a growing extraction of resources and unsustainable production processes. This linear model is fossil-based and waste-generating (Sillandpää & Ncibi, 2019; Graedel et al., 2009; Hobson, 2016; Dora, 2020). A change is needed on the global level, where sustainable products become the norm (Rijksoverheid, n.d.-a; Graedel et al., 2009). To make practices, processes, and products more sustainable, innovative and creative actions are necessary to meet the needs of the current and future population (Hobson, 2016; Gutterman, 2018).

Sustainable development plays a substantive role in the steps that should be taken and is gaining more and more attention. The concept of sustainable development emerged in the 1970s as a result of the degrading environment emerging from the imbalance created by humans (Caradonna, 2014; Sachs, 2008; Constantinescu & Planton, 2014). Sustainable development moves away from the capitalist approach (Hobson, 2016), and focuses besides economic growth also on the environmental and societal aspects (Streimikiene, 2020; Weybrecht, 2013). Sustainable development aims at creating places that are livable for both people and nature, including a green, carbon-free, and resilient economy (Sachs, 2008). Accordingly, it is important to combine the three aspects in the development towards a more sustainable world (Streimikiene, 2020). Within sustainable development, the goal of companies to gain economic growth does not disappear, although a new form of competitive advantage will be created (Gutterman, 2018).

One of the main economic concepts that is adopted in the shift towards a more sustainable world is the Circular Economy (CE) (Sillandpää & Ncibi, 2019). This concept first emerged in the 1990s, two decades after the emergence of the concept of sustainable development (Graedel et al., 2009). The CE is an alternative for the linear economic model (Graedel et al., 2009; Hobson, 2016). The move towards this new economic model is not only placed high on the political agenda at different geographical levels, but also non-governance parties have a high interest in this model (Hobson, 2016). The circular model aims at reducing waste, reusing by-products and waste, as well as recycling of products (Dora, 2020).

1.1 Research problem

The linear economic model leads to high levels of waste and high emission rates, which harm the environment as well as the people and animals living within. Moreover, waste creates an inefficient economic process (Dora, 2020; Roderigue, 2020). The environmental problems caused by this never-ending production will in the end lead to collapsing societies if no steps are taken (Diamond, 2011). Within the linear economy, approximately half of all materials used are burned or discarded after use and thus ends up in landfills or the environment. Within this linear system, only a quarter of the products is input for recycling. The high amount of waste in the linear system is the result of the low costs of new materials, compared to the process of reusing and recycling, which arises from the capitalistic approach (Roderigue, 2020; Hobson, 2016). A CE shows great opportunities and results in theories to move away from the unsustainable model, although it is questioned if this success, in theory, is also achievable in practice. Moreover, there is no clarity about the size of the geographical area in which a CE should operate to achieve the greatest success (Dora, 2020), the most successful scale level is still open for discussion.

1.2 Research question

The problems arising from the current situation as well as the lack of knowledge about the scale level in the scope of the CE and the implementation in practice led to the following research question and sub-questions:

At what spatial scale achieves the circular economy the highest success in practice?

- How is the circular economy modeled in theory?
- What role does geography play in the literature about the circular economy?
- How is the case study area performing as opposed to the theoretical model of the circular economy?

1.3 Goal and end product

This research aims at creating an understanding of what in theory is described as a circular economy, how it should best function and how it can succeed in practice. The research creates insights into the functioning of the theoretical model in practice and the geographical proximity of collaborations. The main focus is on the spatial and geographical aspects to find out what spatial scale provides the most optimal results. By performing qualitative research in the form of in-depth interviews, it is investigated to what extent the circular flow of materials, mentioned within the theoretical model of a CE, is achieved in practice and what can be improved. Business park Haskerveen and Ecopark de Wierde in Heerenveen, the Netherlands, are used as a case study for this research. This area is located on the west side of Heerenveen, near the A7 highway. At the business park, a chain of innovative, biobased companies is located (Gemeente Heerenveen, 2020), which creates a suitable location for explorative research. The results of the research are used to write a recommendation for the municipality of Heerenveen on how to proceed with the waste cluster at the case study area, located at the case study area, within the ambitions of 'Circular Valley Heerenveen' (Appendix D).

1.4 structure

The second section of the research reviews relevant literature, to find out what has already been researched and how to define the concept of a CE within the research. This section is flowed by the conceptual model and expectations based on the literature. In the next section, a theoretical model of the CE is framed to answer the first two sub-questions. In the fifth section, the research methods are described. Thereafter, the case study area is explored and information about the involved companies is given. In the results section, the data collected by the interviews is described and visualized. In the last section, the third sub-question and the research question are answered in the conclusion. Following, the discussion reflects on the research and presents the opportunities for the CE.

II. Literature review

2.1 Sustainable development

To first set a broader point of view, the overarching sustainable development, in which the Circular Economy (CE) functions, is discussed. The concept of sustainable development started emerging worldwide in policies and discussions at the end of the 20th century. The concept arose from the social and political awareness of environmental degradation caused by economic growth (Caradonna, 2014; Gutterman, 2018). Sustainable development first emerged as a framework, shortly after it became a paradigm, succeeding the economic growth paradigm (Constantinescu & Planton, 2014).

Sustainable development can be defined as a focus on long-term development to meet the needs of both the present and future generation (United Nations, 1987; Gutterman, 2018; Eccles et al., 2012; Santis et al., 2016; Shan, 2016). It thereby focuses on the acknowledgment of the imbalance created by human activity (Sachs, 2008). Sustainable development moves away from using resources in an unsustainable approach to preserve the contemporary population growth as well as their consumption. To achieve this sustainability, the use of renewable resources has to be equal to or greater than the use of natural resources. At the same time, the use of these natural resources has to decrease and the substances put into the environment originating from human activity have to be brought to a minimum level. In total it should thus lead to the conservation of the living environment (Heinberg, 2007; Geissdoerfer et al., 2017).

Sustainable development is as a result performed by, and for people, and therefore includes a transformation of human lifestyle (Constantinescu & Planton, 2014; Geissdoerfer et al., 2017). This lifestyle transformation can help to ensure a substantial quality of life for everyone, including environmental conditions, state of personal and public health, security, material welfare, psychological well-being, emotional conditions, and social ties. To achieve this substantial quality of life, a strong economy is required (Streimikiene, 2019; UNESCO, n.d., Dutta et al., 2012). Sustainable development focuses on three key aspects. First, the environmental problem, which is related to a loss in biodiversity, the pollution of air, water, and soil, but also the depletion of resources and excessive land use. Second, social aspects, which are related to high unemployment numbers, poor working conditions, vulnerability, the poverty trap, and equality as well as equity. Lastly, contemporary economic challenges are found in supply risks, ownership structures, deregulated markets, and financial and economic instabilities on different levels (Geissdoerfer et al., 2017).

Furthermore, business management started to include the concept of sustainable development as it has value potential for both the company and its stakeholders (Caradonna, 2014; Gutterman, 2018; Geissdoerfer et al., 2017). These businesses aim to achieve economic growth and stability and at the same time include social and environmental goals (Constantinescu & Planton, 2014). To become a sustainable business, large changes are involved to contribute to a sustainable society, including innovation and a shift away from the traditional business model (Eccles et al, 2012; Constantinescu & Planton, 2014; Laszlo, 2008). Companies that include social and environmental policies into their business plans, also financially profit from becoming more sustainable. This profit is mainly a result of socially responsible investments and the additional increasing stock (Eccles et al., 2012; Santis et al., 2016). Sustainable development offers many opportunities for the future, to which society and businesses have to contribute. One of the changes needed to provide these opportunities is a shift from the linear towards the Circular Economy.

2.2 Linear economy

The CE is often considered as an alternative for the traditional linear economy. Accordingly, it is important to first have a clear description of what this traditional model includes. The linear economy is based on the end-of-life concept as well as the 'take-make-consume-throw away' pattern; this system can be described as open (Sillandpää & Ncibi, 2019). The linear economy is extracting resources, manufactures products, and after use, these products are incinerated or landfilled. This straight line and open-ended model leads to high amounts of waste like it is designated from the starting point of the process. The model is lacking in key elements to creating a sustainable process and has a high focus on neoclassical and capitalistic economic growth (Sillandpää & Ncibi, 2019; Andersen, 2007). This focus is a result of low costs for materials and natural resources and the costs involved with sustainable options and processes. The linear economy is seen as a cost-effective process (Andersen, 2007; Stocker, 2019). However, by continuing with these processes, in the end, society as we are used to, can no longer continue. Therefore, an alternative like the CE is needed.

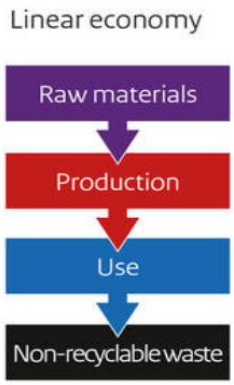

Figure 1 - The linear economy (Rijksoverheid, n.d.-b).

2.3 Definition of the Circular Economy (CE)

Since the emergence of the concept of the CE many different definitions have been stated and are included in a growing number of academic studies. Legislation, strategies, and policy development are dependent on the definition that is used. The most relevant definitions are stated in this section, to create an overview as well as a short description of what a CE is or should include. (Sillandpää & Ncibi, 2019; Geissdoerfer et al., 2017). Most definitions focus on either the use of resources and the total flow or on the change in the system (Ellen MacArthur foundation, 2015).

Within the definition of the European Union (EU), the CE model is focused on production and consumption but includes reusing, repairing, refurbishing, and recycling of the involved materials and products and keeping the materials within the economy. If it is no longer possible to keep the materials in their original form in the system, the waste is transformed into new resources, which will minimize the amount of waste that is produced. The EU is thus focused on the use of resources and the process. Within the definition used in the United States (US), the focus is more on the operationalization of the model for businesses and thus views from the perspective of the business strategy. A CE is then defined as a model that includes careful management of materials in the total flow. This is achieved by product design, reverse logistics, business model innovation, and cross-sectoral collaboration (Sillandpää & Ncibi, 2019; Bianchini et al., 2019).

Considering all different definitions, most seem to include elements of both the EU and US definitions and thus focus on both the use and flow of resources and the change in the business strategy. The CE is then defined as an industrial system that is regenerative and restorative in terms of intention and design. Accordingly, restoration, renewable energy, the elimination of toxic chemicals, and reuse are needed to reduce the high amounts of waste. To achieve this reduction, superior designs of materials, products, systems, and business models are involved (Sillandpää & Ncibi, 2019; Hobson, 2016). The combination of both elements is likewise used within the definition of the Central government of the Netherlands. This definition describes the CE as a model in which waste is the new resource. All products will be used again to reduce the use of materials and resources as well as preserve the environment. The CE will reduce emissions and stimulate innovation, new businesses, and employment (Rijksoverheid, n.d.-a).

Within the definitions, it becomes clear that not only renewable energy should be used, but also the total use of energy should be reduced. Moreover, the processes should extract the maximum value out of materials and products. Key processes in getting the maximum value of materials and

products are: reusing, repairing, recycling, recovering, regenerating, remanufacturing, and maintaining. In addition, the minimization of energy and resources also plays a role in achieving the energy goal. The process needs to be a closed-loop to be a CE. To close the loop, cooperation between producers, consumers, and other societal actors is needed (Sillandpää & Ncibi, 2019; Geissdoerfer et al., 2017).

For a consensus on the definition, four main components should be included. These components relate to 1) the recirculation of resources and energy, reduced resource demand and recovered value from waste, 2) A multilevel approach, 3) the model should contribute to the tridimensional aspect of sustainable development, and 4) there is a close relationship with innovations within society (Sillandpää & Ncibi, 2019). To complete the definition, the change in the business model needs to be included. For this research, the focus is on the flow of resources and material within the closed-loop, and therefore. However, to succeed, a change in the business strategy of companies needs to be made.

2.4 Circular economy (CE)

The CE has emerged as a holistic, restorative, and resilient model, which is mainly used within the industrial context (Sillandpää & Ncibi, 2019; Bianchini et al., 2019). Within this model, nature is no longer seen as a depot for waste and emission. The model includes a closed-loop network process in which resources are recirculating. Every output of one process is the input for another process. This network contributes to a retained value of products or parts of these products (Sillandpää & Ncibi, 2019; Bilitewski, 2012; Graedel et al., 2009).

The closed-loop system of the CE can be described as the design, control, and operation of resources, to receive the highest product value over the entire life-cycle with a dynamic recovery of value from different types and volumes returning over time. The supply chain includes four layers for the reverse logistics of products, namely: repair, reuse, remanufacture and recycle (Roderigue, 2020). The system of a CE can be achieved by a change in technology to create a cleaner production, in which resource efficiency is the first step (Sillandpää & Ncibi, 2019; Bilitewski, 2012; Hobson, 2016). At the same time, the interdependence between organizations and the natural environment is the main source of complexity in the practical implementation of a CE (Graedel et al., 2009). Nonetheless, there will arise a point in which the recycling process will become too difficult to generate benefits, a process in which also society plays an important role (Anderson, 2007). To retain the positive benefits of the CE, it is essential that the energy used by companies is generated by sustainable sources, as some energy sources can lead to higher environmental problems than are created by the waste in a linear economy (Geissdoerfer et al., 2017).

