Tracking Local Circular Progress

Monitoring the circular economy in Rijk van Nijmegen

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Preface

In front of you lies my master thesis within the master's specialisation Corporate Sustainability. This piece of work exhibits a long, interesting journey that taught me a lot and is something I consider to be a great achievement. I would like to take a moment to express my gratitude to certain individuals that helped me on this journey.

Firstly, I would like to thank my supervisor Mark. He guided me through the whole process of this research paper and gave me the necessary encouragement to keep excelling in my work. Our brainstorm sessions and discussions ensured a clear focus and challenged me to stay critical.

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Secondly, I would like to extend my thanks to all my respondents for their time, cooperation and valuable contribution to my thesis. I hope my thesis aids them in their work and can be put forth to new research.

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I hope you enjoy reading my thesis.

Catharina Notermans
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Executive Summary

The Dutch national government has set a goal of achieving full-scale circularity in the Netherlands by 2050, with an intermediate goal of 50% circularity in raw materials by 2030. Currently, there is no uniform way to measure circularity in any given region, which makes it difficult to track overall progress. Present day efforts in the Netherlands towards monitoring the transition to a circular economy (CE) mostly take place on (inter)national and provincial level, but less so on municipal or local level. Certain indicators are essential to monitor on a local level such as recycling rates, circular employment and circular awareness. Nevertheless, local networks exist in an effort to track the progress in this transition towards a more CE. One such region is Rijk van Nijmegen (RvN), situated in the province of Gelderland, made up of seven municipalities (Berg en Dal, Beuningen, Druten, Heumen, Nijmegen, Wijchen and Mook en Middelaar). In this region, there are already some activities and actions that take (or have taken) place, relating to building a more CE. For example: Nijmegen was crowned Green Capital in 2018, and RvN@ was set up as a platform for businesses to connect with each other in favour of themes like CE. A clear monitoring system is required in order to track the contribution and progress of such actions and activities within a region. Hence, this research analyses the monitoring process in the region RvN and ultimately provides recommendations for possible improvements in the monitoring process. The following main question is posed for this research: '*what indicators and factors contribute to a better monitoring towards a more circular economy in Rijk van Nijmegen (RvN) and what recommendations can be given to RvN to further stimulate the monitoring of the transition towards a more circular economy?'.*

In answering the aforementioned research question, an existing framework is used by Roemers et al. (2018), identifying primary indicators, dashboard indicators and transition indicators. Additionally, barriers to monitoring the CE are identified, and opportunities are established to improve the monitoring. Data is collected through desk research (literature study) and semi-structured interviews, both with respondents within RvN (case interviews) as well as expert respondents. Although data is primarily collected in a qualitative manner, quantitative data is also sought to supplement the answer to identifying the availability of primary and dashboard indicator data.

A lot of data is still lacking for primary and dashboard indicators. Primary indicator data is not yet readily available, especially growth in net assets. However, methods for obtaining such data are being developed, for example, by creating material passports of buildings, which portray the types and volumes of materials used in such a building. As for the raw material

use and input indicators, there are various tools available that estimate certain flows of raw materials, but lack greatly in accuracy.

For the dashboard indicators, some data is readily available for a specific sector, like the construction sector. Other data is available in detail for a specific institution within a sector, like the Radboud UMC hospital in the medical sector of RvN. However, many sectors are still missing.

Furthermore, data for transition indicators is difficult to pinpoint, but is off to a good start, especially thanks to the multiple policies currently in place concerning – amongst others – circular waste, housing construction and procurement. However, many goals and indicators mentioned in local policy documents often match that of (inter)national policy, as opposed to matching provincial goals and indicators. Additionally, not all municipalities pertaining to RvN have as much policy written on or relating to the CE as others do.

As for the barriers hindering the monitoring of the CE, the most dominant one for multiple actors and sectors is a lack of a clear definition. Each (group of) actor(s) across different scales have their own interpretation of the term CE and act accordingly, partly due to the broadness of the term itself. However, this triggers many more barriers like there being no uniform method for monitoring, a lack of cooperation between scales and a lack of long-term vision in policy making and activities. Naturally, each barrier presents an opportunity to be solved. However, there are two main opportunities identified in this research. The first leading opportunity is to define the concept of the CE, including what aspects and factors are encompassed and which are not, and appoint responsibilities to specific actors, hereby proposing to solve the most recurring barrier. The second main opportunity for RvN is to better define and align indicators used for monitoring, across scales. Improving communication between municipal and provincial level on indicators would greatly increase effectiveness and accuracy in the monitoring process. In this way, the municipalities pertaining to RvN and the province of Gelderland could set up a dashboard with indicator data that is managed and supplemented centrally.

Keywords: circular economy, monitoring, indicators, barriers, opportunities.

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List of Abbreviations

CBS	Centraal Bureau voor de Statistiek
CE	Circular economy
CI	Circularity indicator
ICER	Integral Circular Economy Report
IPCE	Implementation Programme Circular Economy
LMA	Landelijk Meldpunt Afvalstoffen
NEAA	Netherlands Environmental Assessment Agency
NEC	Nijmegen's Economy Circular
PBL	Planbureau voor de Leefomgeving
RHDHV	Royal HaskoningDHV
RvN	Rijk van Nijmegen
SD	Sustainable development
SDGs	Sustainable Development Goals
SDI	Sustainable development indicator
VANG	Van Afval Naar Grondstof
WBCSD	World Business Council for Sustainable Development

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1 Introduction

Since the publishing of *'Limits to Growth'* by the think tank Club of Rome in 1972, the trend of resource use over the past four decades has spoken true to the book according to Turner & Alexander (2014). Previous research has shown that the abundance of raw materials is rapidly decreasing, insinuating that humanity's current metabolic rate exceeds the ecosystem's capacity to recover and is hence considered extremely unsustainable (Haas, Krausmann, Wiedenhofer & Heinz, 2015; Van Berkel & Schoenaker, 2020). Our dependency on natural resources mainly originates from the need for economic success and for infrastructural projects (Oberle, Bringezu, Hatfield-Dodds, Hellweg, Schandl and Clement, 2019).

In 2016, the Dutch national government published a report on its ambition to become fully circular by the year 2050 (Rijksoverheid, 2016). As an intermediate goal, the Dutch national government aims at reducing the use of raw materials by 50% in 2030 (Rijksoverheid, 2016). This goal entails creating an economy without any waste and where everything is fuelled by renewable materials (Ministerie van Infrastructuur en Milieu, 2016). The focus of this plan lays on multiple aspects, such as material use, waste production and secondary input, and various economic aspects.

In order to achieve this goal, there is a need for a complete shift from the current linear economy to a circular economy. The Ellen MacArthur Foundation refers to the current linear model as having a "'take-make-dispose' pattern" (Ellen MacArthur Foundation, 2013, p. 16) in which manufacturers and other organisations take extracted raw materials to make into a product, sell it to end consumers in society, who in turn dispose of it when it's no longer of use to them. Companies have progressively come to realise that such a system that revolves around consumption leads to major disadvantages in costs, as prices for raw materials increase due to their decreased abundance, but also due to increased urbanisation as a result of population growth, which increases demand for more raw materials to create new goods (Ellen MacArthur Foundation, 2013).

1.1 Circular economy

There are various interpretations of what exactly makes up the concept of a circular economy in the literature, each illustrating a slightly different point of view or context (Moraga et al., 2019; Gravagnuolo, Angrisano, & Fusco Girard, 2019; Avdiushchenko, 2018; Kirchherr et al., 2017b). Kirchherr et al. (2017b) analyse 114 definitions of CE in their research and conclude

that “the main aim of the circular economy is considered to be economic prosperity, followed by environmental quality; its impact on social equity and future generations is barely mentioned.” (p. 1).

The definition of a circular economy used in this research, formulated by the Ellen MacArthur Foundation, is as follows:

> An industrial economy that is restorative by intention and design. In a circular economy, products are designed for ease of reuse, disassembly and refurbishment, or recycling, with the understanding that it is the reuse of vast amounts of material reclaimed from end-of-life products, rather than the extraction of resources, that is the foundation of economic growth (Ellen MacArthur Foundation, 2013, p. 16).

In such a context, the emphasis on limited resources (raw materials) in economic processes, is shifted to unlimited resources, such as labour. This idea is further elaborated on in chapter 2. In some cases, it may be tempting to use the terms circularity and sustainability interchangeably but this would be a mistake. The concept of a circular economy is substantiated by various indicators added up together that are to be found in various different fields of study and can be both qualitative and quantitative in origin. The former set of indicators refers to, for example, policy in place and circular activities, whereas the latter refers to weight of waste material, CO_2 footprint and the number of circular activities organised. Hence, the level of circularity refers to the degree a given region achieves high scores in as many indicators – that are related to creating a circular economy – as possible. The Netherlands is considered to be a frontrunner in the transition towards a circular economy (Circular Economy, 2016). In order to determine whether regions in the Netherlands contribute to the national goal in 2050 mentioned in the previous paragraph, such indicators need to be closely measured and monitored at a local scale.