Product design plays an important role in the practical implementation of the circular model. Products need to be designed in a way that they not only last longer, but also can be reprocessed if the life-cycle is complete (Graedel et al., 2009; Hobson, 2016). For capital goods, a sharing aspect is developed to create a lower need for products and resources by sharing machines to create a more intensive use and thus a higher service level (Rijksoverheid, n.d.-a.; Graedel et al., 2009). A concept related to product design is Cradle to Cradle (C2C), which includes the remaking of products in a way that these products generate benefits for society, during the total life cycle and processing. C2C focuses on how products are designed and how to minimize the damaging effect on the environment (Sillandpää & Ncibi, 2019; Geisendorf & Pietrulla, 2018).

To achieve the best possible results, the flows of materials, money, and information need to be managed in the most effective way. This management will lead to a sustainable supply chain of raw materials, products, energy, water, finances, and information. Integration of this supply chain management leads to sustainable competitive advantage and sustainable economic growth and at the same time promotes social welfare and preserves the environment. Each step that is taken within the

system also needs to have an economic sense (Sillandpää & Ncibi, 2019; Graedel et al, 2009). Key aspects in this are: reduced use of resources, saving material costs, minimized energy consumption and waste generation, and incorporating more digital information about the exact resources to determine value. (Sillandpää & Ncibi, 2019; Roderigue, 2020).

Multiple models are created to visualize the circular business model and all have advantages and disadvantages. One of the most used is the butterfly diagram (figure 2), which divides the biological and technical materials in the value chain (Sillandpää & Ncibi, 2019; Bianchini et al., 2019). This model assumes that the CE is based on natural principles. Within this system, a higher amount of direct reuse will lead to lower costs in terms of material, labor, and energy. The butterfly model is the only model that divides different materials. Alongside this often used model, other relevant models can be found in the literature. First, the model of Accenture provides a diagram that completely visualizes the product life-cycle. This model is widely used to explain the wide concept of the CE. The model includes five underlying characteristics, namely: circular supplies, resource recovery, product life extension, sharing platforms, and product-as-a-service. Second, the moonfish model, which is a model visualized as an infinity sign in which there should be no waste. The focus is on maintenance, re-selling, refurbishing and remanufacturing, and recycling. This model also includes a clear network of collaborations, where partners ensure the circular process. Nonetheless, a cycle without any waste might be utopian, therefore, the model of EIT raw materials includes waste in every step of the model. Lastly, the Reike model visualizes a complex system of a CE, but is in practice too hard to understand (Bianchini et al., 2019).

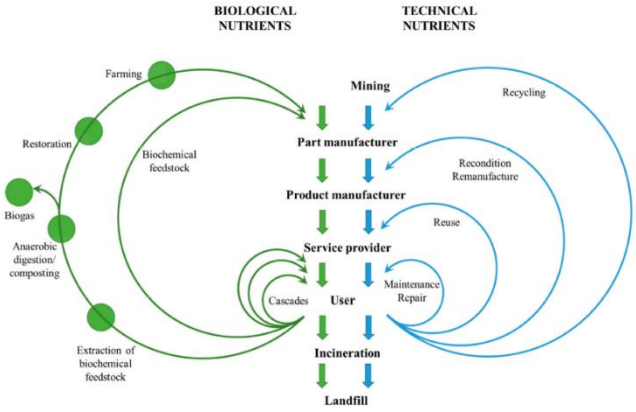

Figure 2 - The butterfly diagram (Bianchini et al., 2019).

The distinction can be made between two variations of the CE. The closed-loop system of the CE can be completely closed. In this case, the manufacturers reclaim their products from the consumers and return this into their system (Sillandpää & Ncibi, 2019). This type is covered by the extended producer responsibility (EPR) where the producer is responsible for the environmental impacts of their goods in terms of material sources (upstream) and product disposal (downstream) (Hobson, 2016). On the other hand, the closed-loop system can also be partly open. In this case, the marketed products are not recovered by its manufacturer, but by third parties that have different kinds of infrastructure, technology or expertise and thus have better ways to recover, reuse, or remanufacture the products (Sillandpää & Ncibi, 2019). Within a CE, collaborations increase the value through sharing data and working together towards innovation and investments (Dora, 2020).

To create the optimal results of initiatives within a CE, a corporation is needed between stakeholders internally as well as externally. Moreover, a clear target should be set to achieve the circular goal. To be a successful circular company, businesses should show that they are able to capture and create value as well as generate economic benefits (Bianchini et al., 2019).

2.5 Geographical aspect of the circular economy (CE)

The focus on a network of multiple contributing companies shows benefits compared to a completely closed system. A complete closed system within one specific location or company is hard to realize, as all the needed resources need to be available at the location at all times. Moreover, the manufacturing systems need to consist of all the right components and technologies that fulfill the aims of a CE (Graedel et al., 2009; Bianchini et al., 2019; Geissdoerfer et al., 2017). Furthermore, collaborating with

other companies helps to increase the use of the resources and creates the possibility to interchange waste and by-products (Dora, 2020). Porter (1998), describes these collaborations within a geographical area as economic clusters in which small and big, specialized companies work together to create multiple benefits working towards (sustainable) growth. Collaboration between interconnected companies also increases the audience that can benefit from these circular practices (Bianchini et al., 2019; Swords, 2013; Martin & Sunley, 2003). Thereby, a collaboration of companies with educational and governmental institutions, which is defined as the Triple Helix, will increase productivity within the cluster (Gachie, 2020). Clusters in literature are also mentioned as industrial districts, new industrial spaces, regional complexes, agglomerations, regional innovation systems, learning regions, or high-tech milieux (Swords, 2013; Martin, 2001; Ingstrup, 2014). Clusters vary in type and form but share the characteristics of proximity, linkages, interaction, and critical mass. Clusters can be formed top-down by government initiatives and policies or bottom-up by business initiatives. Both types of clusters often have one or more lead firms that have a higher level of growth compared to the cluster average. Lead firms have a facilitating role to provide opportunities for the cluster as a whole. The role of a lead firm is often fulfilled by a firm with access to the needed capital and technological and organizational skills. Within a top-down cluster, a lead firm has a central place where it proposes new initiatives as a decision-maker. In a bottom-up cluster, the lead firm is part of the network with participating actors and decentralized decision-making (Ingstrup, 2014). An example of collaborating companies within the system of the CE is eco-industrial parks, where companies are located at close geographical proximity to facilitate the exchange of materials that then form the closed-loop system (Hobson, 2016). Every CE functions within a geographical area, but at different scale levels, however, the distance depends between these companies on the demand for the product (Dora, 2020; Parr, 2017).

Next to the interchange of resources and materials, information also can be exchanged between collaborating companies to increase the results of the CE by reducing waste and increasing the raw material utilization, but also building competitive advantages. To achieve this result within collaborations, the business models of the companies need to connect (Dora, 2020; Bianchini et al., 2019; Sword, 2013). This interchange has so far shown the best results at a local level (Graedel et al., 2009; Dora, 2020).

Collaboration is often mentioned within the literature concerning the circular economy, however, the impact of geographical proximity on the collaborations is often neglected. Within the literature in which it is included, the scale level and geographical range are rather vague (Dora, 2020; Martin & Sunley, 2003). Geographical proximity does not only play a role in the functioning of a cluster, but also the forming and identification (Martin & Sunley, 2003). Within the CE, the waste disposal systems are also related to this proximity (Dora, 2020). According to Porter (1998), the scale level of clusters, in general, can vary from the local to the national level or can even be international. Withal, the interchange between the companies within the cluster shows the best results when these companies are geographically concentrated (Porter, 1990). Moreover, geographical proximity can be about both the absolute and the relative physical distance between different actors (Cetty & Michailova, 2011). According to Omobhude and Chen (2019), time is more influential for optimal proximity than absolute distance. Thereby, over the years, technological developments have decreased the distance in time of which some of the elements of clustering can benefit.

Face-to-face interactions, contact, and trust promotion play an important role in the collaboration. Close geographical proximity is needed to achieve the highest level of knowledge sharing and innovation (Dora, 2020; Cetty & Michailova, 2011). The smaller the distance between actors, the higher the amount of interaction appears to be (Omobhude & Chen, 2019). Notwithstanding, Graedel et al. (2009) state that it is not possible to have a completely closed CE within a single region or individual country. This demarcation is related to the availability of the right resources as well as manufacturing

technology to fulfill the aims of recovery, refurbishment, reuse, and recycling. This availability is not achievable for most areas. Therefore, a balance is needed between the proximity essential for the process and the availability of resources. The distance to and from certain companies and the resources depend on the importance of the products. For products with a unique value, distances might be larger, for more common products a location close-by is preferred. Nonetheless, economic clusters can choose to locate at the biggest central place, as all types and varieties of goods are in close proximity (Parr, 2017; King, 2020). The products mainly influence the location of the lead firm, from which the cluster originates (Ingstrup, 2014).

Although there is no uniform and clear definition on the most successful scale of the CE, researchers agree on the fact that the physical distance between the actors in the system influences the level of success. In an economic sense, it is not efficient to keep the system within arbitrary geographical borders and, thereby, geographical proximity is an elastic concept (Graedel et al., 2009; Martin & Sunley, 2003). The regional scale is the scale level that is most often used in literature about economic clustering, but no specific distances are mentioned (Martin & Sunley, 2003; Omobhude & Chen, 2019). In terms of distance, Omobhude and Chen (2019) defined that if the proximity between partners is less than 5 kilometers, a cluster can be defined as ultra-local. A cluster is local if the distance is between 5 and 50 kilometers. A distance between 50 and 250 kilometers is seen as a regional cluster. All networks with a distance of over 250 kilometers are defined as a national cluster. Moreover, it is already known that most collaborations happen with actors that are located in areas with similar geographical conditions. The optimal distance requires a balance in the distance in the way that geographical proximity will not create a lock-in effect and hold back innovation (Omobhude & Chen, 2019). To decide on the best functioning scale level for a specific economic cluster, it is important to know the linkages, spillovers, rivalry and the network that are linked to this cluster (Martin & Sunley, 2003).

To conclude, both the linkages between companies (horizontal/co-operative and vertical/ competitive) and geographical proximity play an important role in the functioning of economic clusters and are interdependent (Martin & Sunley, 2003; Dora, 2020). For the CE working within a cluster leads to shorter distances on which the materials have to be transported and gives opportunities for spillover effects. Both aspects will lead to a more successful CE.

III. Conceptual framework and expectations

3.1 Conceptual framework

The conceptual model (figure 3) shows the influential factors that will, according to literature, determine the right spatial scale for optimal success within the practical application of the circular economy.

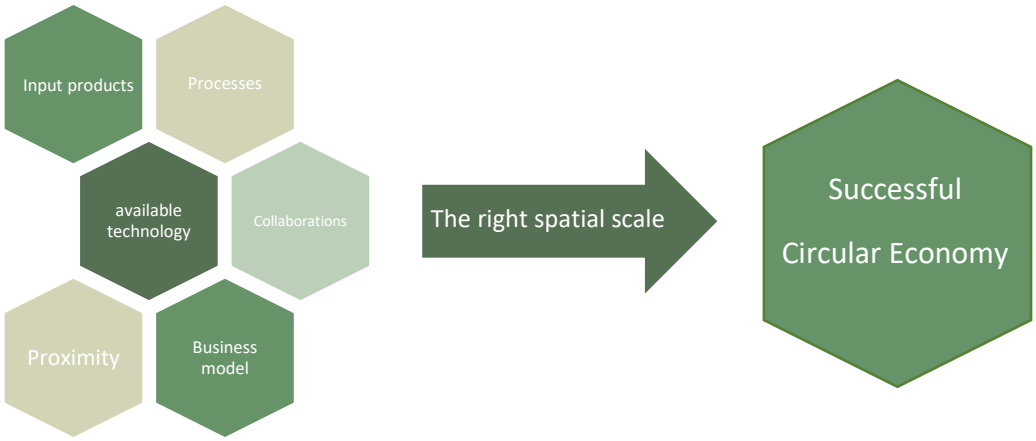

Figure 3 - Conceptual framework.

3.2 Expectations

Based on the literature and theories that are related to the circular economy (CE) in general, its performance, and the spatial location, expectations are set for the research questions.