In 2018, the national government presented its five transition agendas – reports that illustrate what is required to accelerate the transition towards a circular economy (Mul, 2018). The transition agendas highlight five key themes, namely: biomass & food, plastics, manufacturing industry, construction and consumer goods. These themes each represent sectors that are important for the Dutch economy but simultaneously put pressure on the environment through pollution. In January 2021, the first Integral Circular Economy Report (ICER) (translated: Integrale Circulaire Economie Rapport) was published by the NEAA.

In 2020, Rijk van Nijmegen (RvN) presented their Implementation Programme Circular Economy (IPCE) (translated: Uitvoeringsprogramma Circulaire Economie). In broad terms, the

IPCE matches the governments' aims to become fully circular in 2050, but some specific goals of the programme include: monitor the progress and actualise the programme yearly (RvN@ Circulair, 2020).

1.1.2 Rijk van Nijmegen

In 2018, Nijmegen was crowned European Green Capital, which led to the organisation of multiple activities and information seminars. A difficult aspect hereof is to be able to see the direct effects that this title has had on the city of Nijmegen and its inhabitants. It could well be that participants of the green activities were active for a given period and have now gone back to old habits for example. Likewise, some citizens could be very environmentally aware in one suburb, whereas their neighbours not so much, leading to a perhaps misleading interpretation of actions and attitude towards CE within the same region. The breadth of measuring and monitoring circularity has been highlighted above. In order for this research to be carried out, the field of research needs to be specified to a reasonable scale. The data for circularity must be attributed to a given geographic area (region) for it to be put in perspective and be useful for policymakers for example. For this reason, this research will be bound to the region Rijk van Nijmegen (hereafter: RvN). The region RvN is situated in the south-east of the province Gelderland and is made up of the following municipal regions: Nijmegen, Beuningen, Berg en Dal, Heumen, Wijchen and Mook en Middelaar – of which the latter is situated in the province of Limburg. This region is directed by an administrative partnership (Regio Rijk van Nijmegen), in which the municipal region of Druten is also included (Regio RvN, n.d.).

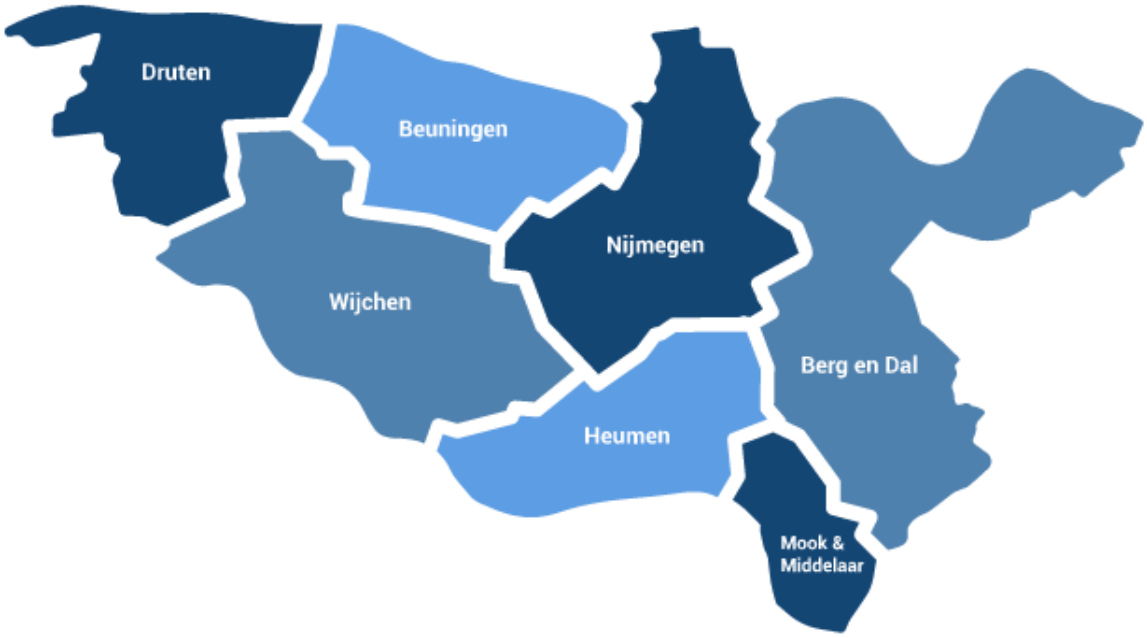


Figure 1: Region Rijk van Nijmegen (iRvN, n.d.).

There are various aspects of interest to examine in this case. Firstly, what circular policy is in place and how that relates to provincial and national government policy. Secondly, what perception society has on this transition and the term CE itself. Furthermore, which indicators are and are not currently being monitored and why. In addition, it would be interesting to discover any barriers that hinder further progress in the transition and highlight areas of improvement for the actors within Regio RvN.

1.2 Research aim and question

As the primary guide for this research, a research aim has been formulated which encompasses the essence of the topic under examination. The aim of this research is to illustrate the progress of monitoring the transition towards a CE in the region RvN, by adapting an existing framework from the literature. Hereby analysing the indicator availability in RvN, the external factors that influence the indicators being measured and possible opportunities for the region RvN to further their progress towards a more CE. Additionally, this research aims to be an example for other local regions on how to track progress of monitoring the CE on a local scale.

To fulfil the previously mentioned research aim, various fields need to be studied. Goals referring to achieving more circularity need to be identified. As such, the main research question is formulated as follows:

What indicators and factors contribute to a better monitoring towards a more circular economy in Rijk van Nijmegen (RvN) and what recommendations can be given to RvN to further stimulate the monitoring of the transition towards a more circular economy?

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

- *What monitoring frameworks and tools are available in the literature?*
- *What is the current state of monitoring of primary indicators?*
- *What is the current state of monitoring of dashboard indicators?*
- *What is the current state of monitoring of transition indicators?*
- *What main barriers can be identified that influence the indicators for monitoring?*
- *What recommendations can be given for improving monitoring?*

1.3 Relevance

In this section, the relevance of this topic will be specified, sectioned into scientific relevance (section 1.3.1) and societal relevance (section 1.3.2).

1.3.1 Scientific relevance

The change from a linear economy to a circular one is a trend that has been researched in recent years which impacts various aspects of society. Previous research makes it clear that there are various factors linked to making a region more circular and sustainable (such as: the economic system, the use of raw materials and human activities and initiatives (Roemers, Van Der Zande, Thorin, & Haisma, 2018)). There are also multiple initiatives on how to create a more circular environment for businesses (Het Versnellingshuis Nederland circulair!, 2020). However, there is no uniform or universal way of measuring the degree of circularity in a given region that can be compared to other regions. Previous research focuses on CE in general and monitoring on a larger scale, instead of a more local scale within a region. According to the Ministry of Infrastructure and Water Management, there is a need to identify effective ways of monitoring at a local level for two main reasons. The first being that it helps the national government further define what a CE actually is, identify what can be measured and in what

way (respondent 2, personal communication, August 20, 2020). Once this is clear, experts can focus their research on further developing indicators and collecting data that show progress of the transition towards a more CE. This research helps to identify what indicators are being monitored and what is not, hence helping to advance the transition process. The second reason being that civilians will have a better understanding as to their role in this important issue and how they can offer their personal contribution. Based on this information, government officials will have a more concrete academic basis to determine their progress in achieving full circularity in 2050, something that is currently greatly lacking according to the national government (Rijksoverheid, 2016). Therefore, this research is worth carrying out, as it will contribute to a gap in current knowledge in an example of how CE can be measured and monitored on a local level. In addition, the results of this research can also be used for future analyses on circularity in the region RvN, which can inspire policy makers to adjust and advance their policy on the topic of CE. Moreover, this research will further aid closing the data gap between scales. As Roemers et al. (2018) state, bodies like CBS and PBL can help improve top-down estimates of materials flows, while regional (and in this case local) actors are most useful in collecting bottom-up data.

Roemers et al. (2018) recommend that other studies regarding the monitoring of CE in regions and cities should be carried out using the same framework so that eventually, regions and/or cities can be compared to one another to determine progress. In addition, by using the same framework in multiple studies, this framework is further developed and tweaked instead of constantly setting up new frameworks.

1.3.2 Societal relevance

In some cases, the need for a drastic change from a linear economy to a circular economy is very much apparent and relevant for all of society. Moreover, this topic addresses a global issue, not just a local one. This research helps create more awareness in society in various aspects. Firstly, for businesses to increase their competitive advantage in becoming more circular and become more profitable as a result of this (Mul, 2019; Stooker, 2021). Secondly, for civil society to look up to businesses that manufacture their goods and provide their services. In this way, a lot less will be thrown away or wasted unnecessarily, which in turn contributes greatly to the reduction of waste pollution to the environment. This argument is also highlighted as a recommendation for future research in a report by the Netherlands Environmental Assessment Agency (NEAA), pointing out that policy change is not the only

way forward in planning for a CE. Consumer behaviour needs to change simultaneously in order for the transition to succeed across various scales (PBL, 2019).

1.4 Reading guide

This thesis is built up with a particular structure for the reader to be able to follow the research in an orderly fashion. Although the chapters are placed where they are, the process of carrying out the research is iterative. This entails that the research was not necessarily carried out in the same chronological order as portrayed by the chapters. The second chapter elaborates on the theoretical concepts and background ideas of this research. In this chapter, previous research on monitoring the CE is discussed. The methodology used to collect all data is explained in the third chapter. In the fourth chapter, the results are presented and analysed. Hereafter, this analysis is discussed in the fifth chapter, also addressing any limitations to the research. Lastly, the conclusion is presented in chapter 6, in which the research question is answered. Additionally, recommendations for further research are given in this chapter.

2 Theoretical framework

In this chapter various theoretical concepts from the literature are illustrated and discussed. These concepts serve as a basis for this thesis. First, the term circular economy is further defined (section 2.1). Secondly, existing monitoring frameworks and models in the Netherlands are analysed (section 2.2.) Next, alternative monitoring frameworks and models are discussed outside the Netherlands for comparison (section 2.3). Hereafter, critiques on monitoring frameworks and on methods of monitoring are discussed (section 2.4). Relevant aspects of aforementioned frameworks and models are extracted to ultimately define and build the conceptual model for this research, bearing in mind the discussed critiques (section 2.5).

2.1 Circular economy framework

As described earlier (section 1.1), the CE concept is based on ‘closing the loop’ in processes, regenerating natural systems and eliminating waste and pollution. The aforementioned ‘loops’ can be differentiated into biological and technical cycles. In the former cycle, biologically-based materials (such as cotton) and food are consumed and fed back into the natural system through anaerobic digestion and composting (Ellen MacArthur Foundation, 2017). In the latter cycle in which manufactured goods are made (such as mobile phones), materials, components or the product as a whole is repaired or recycled for other use (Ellen MacArthur Foundation, 2017). Figure 2 outlines these technical and biological cycles of the CE.

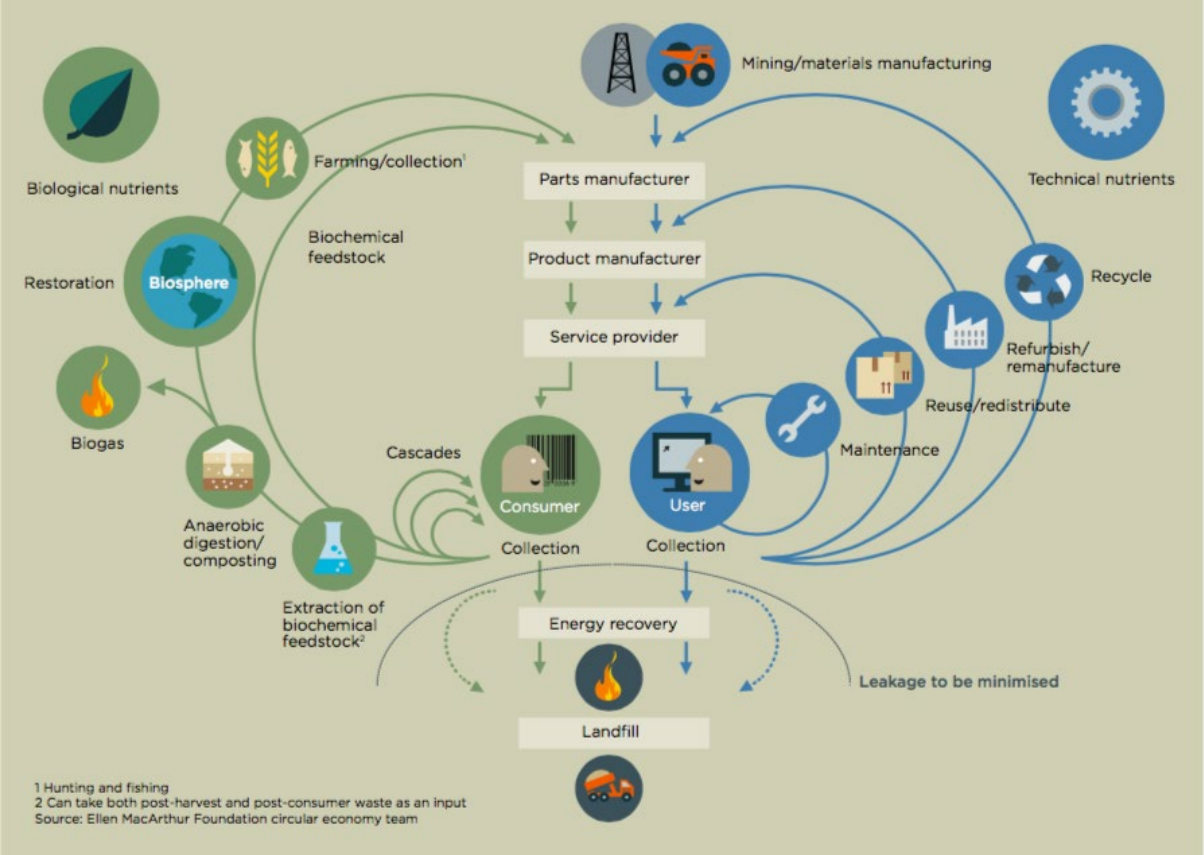


Figure 2: Visualisation of the circular economy (Ellen MacArthur Foundation, 2013).

Furthermore, transitioning towards a CE means "a systemic shift that builds long-term resilience, generates business and economic opportunities, and provides environmental and societal benefits" (Ellen MacArthur Foundation, 2017, The concept of a circular economy section, para. 2). A common misconception is that it only refers to reducing the negative impacts already inflicted by the linear economy (Ellen MacArthur Foundation, 2017; respondent 4, personal communication, December 1, 2020). This idea is further reflected in the R-strategy model which prioritises actions and circular strategies (see figures 3 and 4).

2.2 Monitoring frameworks and models in the Netherlands

The R-ladder – also known as the circular ladder – serves as a means of being able to determine the degree of circularity of a certain activity or action (PBL, 2019). The circular ladder has different variations in level of detail and can vary in literature from 3Rs, 4Rs, 6Rs (figure 4) or 9R's (figure 3) (Kirchherr et al., 2017b; Potting et al., 2017). Each consists of strategies which are aimed at reducing the use of primary abiotic raw materials. The higher an activity scores on the R-ladder, the fewer raw materials are being used, which means there is

a smaller environmental pressure present (PBL, 2019). So, in fact, the higher the strategy, the better.

The first strategies ‘refuse and rethink’ (R0 and R1) are based on the principle of refusing products and rethinking a products’ purpose and the opportunities of making it multifunctional (PBL, 2018). In the 6R framework these two strategies are joined into a single R-strategy. R2 ‘reduce’ aims at increasing the efficiency in product manufacturing and use. This strategy is not only aimed at products but also various services, such as the supply of energy for domestic use (PBL, 2018). ‘Reuse’ marks the third R-strategy (R3) which focuses on the reuse of goods, as is the case in second-hand shops. The system of leasing products (such as clothing or washing machines) to another user is also considered to be a part of this strategy (PBL, 2018). The fourth strategy ‘repair and remanufacturing’ (R4) aims at the refurbishment of products and the reuse of specific product parts. R5 ‘recycling’ is aimed at the recycling of products and the reuse of their materials. The sixth strategy ‘remanufacture’ (R6), is when the structure of a certain product is taken apart, revised and cleaned, and rebuilt (by substituting faulty parts if necessary) and otherwise used for other products (Vermeulen et al., 2018). R7 ‘repurpose’ refers to: “reusing discarded goods or components adapted for another function” (Vermeulen et al., 2018, p.2). In the 6R framework, R4-7 are all considered to pertain to one strategy, namely ‘repair and remanufacturing’. R8 ‘recycle’ is perhaps the most commonly applied method throughout various sectors and on a large and small scale. The final R-strategy (R9) is aimed at the recovery of energy from product materials (PBL, 2018). This model acts as a starting point for circular system thinking, given that innovators are forced to think of new ways to implement processes or manufacture goods within a R-strategy that is as low as possible.