For the first sub-question, touching upon the theoretical model of the CE, the literature review reveals that in the theoretical model the CE is described as a closed system with a focus on the industrial context, including raw material. The system relies on the model that does not include any waste and in which all resources will remain in the cycle. Within a circular system, all companies are expected to also have a closed-loop system for their processes. For the case study area it is expected that this leads to multiple companies focusing on a specific circular production system, but also being circular within their processes. The waste will be used as input for another company at the business park.

For the second sub-question: 'What role does geography play in the literature about the circular economy?' It is expected from the theory that clusters focus on a short distance between actors and that geography plays a significant role in closing the loop. For a cluster with multiple circular businesses, this distance will apply to the proximity of different companies within the cluster and not directly to the distance to consumers.

For the case of Heerenveen, it is expected that the theoretical model is not completely met yet. As described in the literature, it is hard to implement the theory in practice. CE is relatively a new concept, and accordingly, it can not be expected that everything works out well immediately. For the geographical aspect within the theoretical model, it is expected that the CE in Heerenveen can not achieve the best possible results by only focusing on the business park. The focus should be on a larger to achieve a closed-loop system. This scale depends on what is seen as geographical proximate and the location of collaborating businesses. It is expected that the closed-loop system, focusing on Haskerveen, can be achieved within the province of Friesland in the North of the Netherlands.

Taken together, for the most successful spatial scale for a CE it is expected that the factors stated in the conceptual framework will have an equal influence on the right spatial scale. Thereby, theory shows that most advantages are present within a smaller geographical area. The most successful spatial scale for the CE is thus expected to be at a medium level in which a balance between the factors is found.

IV. Preliminary conclusion: Theoretical model of the Circular Economy.

Based on the information gained from the literature, a theoretical model of the circular economy (CE) is sketched to answer the first two sub-questions. For this research, the focus is on the closed-loop system within a network of companies. Within this research, the CE is seen as a part of the sustainable development paradigm, rather than a paradigm itself (Sillandpää & Ncibi, 2019). The CE model is a sustainable alternative with the aim to replace the traditional linear economy to achieve the goals of sustainable development. Economic growth is no longer the only goal, but now, the focus is equally on the environment, society, and economy, which create a new competitive advantage (Gutterman, 2018).

The CE as a concept includes a focus not only on the use of resources but also a change in business models as well as society (Sillandpää & Ncibi, 2019; Bianchini et al., 2019). The idea behind the CE is to create a closed-loop system of flows in which products and resources are reused, repaired, remanufactured, and recycled to extract the maximum value (Sillandpää & Ncibi, 2019; Geissdoerfer et al., 2007). A visualization of this circular flow, based on knowledge from the existing literature, is shown in figure 4. This closed-loop system can be achieved on different scale levels and is focused on the raw materials within the flow of the CE. Within a well-performing CE, waste is reduced to the bare minimum, but preferably not present within the process, and as such the CE has a high resource efficiency (Geisendorf & Pietrulla, 2018). If there is any waste, this should be the input for one of the collaborating processes. Moreover, the energy used for the process should be generated sustainably, but should also be used most efficiently, so less energy is needed. However, energy is not directly included in the circulatory system, which focuses only on reprocessing organic materials (Geisendorf & Pietrulla, 2018).

To work within a closed-loop system, innovation is necessary. This includes innovations in technology for cleaner production, as well as product designs to maximize the value (Eccles et al, 2012; Constantinescu & Planton, 2014; Laszlo, 2008). To make a collaborative form of a CE possible, all resources need to be available in the designated geographical area (Graedel et al., 2009; Bianchini et al., 2009; Geissdoerfer et al., 2017). Geographical proximity plays a significant role in the success of the CE, nonetheless, geographical proximity is an elastic concept including both absolute and relative distance and thus context-dependent (Hobson, 2016; Dora, 2020; Graedel et al., 2009). Within a CE in the form of a cluster, it is important to be located at a reasonable distance from the input and output companies as well as educational and governmental institutions (Garcie, 2020). To create higher success, all the right components need to be available in the geographical area. This geographical area will cover a region, one of these components is a lead firm to provide extra opportunities (Ingstrup, 2014). The CE flow within a cluster network is shown in figure 5, for which the distance between the companies is still unknown. The scale level for the area can be defined if the location of the different firms in the circulatory system is known. In theory, a regional system, and its additional benefits is most often mentioned (Martin & Sunley, 2003; Omobhude & Chen, 2019). Knowledge about the spatial scale of the geographical area helps to apply the theoretical model in practice and to create the closed-loop system.

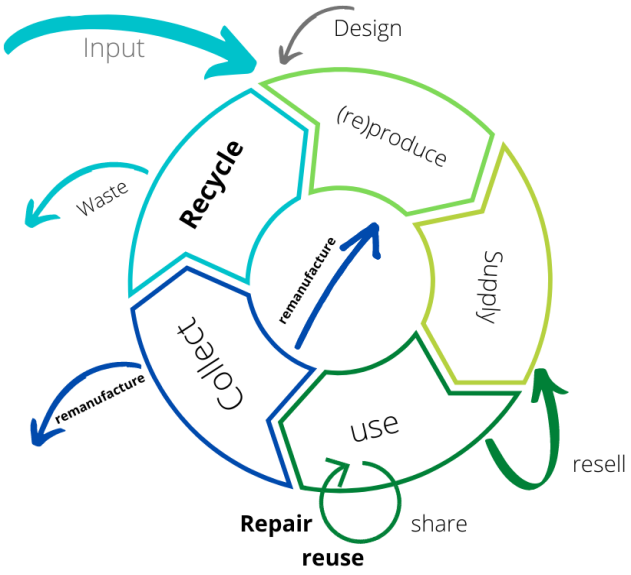

Figure 4 – The CE flow. Own design, based on Bianchini et al., 2019 and European Parliament, 2015.

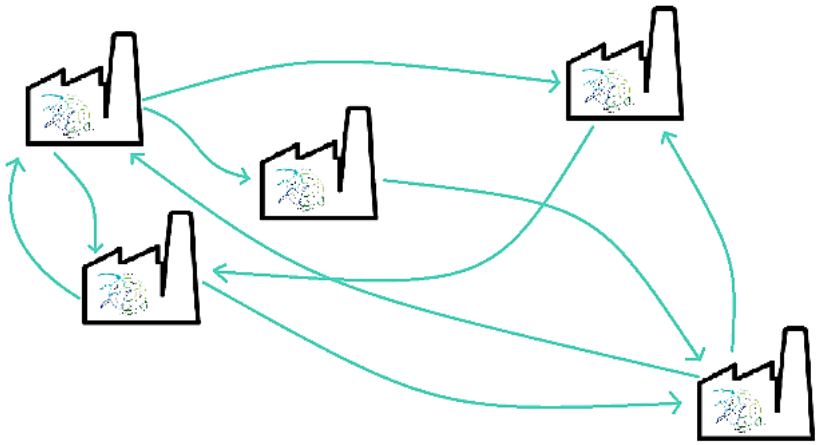

Figure 5 - The CE network of the close- loop flow.

Research shows, it is hard to have a practical implementation that mirrors the theoretical model of the CE. This difficulty is a result of a lack of consistency and precise information of the resources and products in the process, but also the process itself. To close the gap between the theory and practice a model is needed that is easy to understand for businesses, and applicable to different products and (industrial) sectors (Bianchini et al., 2019). For the implementation of the circulatory system, a business needs to make changes and focus on innovation. Moreover, there is a need for shared responsibility between producers and consumers to collect products after use, and the willingness to consume reusable or remanufactured goods. For the success of a CE, the geographical area in which the system should function needs to be defined. As mentioned before, there is little information on which spatial scale level works best for a circular cluster. Thus, it is important to collect information concerning to what extent the system of resources and materials is closed, and to what extent all waste, materials, and resources are used within the same or collaborating processes. This information collection is part of the practical implementation of the theoretical model, which in the end should be regenerative and free of waste. The success of the CE on a specific scale level can be measured by looking at the flow of (raw) materials within the system, how this is processed, and the decline in value of products and materials. Moreover, no nonrenewable materials can be used in the process and the used resources should be utilized the most efficiently and thus decrease over time. The total of the measurements then shows how successful a CE is within a designated geographical area.

V. Methods

Within this research, a combination of methods is used. First, a literature review was performed to gain insight into the theoretical model of the circular economy (CE). Second, in-depth interviews are held with respondents of companies that are located in the case study area. Lastly, a geographical analysis is used to visualize the networks of the companies in the case study area.

5.1 Literature review

Based on the literature review in the previous section, a theoretical perspective of the CE is created, which uses inductive reasoning. The literature review provides insight on the spatial aspects that are connected to a CE and answers the first two sub-questions of the. This systematic literature review provides a critical, but careful analysis and evaluation of the relevant literature about the CE and related concepts. This reveals what is already known, but also what knowledge is missing. Different points of view are included to find a larger pattern and connect different works (Punch, 2014; Harris, 2020). By reviewing the literature; ideas, concepts, and discussions related to the CE are explored, consequently, the literature review has a theoretical approach. To identify the relevant literature for the topic of this research, substantive screening was performed (Punch, 2014). This screening focuses on the general information about an article and the abstract (Harris, 2020), resulting in the inclusion or exclusion of literature. This process is performed to be as most unbiased as possible.

The literature search is performed within the online environment. First searches are done by using Smartcat, which is the academic database of the University of Groningen, and by the use of Google scholar. Both databases were searched systematically used the following search terms: *spatial aspect of circular economy, circular economy, linear economy, sustainable development, circular economy AND Geography, circular economy paradigm, Industry 4.0, Green economy, Circular Valley, Quantitative research AND circular economy, Cluster theory, Central place theory, Geographical proximity, Lead firms AND Clusters OR Circular economy.* To create a first impression, the most general terms and concepts were searched first ('circular economy', 'sustainable development' and 'linear economy'). In addition, grey literature, including governmental documents, is included to gain a more context-specific insight.

For the analysis, all relevant literature is grouped, based on the main topic. This arrangement contributes to performing a comprehensive review. Moreover, these classifications helped to get insight into missing knowledge (Onwuegbuzie & Frels, 2016). For the validity and reliability of the literature review, the quality of the literature used is important. Therefore, all academic literature used is peer-reviewed, and for most topics, recent literature has been included. Moreover, the articles are criticized on how it matches the research topic and if the literature includes an in-depth analysis with a clear research objective. The structured review, including multiple topics, helped to draw a partial conclusion about the theoretical model of the CE and the role of geography within.

5.2 Qualitative data

The third sub-question is answered by performing qualitative research in the form of in-depth interviews. Already plenty of quantitative research has been performed on the results of a circular economy. However, qualitative additions were missing. Therefore, this research used a qualitative approach to identify and characterize how a CE is performing compared to the theoretical model, with a focus on the geographical aspects within the literature. The in-depth interviews with respondents of companies located at the case study area provided insight on collaborations to close the loop and the geographical locations of these collaborations. The interviews shed light not only on the collaborations themselves, but also on the reason behind these collaborations. Moreover, the aim is to figure out how the theoretical model, in general, is included within the companies and the complete system.

The in-depth interviews were carried out with a semi-structured outline, the most important questions are written down beforehand, but there is also the possibility to let the interviewee give their input (Punch, 2014). The interview guide helped in having a constant factor within the interviews and made responses comparable (Flick, 2008). With the in-depth interviews information of the employees of the companies about perceptions and definitions of the CE was collected. Questions related to what they define as a CE and why they do participate are included. These questions formed the introductory part of the interview, together with some questions about the company itself. The core companies are selected in collaboration with the municipality of Heerenveen, specifically based on their location within the case study area, and if circular activities are performed within the company at this moment in time. Additional companies are a result of recommendations by the core companies during the interviews.

The core questions of the in-depth interview focus mainly on the input and output of resources and materials. The foundation of the questions is based on the relevant literature. Thereby, questions about collaboration with other firms and the influence of location were asked. These core questions focus on what kind of collaborations companies have with third parties, which of the processes within the model they perform themselves, and what processes are in the hands of such third parties. The interview ends with closing questions where the interviewee gives some last input or asks questions. A comprehensive list can be found in Appendix A. All interviews were held in Dutch and were translated within the results section.

The interviews were transcribed, coded, and analyzed (Punch, 2014) to find an answer to the third sub-question. This process is executed by using Altlas.ti, which assisted in coding and analyzing the given answers in a structured way, to get the optimal results. By coding the data, the responses of the interviewees were interpreted in the context of the CE. To achieve the right interpretation, correct coding is important, which includes sufficient knowledge about the research topic (Campbell et al., 2013). The first step within the coding process was the creation of a coding scheme based on a sample of the transcripts and the literature review. The coding scheme includes different groups of related codes and can be found in appendix B. The second step in the coding process was applying the codes to the transcripts of the interviews (Campbell et al., 2013; Flick, 2008). During the process, some additions were made to the coding scheme, as not all interviews and analysis of the interviews are performed at the same moment in time. For the final analysis, similar responses were put together and linkages between them were identified. The knowledge from the literature contributed to this data analysis. To make statements about the circular economy, all responses were interpreted and connected to each other. During the process there is reflected on the interpretation of the answers to check whether this was in line with what is described (LeCompte, 2010). This is done in together with the respondents.