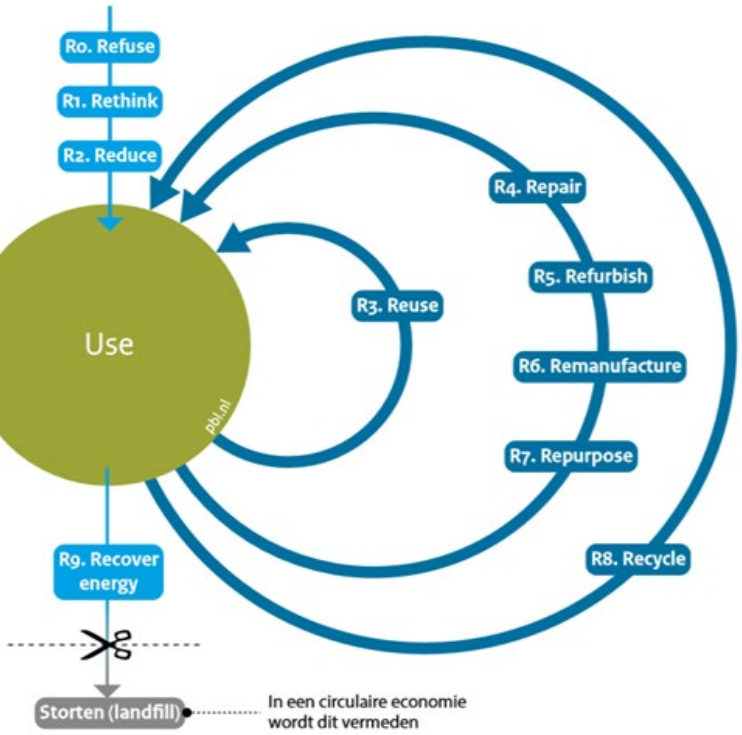


Figure 3: 9R-ladder circular strategies (PBL, 2018).

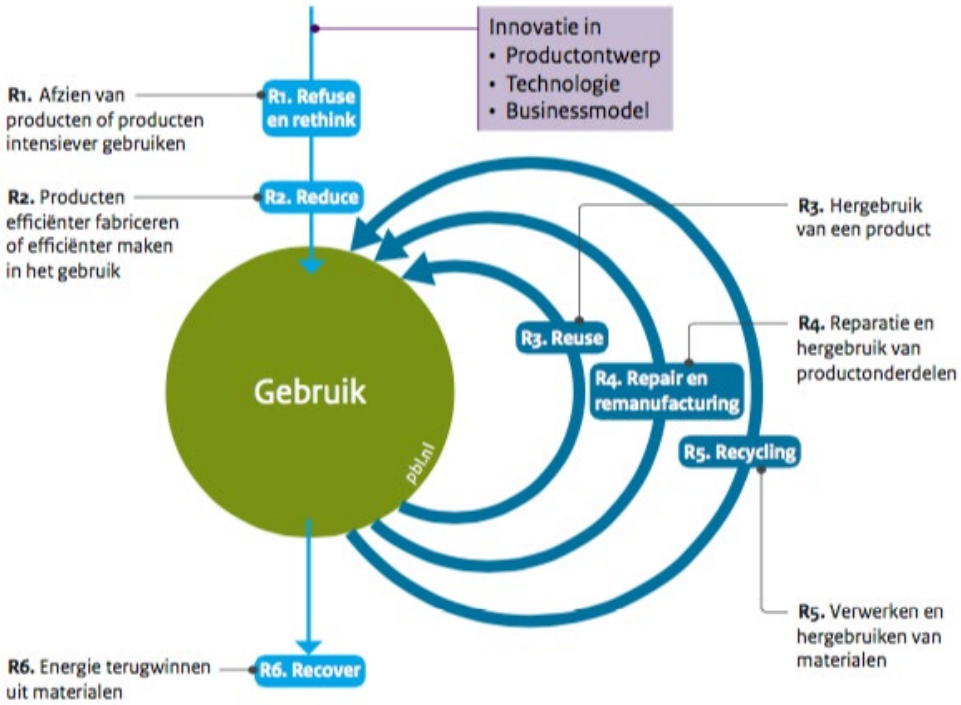


Figure 4: 6R-ladder circular strategies (PBL, 2021).

Following on from laying down circular strategies – which essentially tells you what to do and how to get to a certain circular solution – it is important to track such actions and be able to

monitor overall progress towards a CE. As mentioned before, the NEAA has developed a framework that depicts the transition process towards a circular economy, focusing primarily on what can be measured and what we want to know to achieve a successful transition (see figure 5) (PBL, 2018). The framework is made up of two aspects: the desired effects in a circular economy and the transition process that should lead up to those effects. The reason to include the latter is because the effects are usually not directly visible, but only after a few years of implementation of a certain policy (PBL, 2018). The prime desired effect is the decrease in raw materials use, which in turn lessens environmental pressures and international dependency of raw material import, which then strengthens the Dutch socio-economic position (PBL, 2018). Not all indicators that are included in the framework are measurable yet. However, the NEEA aims at further developing the framework with other research institutes and those involved with the national transition agenda in years to come so that in the end, all indicators are measurable (PBL, 2018).

An important aspect of this framework is the distinction between the process of transition and certain effects thereof. The former will mainly be based on policy documents and visions of RvN and the discourse that relates to how inhabitants view the circular economy and their level of awareness.

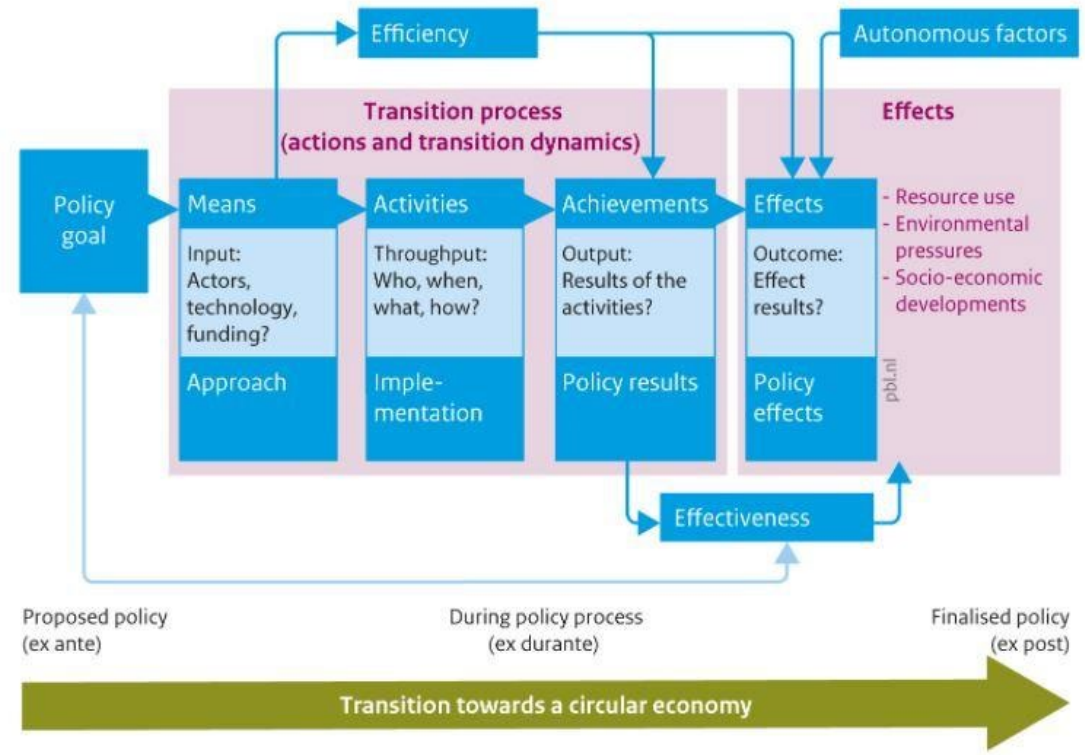


Figure 5: Policy evaluation framework for monitoring and guidance of the transition towards a circular economy (Netherlands Court of Audit, 2005, adapted from PBL, 2019).

Developing a framework for measuring and monitoring circularity is a difficult task for a number of reasons. As Vervoordeldonk (2019) describes, each region is unique and has its own specific targets which requires its own adapted monitoring framework.

In the research on the metropolitan region of Amsterdam (MRA), a framework is applied combining three aspects, namely: the transition of raw materials, the energy transition and various sustainability goals related to air quality, social wellbeing and employment (Roemers et al., 2018). Based on these aspects, various indicators are set out that capture the aspects on three different regional levels, referred to as: transition indicators, dashboard indicators and primary indicators. This framework is depicted in figure 6. These indicators were based on five criteria, namely that they must be: holistic in meaning, approachable for public understanding, applicable in practice, able to be influenced by the region it is applied in, and replicable for other regions to apply also (Roemers et al., 2018).

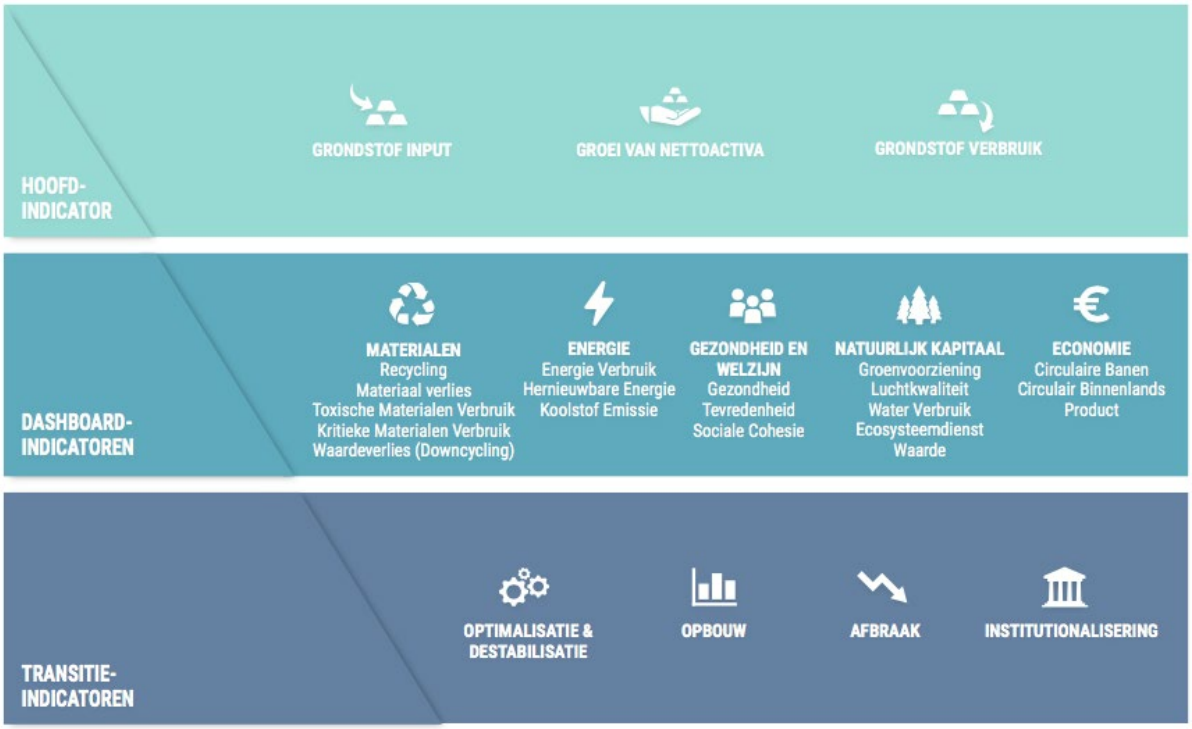


Figure 6[1]: Monitoring framework for a circular economy (Roemers, et al., 2018).

[1] Figure 6 is only available in the literature in Dutch. The entire content of figure 6 is explained in the text in English.

The primary indicators give a clear image of the state of the circular economy through the input and use of raw materials. However, they do not say anything about the direct impact of this use in society (Roemers et al., 2018). The primary indicators include measuring primary material input and overall use, and the growth in net assets. Firstly, the former two indicators respectively refer to the in-flow of raw materials into the region (input) and secondly, the overall use of raw materials throughout the value chain (i.e. everything that was needed to create a given product). This indicator is measured in type and weight of waste of a product (Roemers et al., 2018). The latter indicator refers to all raw materials 'held' in the economy as products or buildings, for example (Roemers et al., 2018).

The dashboard indicators form the context for the primary indicator and give a broader view of the circular economy and its social and ecological effects. Like the primary indicators, dashboard indicators are a means to, not an end in itself (Roemers et al., 2018; Respondent 1, June 5, 2020, personal communication). This means that they measure the development of a certain action or change towards the goal of achieving circularity (Roemers et al., 2018). These indicators include: materials (recycling rate, loss of material, toxic material use, loss of material value through downcycling and use of critical materials), energy (total use, renewable energy use and CO_2 emissions), health and well-being (human health, satisfaction and social cohesiveness), natural capital (greenery, air quality, water consumption and ecosystem service value) and economy (circular employment and circular domestic product) (Roemers et al., 2018).

Finally, the transition indicators illustrate the more gradual and structural changes in the economy in the process of it becoming more circular (Roemers et al., 2018). This includes measuring both the transition towards building a more circular economy, but also the destabilisation of the linear economy (Roemers et al., 2018). This transition of building and destabilising has various transition phases. In each phase, change takes place in structure, culture and practices (Roemers et al., 2018). Structural change refers to areas like legislation, physical infrastructure, in finance, and within organisations. This change can take place by passing circular laws (institutionalisation), adjusting circular policy and investing in circular procurements and research on circularity. Cultural changes refer to the urgency people relate to the monitoring of CE transition and in a wider sense, the awareness that prevails around the monitoring of the CE (Roemers et al., 2018). These aspects are, amongst others, mirrored in the number of protests that occur against the continuation of a linear economy, the number of political parties with circular visions, and a circular common train of thought. Lastly, change in practice expresses itself in a decrease in daily routines that encourage the linear economy

(such as Black Friday deals), the number of circular patents, and subsidy requests for projects focussed on process or resource efficiency (Roemers et al., 2018).

According to PBL (2018), viable and reliable indicators to measure and monitor circularity are not always readily available and developed yet, which makes it difficult to pinpoint the exact quality of progress made in circular strategies. The aforementioned framework is based on multiple authors (Metabolic, 2017; Raworth, 2017; Potting et al., 2018; 2016; De Wit et al., 2018; Douma et al., 2017) and on the United Nations Sustainable Development Goals (SDGs), which provides a good basis of indicator research. In order to better understand this framework, other (inter)national frameworks and monitoring tools are briefly discussed below.

2.3 Alternative monitoring frameworks and models

The aforementioned framework by Roemers et al. (2018) was inspired by previous models and frameworks for monitoring circularity around the world. There is no uniform or universal, watertight method of measuring and/or monitoring circularity. One of the reasons which makes this such a difficult task is the level of abstraction and complexity within circularity (Roemers et al., 2018). An economy is affected by many factors which contribute to it being circular or not. The use of and reliance on raw materials, the degree of waste recycling, the organisation of green initiatives, the production of energy, and transport infrastructure, are some factors which contribute to a region's level of circularity, just to name a few (Roemers et al., 2018). Given that the spectrum of factors that influence circularity is so broad, it makes it difficult to operationalise one research and pinpoint an exact method of monitoring to see its progress.

De Wit, Verstraeten-Jochemsen, Hoogzaad, & Kubbinga (2019) suggest the Global Circularity Metric (GCM); a simple measurement unit for an extremely complex system. One major drawback is the variation in data quality; especially in the waste sector, reliable data remains scarce (De Wit et al., 2019). Another challenge is that the GCM does not measure the quality of the product or material that is fed back into the economic system at the end of its life. The quality of the product is of great importance for its reuse, given that products in a better state are more useful than products that come back in a poor state and may not be able to be reused at all (De Wit et al., 2019).

Jacobi et al. (2018) and Mayer et al. (2018) use economy-wide data and like Avdiushchenko (2018) and Llorente-González (2019), focus on the macro-level of European cities. These researches stem from the EU framework for monitoring the CE, set up in 2017 focussed on

measuring a total of ten indicators in the areas of production and consumption, waste management, secondary raw materials, and innovations (Avdiushchenko, 2018). As is the focus of this research, Avdiushchenko (2018) focuses her research on a regional level in order to “support regional policymakers in CE implementation via more effective monitoring actions” (p.3). In addition to this, in 2016, initiatives like Urban Agenda for the EU (Pact of Amsterdam) were introduced that stimulate the shift towards a more CE.