5.2.1 Ethics

Ethics were taken into account ahead of carrying out the interviews. Therefore, the self-assessment of the faculty of spatial sciences[1] is used. As all questions of the self-assessment were answered with ‘no’, thus no ethical approval from the Ethics Committee is required, so the research could be executed by taking into account all ethical principles mentioned before. Next, an informed consent (Appendix C) was set up to give information about the research and its purposes to the interviewee and also states the right of the interviewee (confidentiality, anonymity, withdrawal). Moreover, the interviewee had the opportunity to give agreement to record the interview and further processing of the data (Punch, 2014; Flick, 2008). Moreover, it is important to respect the people that are involved in the interviews. Therefore, the participants and their answers are treated with respect and care. The research aims at

[1] https://www.rug.nl/research/ursi/organization/research-ethics-committee?lang=en

not bringing any harm, when there are conflicting interests within the ideas about the CE or related subjects, all response is collected and processed impartial (Nethics, 2018). Moreover, the benefits and burdens of participating in the research were mentioned beforehand (Flick, 2008). The results of the interviews are scientifically valid and aim at giving relevant insights to the practical side of the CE (Nethics, 2018; Flick, 2008) Processing of the data from the interviews is done according to the General Data Protection Regulation. Only the necessary data is collected and can not be accessed by third parties. All data is processed with confidence (Nethics, 2018; Hoorn & Montagner, 2018). Furthermore, the responses were transcribed and interpreted with accuracy (Flick, 2008).

Due to the Covid-19 pandemic, some more measures are taken. This is visible in online interviews, interviews by phone, or interviews where the 1,5-meter distance is preserved. Moreover, during in-person contact, all other measures set by the Dutch Government were taken into account to secure the safety of both the interviewer and the interviewees. If the interviews are conducted online, the informed consent is sent and signed before the start of the interview.

5.4 Geospatial networks using Geographical Information Systems (GIS)

To gain insight specifically on the scale level on which the CE has the greatest successes, the responses to the interview are used to visualize the geospatial networks of the companies. This process is done by mapping all collaborations of the businesses located at the business park and the interchanged flows of materials within and outside the case study area, using GIS software.

For the case study area, first, all interviewed companies and the companies for which collaboration is mentioned, are placed on the map as point features (nodes). These points are connected by links (line features) (Schöttler et al., 2021). Following, the lines are colored based on the material flow, moreover, arrows show the direction of the flows between companies. Outside the case study area the different companies involved in processing different materials and the distance from the case study area are visualized (nodes) within the city or country of location. These companies are linked to the business park, which is visualized as one node. The links for the collaborations outside the business park are also colored based on the flow of material.

To visualize the collaborations that happen within a certain spatial scale, the different scales used are based on Omobhude & Chen (2019) who defined different areas based on the number of kilometers from the main node (Haskerveen). The different scale levels are visualized using buffers based on the maximum distance from the node for every scale level. The geospatial networks complemented the literature review and the in-depth interviews in deciding on the most successful scale level for the circular economy.

VI. The case of Heerenveen

This research is performed in cooperation with the Municipality of Heerenveen. The location of the municipality is visible in figure 6. The focus within the research is on Business park Haskerveen and Ecopark de Wierde, which are located on the Northside of Heerenveen (figure 7). Within the research, the area together will be designated as Haskerveen in the following sections. The municipality aims to generate a 'Circular Valley' within Heerenveen. Circular Valley Heerenveen should become a hotspot for the circular economy (CE) in the North of the Netherlands. Within Circular Valley, optimal use and chances of materials should be the purpose of the companies involved. The aim of Circular Valley Heerenveen is to inspire, activate and stimulate companies, organizations, and residents of the municipality of Heerenveen towards a circular business model, lifestyle, and future. The total concept of Circular Valley not only includes the economic segment of society but all of society in Heerenveen. Because of the promising possibilities within logistics, construction, food and waste collection, and processing, the start of Circular Valley Heerenveen is within those four designated clusters. For the cluster of waste within Circular Valley, the case study area is designated as the main location. Within the municipality, the focus is on flows of materials, water, and energy, for this research the focus is only on the flows of materials. The municipality of Heerenveen thereby also mentions the special influence of plastics within a circular economy. All flows should be processed nearby, but also wide collaborations will be present (Personal communication, Gemeente Heerenveen, 14-06-2021).

Figure 6 - Location of Municipality Heerenveen within the Netherlands.

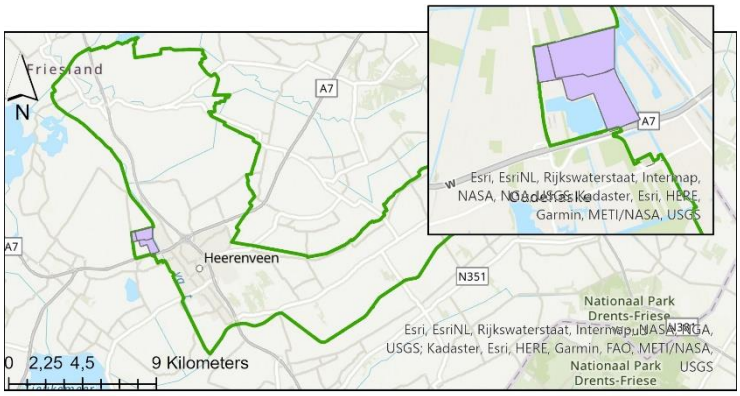

Figure 7 - Case study area Haskerveen, Heerenveen.

Companies of different sizes are located at the business park and perform different kinds of activities. For part of companies and their activities are related to sustainability and environmental issues. For other companies, possibilities can arise to participate within the circular network if the right adaptations are made (Gemeente Heerenveen, 2020).

One of the larger companies, located at the business park, involved is Omrin. Omrin is a company specialized in the collection and recovery of materials and resources from households within the North of the Netherlands, in collaboration with multiple municipalities. In addition to this recycling process, green energy, generated from organic waste, is an important aspect. To achieve the highest use-value of resources, it is important to prevent waste in the production process as well as separate different types of waste. Within the Netherlands, Omrin is a frontrunner in the development of a CE. By working together with the municipality of Heerenveen, Omrin works towards this goal, including many sustainable projects (Omrin, n.d.).

Figure 8 - The circular economic model (Metabolic, n.d.).

On a larger scale level, namely the province of Friesland, also activities towards a CE are performed. Circular Friesland (Vereniging Circulair Friesland) works within an open and active network of multiple knowledge institutions, governments, and businesses (Triple helix). All actors in this collaboration made the switch towards the circular economy, impacting their daily activities. The aim is to transform the province of Friesland into the most circular region of Europe, which can be achieved by taking both small and big steps towards complete circularity. For Circulair Friesland, there are seven important factors in the circular economy (Circulair Friesland, n.d.; Gladek, 2017). These seven pillars are visible in the CE model of Metabolic (figure 8), which is also used by Municipality Heerenveen to define the CE. Some of the pillars have a higher priority than others, based on different impacts. The pillars are seen as an essential tool for the development of the CE. In the surrounding of the seven pillars, three properties keep it together, namely: equity, transparency, and resilience. The definition for a CE of Metabolic is the following: *"The circular economy is a new economic model for addressing human needs and fairly distributing resources without undermining the functioning of the biosphere or crossing any planetary boundaries*." (Gladek, 2017, par. 6*).*

One step higher in scale level is the north of the Netherlands. Within the north of the Netherlands, there are many innovations related to the recycling process of plastics. This is perceivable in the collaboration of municipalities, provinces, companies, and educational organizations to realize the CE goals. This collaboration is known as 'Het Schone Noorden' and includes a high level of knowledge and experience with recycling plastics, including designs, logistics, and the process itself. Within the north of the Netherlands, all technology is present to recycle all different forms of plastics by the use of different processes. At various locations, the plastics are recovered from the waste of the inhabitants and businesses. The ambition is to become the expert ecosystem for circular plastics in Europe, with 100% circular chains (Chemport Europe, n.d.).

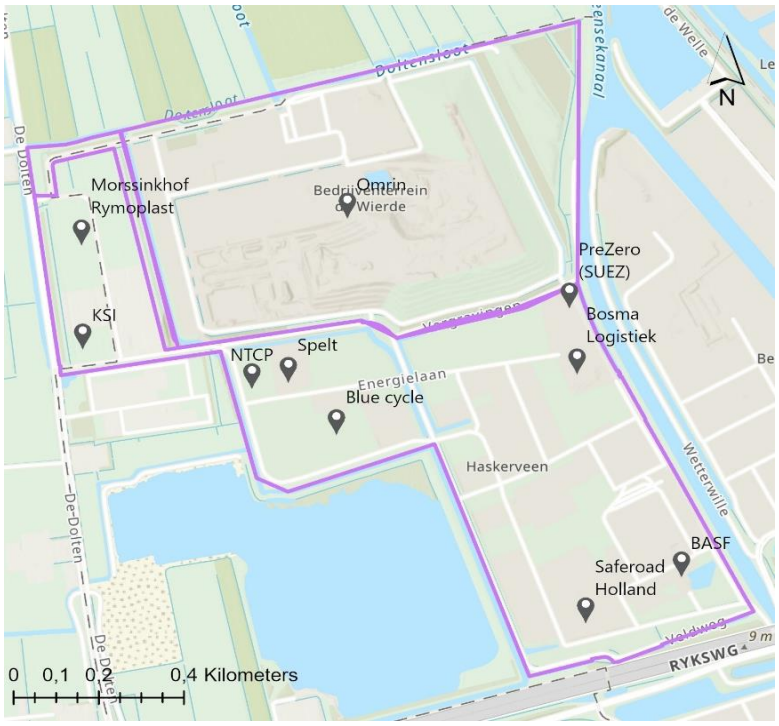

Figure 9 - Location of the interviewed companies.

6.1 Involved companies

Within the research three companies specialized in waste management are involved. These companies are Omrin, Spelt afvalinzameling and Suez. Moreover, companies specialized in processing plastics are included, namely: Morssinkhof Rymoplast, Kunststof Sorteer Installatie (KSI), and Blue Cycle. Also, the Nationaal Test Centrum Circulaire plastics is involved in the research. These companies together form the core companies within the research. These core companies were assigned by the municipality as frontrunners in terms of circularity and sustainability and accordingly most important to include in the research. From the insights gained during the interviews with these core companies and the contacts of the municipality, a few other companies are included in the research. These companies are Saferoad Holland BV, BASF and Bosma Logistiek. The locations of the participating companies at the case study area are shown in figure 9. More information about the nine companies involved in the research can be found in table 1.

Table 1 – Companies, their activities, and the function of the respondent participating in the research (Personal communication).

Company	Main activity at Heerenveen	Category	Function of the respondent
BASF	developing and producing chemical products for the printing ink and coating industry.	Other	Sustainability manager Benelux
Blue Cycle	Transforming residual plastics to oil	Plastic processor	Partner
Bosma Logistiek	Transport and storage	Other	Personnel and administration
Morssinkhof plastics Heerenveen B.V.	Transform HDPE and PP into plastic granules	Plastic processor	Supply chain and QHSE manager
Nationaal testcentrum circulaire plastics (NTCP)	Develop and test plastic packages	Research	Director
Omrin/ Kunststof Sorteer Installatie (KSI)	Collecting household waste/ sorting plastics	Waste management / plastic processor	Senior advisor Director recycling
Saferoad Holland	Design road safety materials	Other	Director
Spelt afvalinzameling Heerenveen B.V.	Collecting construction and demolition waste	Waste management	Location manager
PreZero (SUEZ)	Collection and transshipment of waste for recycling	Waste management	District manager Northern-Netherlands

VII. Results

7.1 The business park

Within the case study area Haskerveen (Business park Haskerveen and Ecopark de Wierde), multiple companies focus on waste and how to reuse this, three of them are focused on collecting and sorting waste. The location of part of these companies at the business park is the result of the former dump, this is indirectly the case for half of the companies that are involved in waste management and processing. In the past, waste was not processed with a focus on recycling, repairing, reusing, and remanufacturing, but all of it was dumped at different designated areas in the Netherlands. For the province of Friesland, the municipalities voted to create this dump in Heerenveen. By the time the rules and regulations regarding waste disposal were introduced, changes in the system needed to be made. Regarding this, the Ladder of Lansink shows a hierarchy of actions to reduce and manage waste. The most favorable option is to reduce waste, followed by reuse, recycling, energy generation, incineration, and ending with the least favorable landfill. This hierarchy aims to maximize the efficient use of natural resources and to stimulate the CE (Recycling, 2019). **Omrin**, and everything the company includes by today, has arisen from this former dump. The companies, other than waste collectors, located at the business park are located there because of the possibilities that **Omrin** created, mainly regarding waste as input. For instance, the respondents of **Blue Cycle** and **NTCP** mentioned:

> *"I have read many good things about Heerenveen, with Omrin and Morssinkhof and the test factory. I would say, you have to be close to the fire."* (Personal communication, **Blue Cycle**, 20-04-2021).