Gravagnuolo et al. (2019) and Cavaleiro de Ferreira & Fuso-Nerini (2019) show applied examples of baseline monitoring frameworks on a city-level, respectively on eight self-defined circular, European-port cities (Amsterdam, Rotterdam, London, Antwerp, Hamburg, Marseille, Lisbon and Porto), and on Porto. Indicators are kept very broad so that they can be applied to the different cities. Gravagnuolo et al. (2019) explains that European cities have a more “bottom-up and place-based” (p.3) approach to applying circularity based on “specific resources and local challenges” (p.3).

Het Versnellingshuis Nederland circulair! (2020) suggests five tools for measuring the degree of circularity in an organisation or region. The first is the Circle Assessment by Circle Economy. This tool provides organisations with a score for the entire, or parts of the company based on seven key areas of the CE. The second is the Circle Scan tool, also by Circle Economy. This tool showcases various value flows, such as energy, materials and products within an organisation, region or value chain. Additionally, the scan identifies opportunities for circular projects. The third proposed tool is a metabolism analysis by Metabolic. This tool is also aimed at a city, region, business or other organisation and showcases the flows of material, energy, water and waste. Like the Circle Scan, it gives direction to possible interventions. The Circulytics tool by the Ellen MacArthur Foundation is proposed next. This tool is aimed at providing company-level data on “the extent to which a company has achieved circularity across its entire operations” (Ellen MacArthur Foundation, 2017). It scores businesses on indicators such as: material flows, strategy and innovation and has been tested on over 30 companies in 2019, including Philips, Unilever and World Business Council for Sustainable Development (WBCSD) (Ellen MacArthur Foundation, 2017). Finally, the Circular Transition Indicators (CTI) tool by WBCSD (2021) is suggested. This tool analyses circular performance based on ten indicators, like water circularity and renewable energy use (WBCSD, 2021). Companies can upload existing data and calculations are performed to see indicators like in- and out flows of materials. The CTI tool also generates reports that allow visual comparison of indicators and circular progress, specific to business units or product lines (WBCSD, 2021). Such tools help assess current efforts and help prioritise further actions towards more circular business processes. However, they are mostly restricted to a single entity or organisation,

instead of a whole region that encompasses multiple entities, organisations and civilians. These tools could however provide a solution for comparison of organisations and identify frontrunners and areas of organisations that are still lagging behind.

The Regiotool – developed by Royal HaskoningDHV (RHDHV) – is another tool aimed at portraying material flows on multiple scales, including cities, municipalities or groups of the latter, also known as regions (RHDHV, 2021). This tool uses key figures based on averages, and helps initiatives take off in their development towards becoming more circular (RHDHV, 2021).

Table 1: Overview of existing monitoring frameworks and supporting theories (adapted from Roemers et al., 2018, p. 16 and self-elaborated).

Source	**Name publication**	**Function**
European Commission (2018)	Monitoringsraamwerk voor een circulaire economie	Framework
Ministerie van Milieu, Energie en Waterschappen, Frankrijk (2017)	10 sleutelindicatoren voor een circulaire economie	Framework
Planbureau voor de Leefomgeving, Nederland (2018)	Systeem en nulmeting voor monitoring van de voortgang van de circulaire economie in Nederland	Framework
EUROSTAT (2016)	Materiaalstroom boekhouding	Supporting theory
Circle Economy (2018)	The Circularity Gap Report	Framework
Europese Commissie (2014)	Grondstof efficiëntie indicatoren	Framework
OECD (2014)	Green Growth indicatoren	Framework
Planbureau voor de Leefomgeving, Nederland (2016)	Circulaire Economie: Innovatie meten in de keten	Supporting theory
EEA (2016)	Circular Economy in Europe - Developing the knowledge base	Supporting theory
Wuppertal Institut (2014)	Material intensity of materials, fuels, transport services, food	Supporting theory
De Wit Verstraeten-Jochemsen, Hoogzaad & Kubbinga (2019)	The Circularity Gap Report 2019	Framework

Mayer et al. (2018)	Measuring Progress towards a Circular Economy - A Monitoring Framework for Economy-wide Material Loop Closing in the EU28	Framework
Jacobi, Haas, Wiedenhofer & Mayer (2018)	Providing an economy-wide monitoring framework for the circular economy in Austria: Status quo and challenges	Framework
Moraga et al. (2019)	Circular economy indicators: What do they measure?	Framework
Avdiushchenko (2018)	Toward a Circular Economy Regional Monitoring Framework for European Regions: Conceptual Approach	Framework
Gravagnuolo, Angrisano & Fusco Girard (2019)	Circular Economy Strategies in Eight Historic Port Cities: Criteria and Indicators Towards a Circular City Assessment Framework	Framework
Roemers, Galle & kennedy (2019)	Notitie Rijk van Nijmegen Circulair	Supporting theory

2.4 Critiques on monitoring frameworks

The previously suggested frameworks from carried out research serve as a reliable starting point for this research relating to monitoring the CE in RvN. Having said that, regions differ greatly from each other and it is hence important to mention that direct comparison may not be reliable or impede on the relevance. Each region is unique in its composition of population, industrial activity, policy, geography and so on. This makes it difficult to develop a tool that fits each municipal region in a single area, let alone across a whole country. Importance and relevance of certain indicators can also vary per region. Moreover, certain indicators relevant to a certain region present a value that may not entirely pertain to the region alone. In other words, the measured outflux of waste materials will not necessarily be processed in Nijmegen itself. The same goes for energy use for a given region, which may be initially produced elsewhere. This makes it difficult to determine whether such indicators give a good representation of the transition process of a particular region towards a CE.

It remains difficult to fully monitor the transition towards a CE because indicator data is not only sometimes lacking, but also in some cases not accurate. Hanemaaijer et al. (2021) state

that the majority of so-called circular businesses focus on activities like recycling, reuse and reparation; all activities that already existed before the concept of transitioning towards a CE was introduced.

In addition to this, critics from various fields such as Environmental Progress, TNO and Utrecht University state that the focus of indicators for monitoring circularity is sometimes restricted; for example, to the rate of recycling (Van Noort, 2020). However, recycling makes up a small aspect of CE and that there are many more indicators that a researcher should consider when wanting to gain a reasonable overview of progress (Van Noort, 2020).

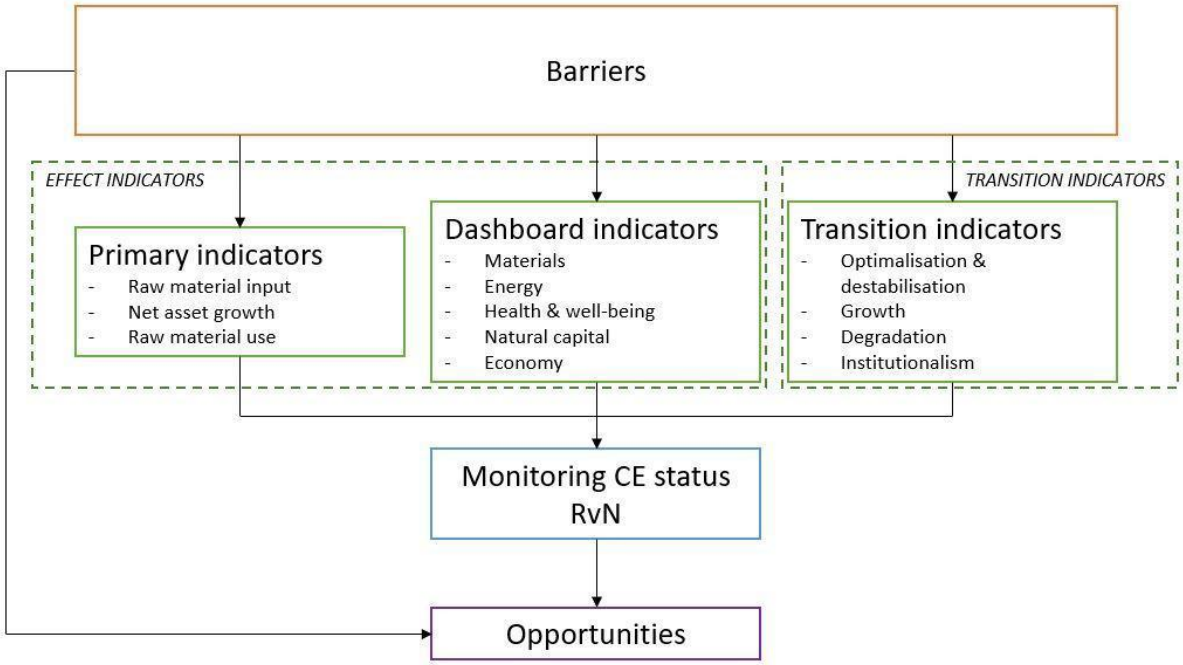
Previous studies by Kirchherr et al. (2017) and Rizos et al. (2016) have shown that "lack of consumer interest and awareness" (p.2) is a main barrier in the transition towards a circular economy in small and medium businesses in Europe (Camacho-Otero, Boks & Pettersen, 2018). According to Camacho-Otero, Boks & Pettersen (2018), there are seven main factors that influence the acceptance of circular solutions (such as: risks and uncertainty, potential benefits, and personal characteristics), which each branch out in various sub-categories (see appendix A1). Due to reasons concerning the scope of this research, this aspect will not be directly included in the research. For this aspect to be included, the inhabitants of RvN would have to participate in a survey for example, where they share their thoughts on the circular economy in their home area or the theory by Camacho-Otero, Boks & Pettersen (2018) would have to be tested in practice. That being said, this indicator is encompassed in the transition indicator so is not completely left out.