> *"Therefore, this location is strategic. And here at the industrial park there are of course more companies located that are focused on waste management and recycling."* (Personal communication, **NTCP,** 03-05-2021).

Six of the respondents mention that the business park has great transportation options, due to the central location close to the A7 highway and connections to other important highways and places, such as the respondents of **Spelt** and **Saferoad Holland**:

> *"[…] And then we had immediately the accessibility to the highways, then you have again the A6 and A7"* (Personal Communication, **Spelt**, 26-04-2021).

> *"[…] Then we chose for the business park at Heerenveen, because it is close to the highways. The rest of the Netherlands is well accessible."* (Personal communication, **Saferoad Holland**, 28-05-2021).

Respondents further appointed knowledge spillovers and collaborations as a result of locating close to similar companies. These spillovers can also happen in an informal setting if the companies are present in a local network. The smaller distance will also lead to more and fruitful collaborations.

> "We have the benefits of a knowledge cluster here, it is easier to share knowledge. *That at least is the theoretical thought behind.*" (Personal communication, **Morssinkhof Rymoplast**, 06-05-2021).

A substantial part of the respondents states that there are different collaborations within the case study area. Nonetheless, most collaborations mentioned are related to the products and materials and not directly to knowledge. Although, the respondent of **Saferoad Holland**, for which the production process is located outside of Haskerveen, states:

"For us [the neighboring company] is facile, we can just walk back and forth, we have already worked together for some decades. The benefit of being located close to each other is that you can switch quickly." (Personal communication, **Saferoad Holland**, 28-05-2021).

An example of the materials for which collaboration is initiated is the metal that is also further processed at Haskerveen. The respondent of **Spelt** mentioned:

"There is [at the business park] a collaboration with de Horne, this is where the metal goes." (Personal communication, **Spelt**, 26-04-2021).

The respondents of **Omrin** as well mentioned De Horne in their collaborations:

"Metal goes to our neighbor [that is De Horne], so that is kept within a short distance." (Personal communication, **Omrin**, 29-04-2021).

The three companies that do not have any collaborations at the business park regarding material flows (Bosma logistiek, BASF, Saferoad Holland), do have a client-supplier relationship with the waste management companies, this means the household waste of the companies, such as cardboard, wood, and plastics is also recycled at the business park.

7.2 Sustainability

The core companies for this research are the companies that are clearly including sustainability and circularity in their daily business. The respondents of two of these companies explained that it is important to know there is a distinction between the two concepts.

"You have sustainability, and I think that sustainability will be more the word than circular. That is my feeling with that, that is the word for now and that circular will be included because that is sustainability." (Personal communication, **Blue Cycle**, 20-04-2021).

"I find sustainability and circularity, which is good to mention, those are actually two different concepts." (Personal communication, **Morssinkhof Rymoplast**, 06-05-2021).

Contradicting, the respondent of **Morssinkhof Rymoplast** mentioned that the focus is on circularity, and sustainability is an element of this focus.

Before exploring the possibilities for a CE, the respondents mentioned the different sustainable measures that have already been taken. All companies take action to lower their CO_2 footprint. These measures vary from solar panels to CO_2 flowers, but also electric vehicles and machines, green gas, transportation by water, more sustainable lighting and heating, and/ or second-hand furniture. Moreover, also for purchasing and tendering, the environment is taken into account, and production processes and applications are made more sustainable. These measures are mainly focused on the reduction of CO2, as is also mentioned by the respondents of **BASF** and **NTCP**:

"One of the most important areas for us [in terms of sustainability] is CO_2." (Personal communication, **BASF**, 10-06-2021).

"In the end, the goal is not necessarily to be circular, the end goal is to lower the CO_2 emission." (Personal communication, **NTCP**, 03-05-2021).

The respondents of **Omrin** also mentioned the three pillars of sustainable development, including their contribution to flora and fauna, as well as social inclusion by creating job opportunities for people with a distance to the labor market. Regarding sustainable development, **NTCP** is the only company that has no focus on making a profit and thus to the lesser extent on the economic aspect, but just to improve the recyclability of plastics. Nonetheless, financial means are needed to cover the daily costs. One aspect half of the respondents agree on is that the amount of waste in general and specific plastics should be drastically reduced, as made clear by the following respondents.

> "When you look at the total waste produced in the Netherlands, that is just absurd." *(personal communication, **Spelt**, 26-04-2021).*

> *"There is still a lot of redundant use of plastics, of which you think, that could have been done with fewer layers."* (Personal communication, **NTCP**, 03-05-2021).

Moreover, the plastics required for food safety and shelf life should be designed in a way that it is possible to recycle and reuse in an easy manner, which decreases the CO_2 footprint.

> *"Thus, there are all kinds of discrepancies in how packaging is designed. […] There are packages where you have to use such a high amount of energy to recycle it in the first place, that you can say, maybe I have to accept in the coming years, as long as those materials are used, that they will not be recycled. The energy and effort that is needed, will lead to a higher footprint than when the material would be burned."* (Personal communication, **NTCP**, 03-05-2021).

> *"We think that when a product is launched on the market, that it should meet some requirements that make it recyclable."* (Personal communication, **Morssinkhof Rymoplast**, 06-05-2021).

Withal, plastic is not the only material for which a good design is needed to make sure it can be recycled. Thereby the concept of cradle-to-cradle (C2C) is mentioned, which can be measured with the environmental cost indicator, focusing on the environmental impact of the total process in which the material is involved.

> *"I am afraid that many of the bio-based materials that are produced nowadays, what you say, have a minimal ability to be reused. They can only be ground as pigment for other products. […] You need to look at the total environmental impact."* (Personal communication, **Saferoad Holland**, 28-05-2021).

7.2.1 Circular economy (CE)

Considering the CE as an element of sustainable development, the focus should be on keeping materials within a closed loop. The respondents have a similar view on the aim of a CE. This aim is to keep resources in the system by processing them into new sources. To close the loop completely a specific market for the recycled products is necessary. The goal is to close the loop for 100% of the materials collected by the waste collectors at Haskerveen. However, in practice, the amount of recycled and reused materials is around 73% at the business park. Thereby, according to four of the respondents, it is important to keep the value of the recycled products and to avoid downgrading as much as possible.

> *"Circularity is actually what I just said, to make from the original product that has become waste, to transform it into the same new product."* (Personal communication, **Morssinkhof Rymoplast**, 06-05-2021).

However, the respondent of **BASF** mentions a second form of the CE included in their vision, which is the replacing of fossil fuels by the recycling of other resources. An example mentioned is the generation of oil out of plastics or car tires, for use in their own factories.

> *"This system is not a closed-loop as we do not produce new car tires. But it is a circle, we are solving the waste problem and keeping the carbon, which it is about in the end, within the circle, as we use it as input for our factories."* (Personal communication, **BASF**, 11-06-2021).

For **Saferoad Holland** already 80-90% of their systems are reused or repaired while keeping their value. Nonetheless, it is not possible to recycle and reuse materials forever, after a certain number of processes, the material is no longer deployable. To prolong the life cycle, possibilities for upgrading the value of the material are mentioned by the respondents. In addition, the respondent of **Blue Cycle** acknowledges that the circularity of materials is not completely circular, but also the residuals influencing the CO_2 footprint of the process need to be redeployed. A CE can be used as a means to achieve sustainability goals such as CO_2 reduction, as three respondents mentioned. Both the processors of the plastics, **Morssinkhof Rymoplast** and **Blue Cycle,** state that the process of plastic recycling already causes a lower CO_2 emission than the production with new resources or the process of the incinerator.

> *"Compared to the incinerator, we save 35.000 kilotons of CO_2."* (Personal communication, **Blue Cycle**, 20-04-2021).

> *"We did some research on that [the difference in CO_2 emission], I think that was a decrease of around 50% compared to a virgin producer."* (Personal communication, **Morssinkhof Rymoplast**, 06-05-2021).

One of the respondents also mentioned that sustainability and circularity is something in which all companies, not only the ones involved in the research, want to lead in this development, which is confirmed during the other interviews. In addition, the respondent of **Spelt** mentioned that this circularity starts with humans, so the producer and the consumers. **NTCP** helps to achieve the effort that should be taken. A CE is something that needs to be done in collaboration.

7.3 Waste management

The process of waste management at the case study area starts with the waste that is collected and transported to the waste processors (**Omrin, PreZero, Spelt**). This includes both waste that already has been separated by the households and the general waste. The three waste processors first start with a general separation of different types of materials. The waste of households and companies has priority in this process, as industrial waste is often more homogenous and thus easier to recycle. Within the first separation, the valuable items are removed, such as plastics, metals, and beverage cartons, together with some sand and pebbles. Elements of the organic waste are fermented and transformed into green gas. At **Spelt**, the first step is again to separate all the different construction materials that are collected. For the debris and stone material, a crusher will on the spot transform the material into stone granules, which then immediately can be used in for instance infrastructure projects. The respondent of **Spelt** states:

> *"The [stone] granules we get in with the garden and stone waste, that are broken over here and made ready to resell and also sold here. So that is circularity first class."* (Personal communication**, Spelt,** 26-04-2021).

Regarding collaborations outside the case study area, the distance to the other companies shows large variations. For some materials, such as the stone granules, it is possible to reuse or recycle them at short distances.

> "The biggest consumption [of stone granules] is done by companies located in Heerenveen." (Personal communication, **Spelt,** 26-04-2021).

At this local scale level, there are also possibilities for organic waste. To close loops at a local level it depends on what is present or available in the local area. The respondent of **PreZero** mentioned however a possibility to also recycle wood within Heerenveen:

> *"You could say, SUEZ [now PreZero], keep those beams separated and bring them to a wood planing at Haskerveen, which makes them decent again and then bring them to [wood company in Heerenveen] that can sell it again for wood construction."* (Personal communication, **PreZero**, 02-06-2021)

The following materials are recycled at a larger scale, namely in the North of the Netherlands: wood, paper, and organic waste. For materials like textile and glass, the processing is currently carried out on the national level. The same scale level applies to the oil that will be produced at **Blue cycle**. The plastic granules of **Morssinkhof Rymoplast** are even transported and processed at the European level. All waste that can not be recycled is transported to the incinerator at Harlingen, where steam and electricity are produced out of the waste. This is the case for the residual waste of all three waste collectors.

> *"We try to avoid bringing waste to the incinerator, next to the fact that that still is a useful application at the moment nothing else can be made out of the waste."* (Personal communication, **PreZero**, 02-06-2021).

7.3.1 Plastics

Only two types of materials collected by **Omrin** are further processed by other companies within the case study area. These materials are metals and plastics, other materials are processed by other companies within different distances from the business park. Of these two materials, processing plastics has significant importance. However, for plastics, it is mentioned that it is not favorable to transport it over great distances. Plastics is also one of the pillars of Circular Friesland and a focus point of the Municipality Heerenveen. Over time the use of plastics has significantly increased and is twenty times as much as it was in 1950. This increase also concerns the increased applications of these plastics. Most of the plastics are produced as single-use plastics for packaging. All different types of plastics, their properties, and the increasing amount lead to problems in the management of plastic waste (Millican & Agarwal, 2021; Ragossnig & Agamuthu, 2021). The plastic collected by **Omrin** is more specifically sorted in the plastics sorting installation (**KSI**). The plastics are sorted into different fractions such as PET, PP, and PE. More information about the different types of plastics can be found in figure 10.

Figure 10 - Plastic Resin Identification. (ATS, 2020).

The next phase at Haskerveen is the transformation of the sorted plastics with high quality. These are the PP and the HDPE plastics, which are sorted out at the **KSI**. These plastics are processed at **Morssinkhof Rymoplast**. An intensive process will sort these plastics based on their color, which then will be washed intensively and ground into flakes. The flakes then will be transformed into plastic granules, which is the end product of **Morssinkhof Rymoplast** (figure 11). These plastic granules then are sold to converters or brand owners and transformed into new plastics of similar high quality. **Blue Cycle**, the company that will operate at Haskerveen in the near future, has the aim to process all plastics that can not be used in the process of **Morssinkhof Rymoplast**. **Blue Cycle** will transform these plastics into oils. This oil will be transported to a company, outside the business park, and be transformed into new plastics. **NTCP** contributes to plastic recycling by experimenting with the recycling of newly developed packing material that will create a higher percentage of reused and recycled plastics in the future for different actors in the market.

Figure11 – plastic granules out of recycled plastics. (Morssinkhof, n.d.).

7.4 Circular Valley Heerenveen

To create the waste cluster within the ambitions of Circular Valley Heerenveen the respondents agree with each other to include the plastics cycle as a specialization within the waste cluster. Two respondents argue that the focus on plastics will be enough to create a waste cluster within Circular Valley.

> *"Focusing on plastics is a good option […] Omrin and we will still have some residual plastic waste, these can be picked up by Blue Cycle."* (Personal communication, **Morssinkhof Rymoplast**, 06-05-2021).

> *"That is a nice ecosystem, as we call it. As you mention, the collection of waste, plastic secretion, and again the recycling of plastics, which will also create a residual stream. Those can then, by chemical recycling, be processed by Blue cycles to oils. That is an interesting one." (Personal communication, **BASF**, 10-06-2021).*

Most respondents from the core companies state that the main focus should be on plastics, as this is already present at the business park. However, some other material cycles should be included as well. Focusing on all collected materials will be too broad and not feasible.

> *"No, focusing on everything is not possible, they [the municipality of Heerenveen] have to pick areas of interest, of which plastics can be one."* (Personal communication, **Omrin**, 29-04-2021).

> *"You need to be selective in the [waste] flows you want to work with. You should not cause harm elsewhere by saving on CO_2 here."* (Personal communication, **PreZero**, 02-06-2021).

Examples of additional materials are metals, wood, or stone granules. The stone granules already function in a closed-loop system at the business park. Another example is organic waste, for which both Spelt and **Omrin** noted an option for further processing at the case study area. One respondent mentioned that you can use the plastics as a showcase for the waste cluster at Haskerveen. This focus

on plastics is in line with the ambitions of the municipality of Heerenveen and the collaborations within the North of the Netherlands.

> "I think that you already have a partly a great showcase with plastics, thus I would then find out how that can be made stronger. There are for instance one or two other themes to which it also can be applied and where plastics are some sort of pull racket." (Personal communication, **NTCP**, 03-05-2021).

Different components are needed to set up the waste cluster at Haskerveen and Circular Valley in general. These components need to include knowledge, production, and a basis of governmental conditions. Part of these components, which are also needed for the closed-loop system, is already located at business park Haskerveen. An important actor that should be added in the plastics loop, according to a third of the respondents, is a company that can convert the plastic granules and in the future also the oil into new, high-quality plastic packages. This conversion can conceivably be implemented within the process of **Morssinkhof Rymoplast**, as this process is already performed at other locations of the company. With this addition, the end product can be converted into packaging at Haskerveen, but this is not (yet) possible for the complete output as this leads to difficulties with the transport to collaborating companies further away.

> "You can put 20.000 kilos of plastic granules into a truck, but this is not possible for bottles." (Personal communication, **Morssinkhof Rymoplast**, 06-05-2021).

If the focus will be broader than only plastics, there might also be the need for other processors to close multiple material loops.

> *"A company [in plastics] can locate and meet the needs of the other companies located [at Haskerveen], but this then can also be a paper factory."* (Personal communication, **PreZero**, 02-06-2021).

The cluster at Haskerveen can be set up as an experimental location to explore the possibilities regarding the processes. The respondents mention that it is important that the Municipality of Heerenveen presents itself as a driver and a leader of the circular economy during the developments of Circular Valley. This can be expressed through favorable conditions regarding sustainability and circularity. Moreover, the Municipality of Heerenveen should lead by example and contribute to both concepts in its business operations.

> *"The municipality should function as the motive power."* (Personal communication, **PreZero**, 02-06-2021).

The respondents state that the municipality already facilitates sustainable and circular initiatives, more than many other municipalities. All respondents mentioned that the companies are willing to contribute to such a development. All companies should then include a change in their business and processes to be a part of this concept in an inclusive way. The municipality can be the connecting factor to achieve the goal of a circular system, but also by helping less sustainable or circular companies to find out what is already done and what can be improved. By attracting more companies that fit within the cluster and help them with what is needed, the municipality and the companies can together create a positive feedback loop where more companies can be located within the cluster and contribute to closing the loop. Beneficial conditions can contribute to development and attraction. To promote Circular Valley and attract companies, the waste cluster must be more specific to the materials that are or can be processed at Haskerveen. Moreover, the business park in its appearance

could show some more circularity and sustainability to make it easier to recognize Circular Valley and the included clusters, based on their focus.

> *"[…] Then you can of course also say, everything we do at the business park, if the municipality thinks it should be a sustainable or ecological hotspot, then will we also do that sustainable […]."* (Personal communication, **Omrin**, 29-04-2021).

Furthermore, at the business park itself, it is important to keep the environment in mind and make sure no waste can be found in nature. These smaller issues are also elements where the municipality together with the companies located at the business park can work on. Another suggestion for the municipality to lead by example is to become one of the first governmental institutions to have a sustainable purchasing policy.

7.4.1 Spatial scale

For the scale level on which the loop can be closed for the companies located in the case study area, the respondents have different opinions. First, the type of material influences the scale on which a closed-loop system is possible. When focusing on plastics, for some it seems possible to have a close system at Haskerveen in which the high-quality waste is transformed into the same high-quality packaging. This is, however, only possible if the produced resources can be converted at Haskerveen. Moreover, the North of the Netherlands is mentioned as a possibility for a closed-loop system, as this still is seen as proximate. This proximity also has a positive impact on CO_2 emission.

> *"I think when looking at the Northern Netherlands, that things are possible based on volume and supply."* (Personal communication, **PreZero**, 02-06-2021).

In addition, according to most respondents, the distance does not play a great role in considering collaborations but can make things easier. No clear distances were mentioned. Nonetheless, in many other fields, the three northern provinces (Friesland, Groningen, and Drenthe) already collaborate or have overarching institutions. Moreover, arbitrary borders also should not have too much impact.

> "If I accidentally have to hook up with a company in Overijssel or Drenthe to close a certain circle, I think that you should profile more like the party that overlooks and arranges, and if that then is within the border of the province or not, is not that relevant to me." (Personal communication, **NTCP**, 03-05-2021).

However, for many other materials, the market proximity to Haskerveen is not sufficient. Therefore, for these materials, the loop can only be closed at a larger scale level, such as the Netherlands or even Europe. It depends on the availability of recycling possibilities, the capacity, and the demand and supply.

For two of the respondents, the efficiency of the process is the most important factor to create a closed-loop system. The respondent of **Saferoad Holland** mentioned that it is most achievable to create a circular economy on a wider scale level. Withal, it first has been proven to work at a small scale, which can be Haskerveen.

> "The silly thing is, you have to do it at such a big sale, only then you can see the effects, but if you never start small, you can never show it actually works." (Personal communication, **Saferoad Holland**, 28-05-2021).

In the end, most companies think that there are possibilities at close proximity to create a successful CE, and all are open to contributing to making development possible.

7.5 Geospatial networks

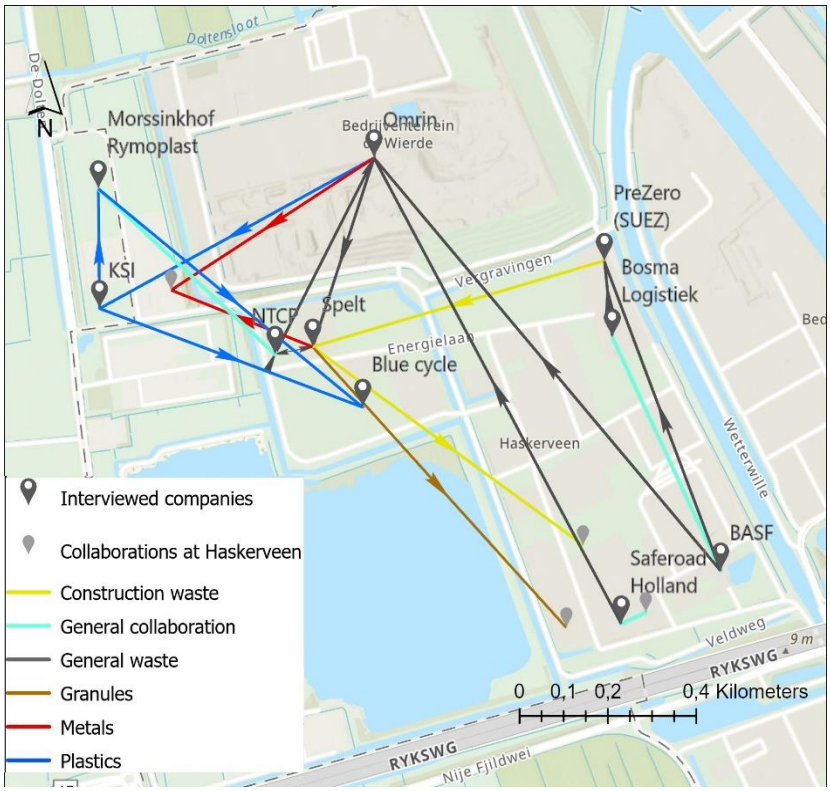

Figure 12 - Material flows at Haskerveen.

7.5.1 Case study area

Figure 12 shows the different flows of materials that run from or to the involved companies. As is visible, five different materials are exchanged at the business park. The most common are the flows of general waste. These flows include the collection of waste by the waste management companies from different companies located at the business park and the collecting of household waste, the further processing of the waste, and the testing of the recycling process. Other material flows are construction waste of Spelt, the further processing of metals collected by **Spelt** or **Omrin**. The stone granules produced by **Spelt** are used for infrastructure projects. The last material flow is the flow of plastics that has been described in the results. The general collaborations include the flow of knowledge, products, and storage.

7.5.2 ultra-local scale

Clusters on the ultra-local scale have all companies within a distance of 0 to 5 kilometers from each other (Omobhude & Chen, 2019). This scale level includes Heerenveen and (parts of) some surrounding villages, both inside and outside the municipality. But the main focus is on the municipality of Heerenveen. For the case of Haskerveen, all mentioned collaborations fall within a radius of maximum 5 kilometers. As is shown in figure 13, only collaborations regarding stone granules and organic waste are present on this ultra-local scale level. For the stone granules, this is further used in infrastructure projects by different companies. For the flow of organic waste, no specific process was mentioned.

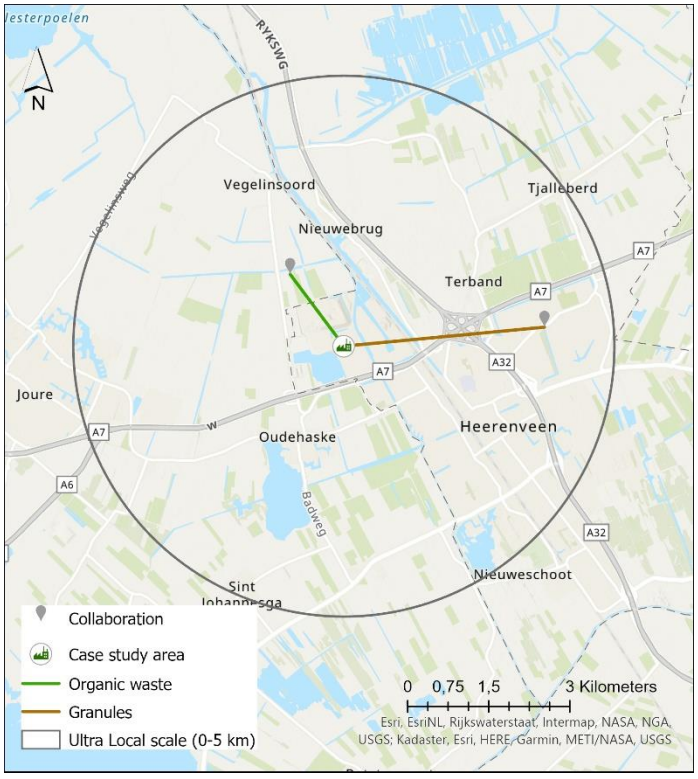

Figure 13 - Material flows on the ultra-local scale.