Prior research often indicates that there is a need to transit from a linear economy to a circular economy (Ellen MacArthur Foundation, 2013). Hence, this suggests that society still finds itself (at least partly) in a linear economy and at the beginning of a circular economy. While parts of this belief may be true, it is also important to state that the transition is already taking place and that society today finds itself somewhere in the middle – even if that means at the beginning stage of the middle. The 'hype' surrounding the transition from a *linear* to a *circular* economy needs to be substituted by the train of thought that society is already circular by definition. Hence, we need to transit to a '*more'* circular economy (respondent 4, personal communication, December 1, 2020).

2.5 Conceptual model

As Green (2013) states, a conceptual framework or model is an instrument to analyse a certain social setting and largely depends on the type of research being carried out. The conceptual model depicted below (figure 7) is derived from the literature study that is discussed in previous sections of this chapter. The conceptual model makes it clear what relationships are present between variables. As is illustrated in figure 7, the state of monitoring the CE in RvN depends on three variables, namely: the primary indicators, dashboard indicators and transition indicators. However, these are each influenced by (external) factors, otherwise known as barriers. These concepts that make up the conceptual model are further explained below. The way in which data was collected for each concept is explained in the next chapter (section 3.1.1), formulated according to the sub-questions (chapter 1).

Figure 7: Conceptual model (own publication, inspired by Roemers et al., 2018).



2.5.1 Indicators and monitoring status

As mentioned before (section 2.2), the framework proposed by Roemers et al. (2018) consists of three levels of indicators: primary, dashboard and transition. The primary and dashboard indicators are mostly hard data, with different measurement units, so that their effect can be monitored. Although not all data may be captured in a database (yet), some data can be extracted from policy reports or analyses on the region of RvN. As for the transition indicators,

these cannot be measured as hard data, but rather take the form of policy documents and reports, laws and regulations in place, and even some forms of discourse. Together, these indicators provide an image of the progress of monitoring the CE of RvN.

2.5.2 Barriers

While the three levels of indicators demonstrate themselves as the independent variables in this conceptual model, they are in fact influenced externally by a series of factors that reside in the (social) context of monitoring the CE. These factors can also be referred to as barriers. In the literature, barriers are manifested in various fields, such as social, financial, legal and systematic (Galvão et al., 2018; Kirchherr et al., 2017a). This research analyses the various barriers for monitoring from the literature in a deductive manner, and then turns to empiricism to analyse which barriers to monitoring the CE are applicable to RvN, inductively. External factors can also encompass positive factors that stimulate CE and the monitoring thereof. However, in this research it is assumed that the positive factors are already adapted in the monitoring framework by Roemers et al. (2018). Hence, why this research primarily focuses on the barriers as factors that influence the monitoring status of RvN.

2.5.3 Opportunities

After having analysed the indicators and barriers related to monitoring the CE in RvN that influence the monitoring status, certain opportunities can be identified that can help improve the transition towards achieving a more CE. These opportunities ultimately form the recommendations for RvN to act upon for a better monitoring of the CE. Evidently, opportunities can directly be identified as possible solutions to the barriers as a result of the literature review. However, in this research the opportunities will be addressed after having identified the indicators and the progress of CE in RvN, because there could be more opportunities identified empirically.

3 Methodology

In this chapter the methodology of this research is explained. It is made up of mixed methods including: desk research and semi-structured interviews. This chapter is built up in the following manner. First, the theoretical paradigms are explained that best suit this research (section 3.1). Next, the research strategy is explained (section 3.2), followed by the data collection methods (section 3.3). Finally, the way in which the data is analysed is made clear (section 3.4), with extra attention to the validity and reliability of this analysis (section 3.5).

3.1 Theoretical paradigms

According to Guba & Lincoln (1994), there are four main paradigms – also known as interpretive frameworks – upon which research can be based: positivism, post-positivism, critical theory and constructivism. Creswell (2013) adds: transformative, postmodern, pragmatism and critical race, feminist, queer, and disabilities theory. Each paradigm has specific features defined by the ontology, epistemology, axiology and methodology of the research (Creswell, 2013; Guba & Lincoln, 1994). Ontology says something about the nature of reality and its (various) aspects, and epistemological beliefs state how such a given reality is known, by studying the subjects of interest in the 'field' (Creswell, 2013). Axiological beliefs describe the role of values and allow the researcher to comment on eventual biases and that the research is value-laden. Finally, the methodology describes the procedures or process of the research (Creswell, 2013).

This research predominantly rests upon pragmatic and post-positivist beliefs. Pragmatism is based on the belief that reality is something that fits and is practical for the particular research being done (Creswell, 2013). Reality is known through various types of qualitative and quantitative data collection and analysis methods, which respectfully reflect both inductive (subjective) and deductive (objective) evidence (Creswell, 2013). Post-positivists believe that there is one reality which the researcher may not apprehend per se (Creswell, 2013; Guba & Lincoln, 1994). With this approach, the contact – through interviews for example – with participants is kept to a minimum while testing and comparing theories is focussed upon more (Creswell, 2013). Aspects from both interpretive frameworks can be identified in this research. As mentioned in the first chapter, the objective of this research is to investigate the degree of monitoring circularity in RvN, and lead to an eventual recommendation for the region in this field. The theories discussed in the second chapter are compared to analyse their effectiveness and applicability in RvN. These are both characteristics that belong to the post-

positivist trail of thought (Guba & Lincoln, 1994). Besides this, this research uses various methods of data collection which fit the research question best, as will be further addressed in the following section (section 3.2), which reflects the pragmatist paradigm.

However, this idea does raise an important point in that this research, both quantitative as well as qualitative indicators are present. The previously mentioned indicators, material flows, energy use and recycling for example, are all quantifiable variables, whereas discourse and policy for example, are not. This makes it difficult to define the research to strictly one paradigm. Combining one objectively grounded paradigm (post-positivism) with a more subjective paradigm (pragmatism) makes things rather complex, given that the beliefs of how reality is perceived are very different. The ontologies of (post-)positivism tell us that findings are respectively true as they are presented, and most probably true (Guba & Lincoln, 1994). Contrastingly, in the case of pragmatism, findings are created, and value mediated (Guba & Lincoln, 1994). When monitoring the CE, different perceptions and ideologies can be identified as to what exactly speeds up the progress of it, which indicators prove this progress of transition and what action should be taken. In this sense, multiple realities are true and discovered along the way, as more research is carried out on the topic. Evidently, these beliefs of how data and reality is perceived somewhat contradict each other which may impede on the quality of this research and further recommendations that come out of it. Nevertheless, it is important to highlight these differences and attempt to incorporate both paradigms into this research.

3.2 Strategy

3.2.1 Research design

An exploratory case study is commonly used in – amongst others – research on innovation and sustainable development projects (Yin, 1981). It helps to understand a given phenomenon or process “in its real-life context, especially when the boundaries between phenomenon and context are not clearly evident” (Yin, 1981, p.2). Hence, this research took form as an exploratory single, holistic/embedded case study. Exploratory research also attempts to serve as a basis for future studies and approach an existing phenomenon or process from a different perspective (Vennix, 2011), which fits the purpose of this research. In addition, this research was initially approached in a deductive manner, as the primary source of data is found through a literature review. Deductive research entails that the information and scope of the research goes from being reasonably broad to being refined and concise to the particular case being

studied (Vennix, 2011). After having found the most suitable set of indicators in a respective monitoring framework for RvN, a more inductive approach was applied.