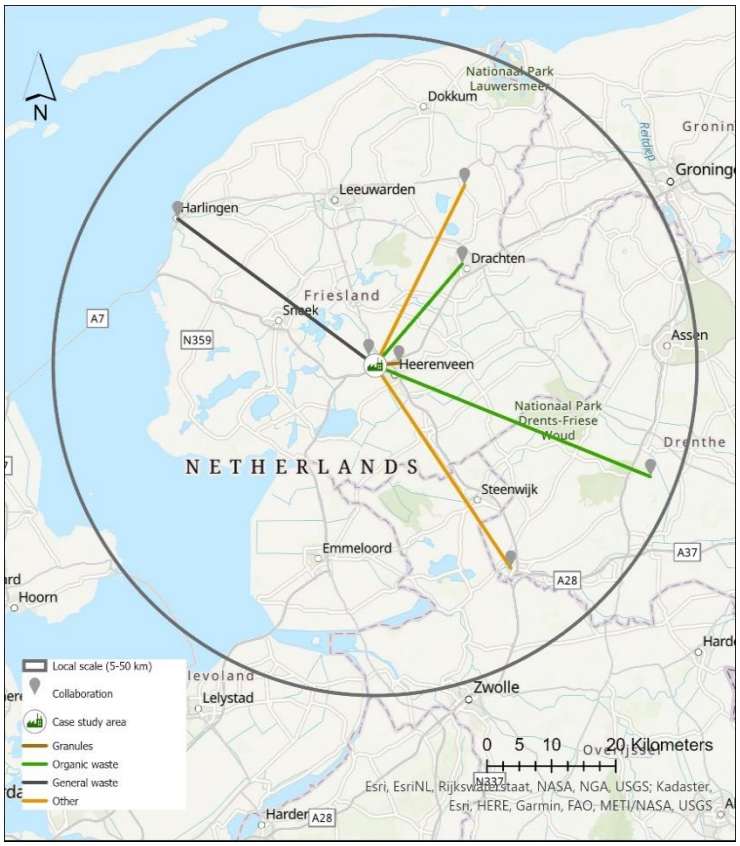

Figure 14 - Material flows at the local scale.

7.5.3 Local scale

The local scale includes all collaborations within a distance of 5 to 50 kilometers from each other (Omobhude & Chen, 2019). The local scale includes mainly the province of Friesland. Compared to the ultra-local scale, the flows of general waste and other waste are added (figure 14). The flow of stone granules stays within 5 kilometers. The flow of general waste within the local radius is the residual waste that is burned at the incinerator. Organic waste is the outflow to processing companies. The flows that include other materials originating from construction and demolition waste. Nonetheless, no specific material was mentioned. The companies outside the case study area process this outflowing waste.

7.5.4 Regional scale

The regional scale has a radius between 50 and 250 kilometers (Omobhude & Chen, 2019). In the case of business park Haskerveen, the regional scale includes the Netherlands as a whole and some parts of Germany and Belgium. This wide radius results in the lack of a scale to appoint the region of the North of the Netherlands, which is often mentioned by the respondents. Within this radius of maximal 250 kilometers, for nine different materials, it is mentioned that these are processed in collaboration with other companies located in this region (figure 15, right). Five of these materials are not processed at Haskerveen, due to a lack of technologies and capacity. The other four materials (plastics, stone granulate, metal, and organic waste) are partly processed at Haskerveen. The only material that is processed by multiple companies in the case study area is, as mentioned before, plastics. The plastics that flow out of Haskerveen are the granules and oil produced by **Morssinkhof Rymoplast** and **Blue Cycle**. As the left map of figure 15 shows, the plastics also flow on the international level, as a result of the supply and demand of different brands and markets. Also, some 'other' flows are visible at the international level. These flows include the systems of **Saferoad Holland**, which are produced outside the Netherlands.

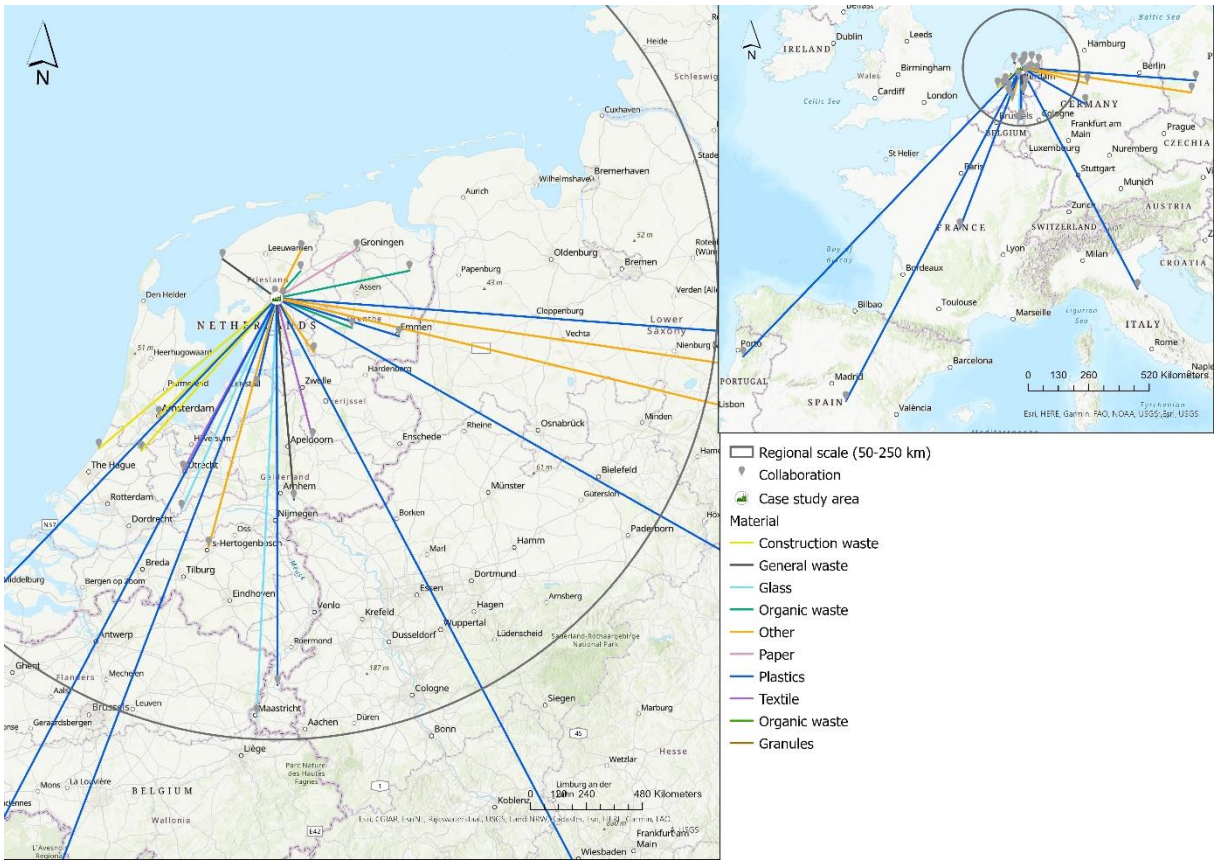

Figure 15 - Material flows at the regional and international levels.

VIII. Conclusion and discussion

Before the spatial scale is decided for which the circular economy (CE) achieves the highest success in practice, first the situation at Haskerveen is compared to the theoretical model. Both questions will be answered based on the information gained from the qualitative data collection and the information from the literature.

8.1 The situation at Haskerveen

To get insight into the situation at the case study area compared to the theoretical model stated in the sub conclusion, the following sub-question is answered: *"How is the case study area performing as opposed to the theoretical model of the circular economy?"* This performance is among other things measured by the flow of (raw) products at the business park, the amount of waste, and the use of new resources.

In theory, it appears that a CE can be either a self-contained development *or* it can be part of sustainable development (Sillandpää & Ncibi, 2019). Within the case study area, the focus is more on sustainability, in which the CE is to a certain extent used as means to achieve sustainability goals, such as a reduction in CO_2 emission. Sustainable development shifts away from the main aim of economic growth, but also includes society and the environment that all three are equally important (Geissdoerfer et al., 2017). Within the case study area, the respondents mentioned that the environment is especially an important aspect of the business model. Nonetheless, economic growth is mentioned to still be very important. Profit is needed for the right to exist. However, for some of the companies, this economic aspect is still more important than for others. Over the years, all companies showed changes within their business model towards a more sustainable or circular company. These adaptations are made in the properties and technologies used. Innovations like this are needed to achieve a closed-loop system. These changes included as well the shift from dumping and burning waste to the recycling, reusing, repairing, and remanufacturing of materials and resources. Similar to the theory, the companies aim to keep the value of the resources at the same level or even upgrade the quality(Sillandpää & Ncibi, 2017). However, for the case of Haskerveen, it is shown that there is still a significant amount of waste that is recycled into a lower quality product or processed with a useful application.

In the theoretical model of the CE, the focus is often on one process, material, or product within one company in the industrial context (Hobson, 2016). Nonetheless, in the case of Haskerveen, three companies focused on waste management are included. These companies include many different types of materials in their processes. Therefore, all products that are input for these companies are transshipped to other companies for further processing. For the processing companies, the input is this waste. However, this is not waste of another process, but waste derived from consumption, collected mostly in the North of the Netherlands. The use of waste makes the case of Haskerveen contrasting with theory, as the companies are not directly focused on production. Haskerveen can be seen as the third party in the system (Sillandpää & Ncibi, 2019), which has the technology to process the products produced by others. In addition, the involved companies do not also include a closed-loop system within the company. At the business park, only two types of materials are supplied in the form of an end product on the market, namely: biogas and stone granules. Both materials are supplied nearby. The other included producing companies only supply resources that need to be further processed for it is available for the general customer.

Another aspect of the theoretical model, which is also frequently mentioned by the respondents, is the design of products. This design is important for both the lifespan and the recyclability of materials and products (Graedel et al, 2009; Hobson, 2016; Sillandpää & Ncibi, 2019; Geisendorf & Pietrulla, 2018). As the respondents mentioned, nowadays, many products are designed in a way that the recycling process costs more energy and causes more CO_2 emissions than the production with new

resources. To decrease the use of new resources and the CO_2 emission, the products need to be designed in a way that this process can be executed in the best way possible. Most advantageous are products that consist of one type of material, or the least different materials possible. This change needs to be made by the producers, and the processes and technologies used (Sillandpää & Ncibi, 2019; Bilitewski, 2012; Hobson, 2016).

At Haskerveen the producing companies that are included in the research do only use waste for their end products. So no new obtained resources are used in these processes. This is in line with the theoretical model, which states no new materials can be used in any production process (Sillandpää & Ncibi, 2019; Geissdoerfer et al., 2017). Moreover, the production processes that are performed by the included companies have less CO_2 emissions than similar processes using new exploited resources.

A well-functioning CE clustering of companies shows in theory beneficial results (Bianchini et al., 2019; Swords, 2013; Martin & Sunley, 2003). The location of companies within a reasonable distance from each other is important to transport the output of one company as input for another. The proximity should be as close as it can and as far as it needs to be. The processes at close proximity are visible at the business park for some of the materials that are collected. For instance, the further processing at the business park. Both processing companies also mention the proximity to the input material as the reason for their location at Haskerveen. For the respondents, an inclusive cluster is needed, but it should not be overdone. The Triple Helix collaboration mentioned in theory (Gachie, 2020) is not completely detectable at Haskerveen, as higher education is not available in close proximity. In addition, a lead company can help to create new opportunities for the entire cluster (Ingstrup, 2014). At Haskerveen, Omrin currently takes this role of the lead company. With Omrin as a participating lead company, the cluster at Haskerveen can be designated as a bottom-up cluster (Ingstrup, 2014).

Within the theoretical model, it is important to use sustainably generated energy for the processes and should be just in the most effective way. Nonetheless, for the circulatory system itself, which is focused on organic materials, energy is not included (Geisendorf & Pietrulla, 2018). For Haskerveen, only part of the companies makes use of sustainably generated energy, most often by the use of solar panels. In addition, the vehicles of Omrin drive with self-generated bio-fuel. BASF also transforms waste into resources for part of their factories, including Heerenveen. For this indirect element of the CE, consequently, steps can be made at the business park. The steps taken by Blue Cycle to circulate the heat, CO_2, and nitrogen released during the process is thus an additional benefit, but positive addition to the CE.

As is shown in Haskerveen, but also mentioned within the literature, is that it is hard to implement the theoretical model in practice (Bianchini et al., 2019). In addition, for the success of the CE, according to theory and the respondents, high efficiency is needed (Sillandpää & Ncibi, 2019; Bilitewski, 2012; Hobson, 2016; Graedel et al, 2009). This efficiency is more important for the respondents than the proximity. Nevertheless, the companies that are included in the research understand the model of the CE, how it works, and what the ultimatum is. Moreover, some of the aspects are already included in the daily business. But after all, in practice, it is hard to exactly work according to this theoretical model with collaborations of different companies. This is the result of the practice of the companies that are located at Haskerveen, which are not completely in line with the industrial companies that are included in the theoretical model. This concludes that there is still waste that needs to go to the incinerator as it can not be recycled, reused, remanufactured, or repaired.

8.2 The spatial scale of a Circular Economy (CE)

To answer the research question: *"At what spatial scale achieves the circular economy the highest success in practice?"* the theoretical model, the results of the case study, including the geospatial network analysis, are combined.

The research shows that the spatial scale that provides the highest success for the CE depends on the type of material for which the loop should be closed. The scale level for each material then also depends on the demand and supply and the processing capacity. The case study area shows that the amount of waste collected by the three companies leads to many more materials than are needed in close proximity. An ultra-local CE, within a proximity of 5 kilometers, is only possible if the materials are also collected and supplied within this radius. Moreover, other actors that can be involved in the CE should also be located within proximity and create a Triple Helix for more benefits. For the CE in general, this ultra-local cluster is not expected.

As shown within the case of Haskerveen, there are possibilities for a CE on the local scale. This means that the loop can be closed within a proximity of a maximum of 50 kilometers. To create the closed-loop system, the materials should be produced, supplied, collected, processed, and again supplied within this local radius. The clustering of these companies will lead to benefits for the CO_2 emission and possibly spillovers. If there is not enough volume of a material for a local CE, the CE can be created at the level for which there is enough for the capacity of companies and machines to recycle and remanufacture the materials. One step above the local level is the regional level with a radius of 50 to 250 kilometers. If the volume is not enough for the regional level as well, the national (>250 kilometers) or international level can be chosen.

For the case of Haskerveen, the materials that are processed, which is household waste, are collected on a regional scale, mainly in the North of the Netherlands. This waste mostly originates from the three northern provinces, nonetheless, some collecting is done at a larger distance. For the processing of the waste, the scale differs for every material, but also per waste collector. For part of the collected materials, the CE can function at the regional scale, based on the areas in which the waste is collected. For the processing and supply of some materials, the scale can be smaller, such as for stone granules and organic waste. For other materials, the technology or capacity is lacking within the regional scale, and therefore the CE for these materials can only be successful on the national or international scale level, such as glass, textile, and plastics. The attraction of companies that contribute to the processing of the materials and the supply to the consumer can help to increase the success of the CE on a smaller spatial scale. Currently, due to the scale level of the waste collection, the regional scale is the smallest spatial scale possible for the successful CE regarding the case study area.

To conclude, the spatial scale on which a CE can have the most success depends on many factors. Withal, the closed-loop system can be enabled at all scale levels, if the right components are present or can be made available. Thereby, the forming of a cluster will increase the success of a CE. There should be different clusters for the processing of different materials to enlarge the results. The interchange between companies has shown the highest success on the local level. However, the regional level that is most often mentioned in literature and the case study also shows highest possibilities on the regional level. It can be determined that the regional scale thus is the spatial scale on which a CE can achieve the highest success. Nonetheless, within this regional scale level, divisions can be made based on the radius. A lower radius within the regional scale would be more successful than a larger radius. Moreover, arbitrary geographical borders should not be the leading factor in defining this radius. If the CE functions at a smaller scale, multiple clusters on the same material can be available within a country, to benefit from the closer proximity.

8.3 discussion

In line with what was expected, the CE, in theory, is described as a completely closed system, where all resources remain in the cycle, with the same value. The expected role of geography for a CE with a network of companies is a short distance between all components. For the case study area, it was already expected that the theoretical model would not be completely met in practice. The expected scale for Heerenveen was Friesland or the North of the Netherlands. The research has shown the role

of geography is not as important as it was expected and that an efficient system will lead to a higher success than close geographical proximity. However, a small spatial scale can lead to multiple benefits. For business park Haskerveen, it is shown that the province of Friesland at this moment would be too small for a closed-loop. For the North of the Netherlands, which falls within the regional scale, there might be opportunities. The most important factors for a successful CE mentioned in the conceptual model are therefore the processes, the collaborations, and the available technology. The other factors have less influence on the level of success, but should not be overlooked.

There are different possibilities to continue with the further development of CE. First of all, it is important to know what the focus is. Within this research the focus is on the materials and the reusing, recycling, remanufacturing, or repairing of the materials. Within the range of this focus on one or more flows of material, information is needed about the materials, but also the input and output market and the related processes. Information should be gained about the technologies needed, the location where these technologies are already present, as well the capacity that is needed to have the most beneficial outcomes. The total CE can in some areas have opportunities on a local or even ultra-local scale. In this case, it is most likely that the producer(s) of the products have the responsibility of collecting the used materials and processing them into similar 'new' products. For other processes, at this moment, the capacity of demand and supply needed for systems is only present at a larger scale. Nonetheless, processing larger capacities can also lead to environmental, societal, and economic benefits compared to the smaller spatial scale. Second, it is already discussed in practice whether this large scale system is still the way to work in the future. It might be the case that in the future the processes will be performed on a smaller scale but at increasing places. This small scale might create opportunities for the effectiveness of the CE. In the end, the spatial scale on which the loop is closed is less important than the results of the process. In addition, collaborations are of great importance, as the CE cannot be successful if there is no willingness to contribute. Proximity of collaborating companies within a CE leads to benefits in the form of spill-over effects, contact, and low travel distances. Most favorable is a triple helix collaboration to achieve the best results.

During the research, few limitations were encountered. First, nine companies are included in the qualitative data collection. This low number is the result of non-response, a lack of participation as well as a lack of means to contact the companies. This applies to companies located at the business park that could have contributed to the research, but are not in direct contact with the Municipality Heerenveen. However, all core companies designated by the municipality participated in the research. Thereby, the case study area is relatively small, relevant conclusions thus still can be drawn based on the primarily collected data. Nonetheless, the results might be biased as most involved companies included, which are the core companies, already perform activities focused on sustainability and circularity. It would thus have given a more complete picture if more, and preferably all, companies would have been included. As the research was executed during the Covid-19 pandemic most of the interviews were conducted online. The online communication led to some difficulties during the interviews, mostly related to connection issues. In the end not directly led to lower data quality, but asked for different skills and interpretation.

Further research regarding the practical implementation of the CE is recommended. Additional research should be done to find out whether the large scales on which many processes currently are performed can be sustained in the future. This research then has to include the three aspects of sustainable development and the CE and can focus on the smaller and larger scales within the regional scale. In addition, research into the organization of a CE can be performed based on best practices. These best practices can include other CE's or other specific clusters within the Netherlands as these clusters work with the same geographical conditions. Other specified clusters can help to form a more general view. These ideas and knowledge of these best practices together can lead to a blueprint for Circular Valley Heerenveen.

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Appendix

Appendix A – Interview guide

Opening questions (introducerende vragen)

1. Can you tell something about [company]?
   Kunt u iets vertellen over [bedrijf]?
   1.1 Can you please elaborate a bit more on what products are made and which resources are used for this and where these originate from?
   Kunt u iets meer vertellen over de producten die binnen dit bedrijf gemaakt worden en welke grondstoffen hiervoor gebruikt worden en waar deze vandaan komen?
2. Why did [company] choose for this location?
   Wat is de reden voor [bedrijf] om op deze locatie te vestigen?
3. In how far does sustainability play a role within [company]?
   In hoeverre is duurzaamheid belangrijk binnen [bedrijf]?
   3.1 Is there a specialization within this sustainability?
   Is [bedrijf] gespecialiseerd in een specifiek onderdeel van duurzaamheid?
4. What are your or the company's ideas about circular economy?
   Wat zijn uw of het bedrijf 's ideeën over de circulaire economie?

Core questions (kernvragen)

1. What companies, at the business park Haskerveen is [company] collaborating with?
   Met welke andere bedrijven op het bedrijventerrein Haskerveen werkt [bedrijf] samen?
2. What companies outside the business park is [company] collaborating with?
   Met welke bedrijven buiten het bedrijventerrein werkt [bedrijf] samen?
   2.1 Where are these companies located?
   Waar zijn deze bedrijven gevestigd?
3. How far is a closed loop system, in which all resources will be reused instead of labeled as waste, included in the business model and on what scale level?
   In hoeverre is een gesloten systeem, waarin alle grondstoffen opnieuw worden gebruikt in plaats van bestempeld als afval, onderdeel van het bedrijfsmodel en op welk schaalniveau kan dit systeem worden gesloten?
4. How far does the proximity of other companies within the closed loop system is important?
   In hoeverre is nabijheid van andere bedrijven binnen het gesloten systeem belangrijk?
   4.1 What then is seen as proximate, at what distance?
   Wat wordt gezien als nabij, tot welke afstand geldt dit?
5. What changes have been made within [company] to become integrated in the circular economy? (e.g. technology, processes, knowledge, business model etc.)
   Welke veranderingen zijn er getroffen binnen [bedrijf] om aan te kunnen sluiten in het circulaire systeem? (bijvoorbeeld technologie, processen, kennis, bedrijfsmodel etc.)
6. How can the municipality of Heerenveen contribute to closing the loop?
   Hoe zou de Gemeente Heerenveen bij moeten dragen aan het sluiten van het circulaire systeem?

7. At what scaler level do you think a circular economy is achievable? (e.g. Heerenveen, Friesland, North of the Netherlands, The Netherlands)
   Op welk schaalniveau is een circulaire economie het best haalbaar? (Bijvoorbeeld Heerenveen, Friesland, Noord Nederland, Nederland)
8. On what should or in what is Circular Valley Heerenveen specialized?
   In wat is of zou Circular Valley Heerenveen zich moeten specialiseren?
9. What do you expect of a Circular Valley in Heerenveen?
   Wat verwacht u van een Circular Valley Heerenveen?

Closing questions (Aflsuitende vragen)

1. What other companies at this business park should be included in this research?
   Welke andere bedrijven op dit bedrijventerrein zou ik mee moeten nemen in dit onderzoek?
2. Do you have any questions for me?
   Heeft u nog vragen voor mij?

Appendix B – Coding scheme

Code	**Explanation**
Circular Economy	The needed and already present factors for a circular economy
Circular Valley	What is needed to create Circular Valley Heerenveen
Collaboration within Haskerveen	The companies located at the business park with whom is collaborated or exchanged
Collaboration outside Haskerveen	The companies located outside the business park with whom is collaborated or exchanged
Municipality of Heerenveen	Suggestions for actions of the municipality and a reflection on the municipality
Process	The processes within the company
Proximity/ distance	The need of companies in close proximity and to what distance a company is in close proximity
Sustainability	Sustainability measures that are taken, will be taken or need to be taken
Theory	Thing mentioned that can be related to the theoretical model

Appendix C – Informed Consent

university of groningen / faculty of spatial sciences

Agreement to participate

In research project for the master thesis:

Reuse, Repair, Remanufacture and Recycle, Rethinking the Circular Economic Model.
Subtitle: A case study on circular valley, Heerenveen (The Netherlands).

I am Nathalie Semplonius and I study the Research Master at the faculty of Spatial sciences at the University of Groningen. Within this master, I specialized in the direction of economic geography. For my master thesis I carry out research about the working of the circular economy in practice and its scale level. The research is carried out in collaboration with the spatial planning and economics department of the municipality of Heerenveen. This research is focused on the business park Haskerveen and Ecopark de Wierde, located in Heerenveen, where multiple businesses are located that are closely involved in the circular economy. The aim of the interviews within the research is to get insight to what extent the business parks 'Haskerveen' and 'de Wierde' are already circular and what improvements or changes can be made to increase the circularity. Within the aim of the research also the mapping of the different actors within the circular network is included.

- I have read and I understand the information sheet of this present research project.
- I have had the opportunity to discuss this study. I am satisfied with the answers I have been given.
- I understand that taking part in this study is voluntary and that I have the right to withdraw from the study until the moment that the study has been published, and to decline to answer any individual questions in the study.
- I understand that my participation in this study is confidential. Without my prior consent, no material, which could identify me will be used in any reports generated from this study.
- I understand that this data may also be used in articles, book chapters, published and unpublished work and presentations.
- I understand that all information I provide will be kept confidentially either in a locked facility or as a password protected encrypted file on a password protected computer.

Please circle YES or NO to each of the following:

I consent to my interview being audio-recorded YES / NO

I/ my company wishes to remain anonymous for this research YES / NO

If NO
The name of the company can be used for this research YES / NO

OR

A pseudonym of my own choosing can be used in this research YES / NO

"I agree to participate in this individual interview and acknowledge receipt of a copy of this consent form and the research project information sheet."

Signature of participant:_____Date: _____

I want to receive a copy of the notes of

the interview, so corrections can be made. YES / NO

I want to be kept informed about the research

and possibly contribute at a later stage. YES / NO

Email:

"I agree to abide by the conditions set out in the information sheet and I ensure no harm will be done to any participant during this research."

Signature of researcher:_____Date: _____

Once again I thank you for taking the time to find out more about my research. If you gave any remaining questions, you can contact me, my internship supervisor or my thesis supervisor by one of the email addresses mentioned below.

Nathalie Semplonius

n.semplonius@student.rug.nl

Dr. Aleid Brouwer

A.E.Brouwer@rug.nl

Jantie van der Laan

Jantie.vanderlaan@heerenveen.nl

Appendix D – Recommendation for the Municipality of Heerenveen

This appendix has been removed as it is written for the municipality only.