3.2.2 Research phases

This research is built up of certain steps that can be categorised into various research phases. Figure 8 illustrates this idea. The first phase is made up of two main sections, namely: a literature study and the theoretical framework. The former mainly encompasses desk research. In this step, the snowball method is applied. The snowball method is a sampling technique which starts with a given publication or source of information which leads to other sources and so forth (Vennix, 2011). The latter is built up of various theoretical concepts and existing ideas that emerge from the literature study. In this step, key concepts are operationalised, and potential models and/or frameworks are developed to support the theoretical concepts (Vennix, 2011).

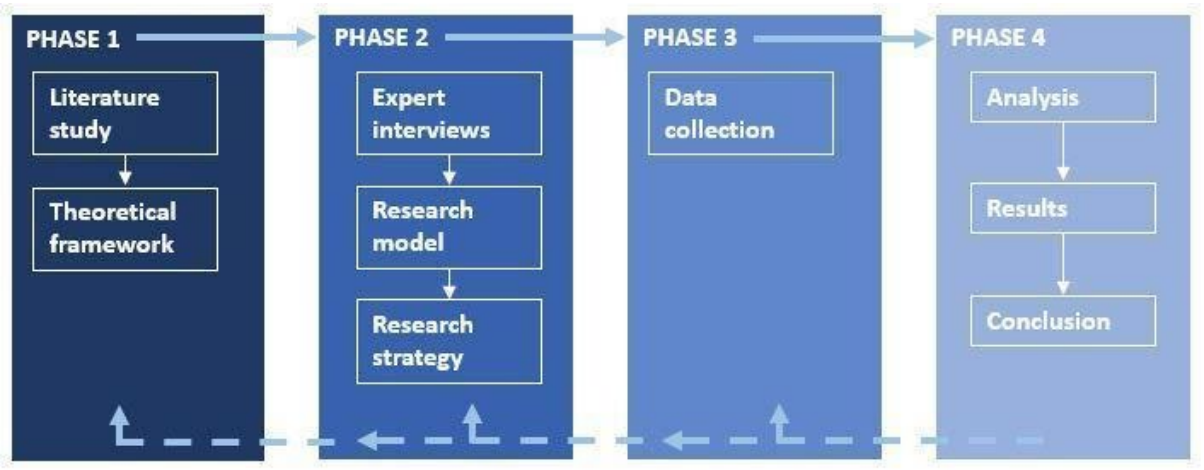
This then leads onto the carrying out of expert interviews as part of phase two. Experts in the field of the chosen topic are selected and interviewed to further explore the topic and theories found in phase one. In this step, deliberation with the internship organisation also takes place and ideas are developed on possible cases for the research. This step helps to redefine any possible theoretical concepts or potential cases. The next step in this phase is to create a research model for this research, illustrating all variables and any relationships between these variables. From here on, a research strategy is developed which describes how the research model is expected to be researched. This step includes various methods that are to be applied in the research, such as desk research and case interviews.

Phase three then forms the data collection step. This is where information is actively collected in the field, based on the research strategy that was set out in the previous phase. The data collection step encompasses various different stakeholders that are relevant to the research. Case interview respondents were carefully selected because of their function that relates directly to the CE in RvN. In this phase, the snowball method is also applied to find new respondents when conducting interviews for example. Important to note in this phase is that certain data collection methods, like observations, will no longer be able to take place, due to the pandemic situation. Instead, other methods are elaborated on, such as desk research.

The final phase is made up of three steps, starting with the analysis of the collected data from phase three. For interviews, this encompasses applying coding techniques and filtering

relevant information. This then leads to the results of the research, extracted from the analysed data. In essence, the results describe what patterns were found or what the data tells us in relation to the research question. Lastly, the results are discussed, and a final conclusion is made that answers the main research question. This step is also made up of a reflection section, which allows the researcher to express any limitations or other thoughts on the research as a whole, which lead to possible recommendations for further research on the topic.

Figure 8: Research phases (own publication).



3.3 Data collection methods

There are various different methods for collecting data that fit different types of research (Fischer & Julsing, 2014; Creswell, 2013; Vennix, 2011). This research has a predominant qualitative basis which is why it was formed by a case study. Typically, research containing post-positivist beliefs apply deductive methods with research techniques such as testing of theories and specifying variables (Creswell, 2013). From the pragmatic point of view both qualitative and quantitative data collection methods are used. In this research, each sub-question is unique, and while some questions may overlap in methods for collecting data, others may require slightly different methods or different approaches within the same method. For this reason, for each data collection method mentioned, the sub-questions are mentioned explicitly.

At first, a content analysis was carried out. This includes the analysis of different types of sources such as scholarly and non-scholarly articles, audio-visual materials and policy documents. Focus was laid on similar previously carried out projects that have either been very successful or perhaps proven quite the opposite. The circular economy is a trending topic

(Galvão et al., 2018), but varies in how much is published about certain aspects of it. In addition, a lot of articles are not of scholarly origin, which may not be as reliable as a scholarly article would be. This is important to bear in mind and try to eradicate possible biased arguments. This method forms the basis for answering all the sub-questions, but especially the first sub-question about available monitoring frameworks and tools. For the second, third and fourth sub-questions, reports and policy documents were reviewed to see which indicators were already being monitored, which indicator data were being worked on and which indicators do not yet have any available data. For the fifth and sixth sub-questions, literature was studied to identify what barriers and opportunities relating to monitoring the CE have already been highlighted by other authors.

Secondly, for this research, nine semi-structured, in-depth interviews with various respondents that are relevant to the case were conducted. These respondents are listed in appendix C and can be categorised into experts and case-relevant respondents. The expert interviews give a more general view on the topic of CE and illustrate examples of monitoring CE outside of RvN, whereas case interviews are specific for the region of RvN. Questions and topics were prepared beforehand in an interview guide (see appendix B). The order in which these questions or topics are addressed does not matter and gives the researcher the flexibility to go to and from a topic, according to how the interview progresses (Creswell, 2013). In a semi-structured interview, it is important for the researcher to pose open-ended questions, which leaves room for interpretation for the respondent. If the researcher is being suggestive in the interview, it could lead to a false interpretation of the respondents' opinion (Creswell, 2013). The interviewing research method supplements the aforementioned content analysis in answering all sub-questions and eventually the main research question. For the second, third and fourth sub-questions, respondents were asked to share their knowledge of indicators that were being measured, being worked on or not yet being monitored. For the fifth and sixth sub-questions, respondents were asked for their view on barriers and opportunities relating to monitoring the CE. Important to note is that the eighth and ninth case interviews were approached in a slightly different manner. The interview guide was not so much adhered to, given that these interviews were specific to the primary indicator material use and input and the dashboard indicator materials. The goal of both interviews was to gain an overview of available data for RvN on the aforementioned indicators. Hence, these interviews were summerised on what data was available and what data was not, and are marked in table 1 as 'case data' interviews.

In context of the current global crisis and national policy and other regulations concerning COVID-19, all interviews were conducted via digital conferencing tools (such as Teams, Skype

and Zoom). Such conferencing tools serve as a decent alternative to face-to-face interviews, given the fact that it allows the researcher to view the respondent just the same in real-time conversations through a computer or other mobile device (Nehls et al., 2015). Another advantage of video-conferencing tools is that it allows flexible meeting times for both the researcher and the respondent and it also saves on possible expenses that could be made on travel, food and lodging (Denstadli et al., 2011). Additionally, video-conferencing allows the researcher to pick up on and observe any non-verbal signs (Fisher & Julsing, 2014). This aspect becomes important in a later stage of the research when analysing the interviews and interpreting the data. In some cases, it could be that the verbal data the respondent gives in the interview does not match the non-verbal signals they give off. Having said that, video-conferencing only shows a portrait sized image of the respondent, which means that the researcher may miss out on any other possible body language that the respondent displays. Thus, this may lead to a mis-interpretation of the data (Denstadli et al., 2011). Moreover, the surrounding environment of either the respondent or the researcher may be disruptive, which may have a dominant effect on the quality of the interview. In addition to this, poor internet connection could also be a problem, preventing the researcher from having a comprehensive conversation with the respondent and lead to repetition and lagged responses (Denstadli et al., 2011). The global health pandemic may also impact the number of interviews I can do and the quality of them. These are all factors to be considered when analysing the results of this research.

In any research, data triangulation should be a general aim in order to increase its validity (Vennix, 2011). Normally, the observation method could be applied to achieve this. However, given the current circumstances of working at home due to the global health pandemic, this method is no longer applicable. Instead, relevant desk research is of extra importance, and so for this research, extra official and/or non-official documents were consulted from respondents to extend the data sources.

3.4 Data analysis

As stated before, this research topic involves a lot of policy documents that are relevant. It is essential to analyse these documents thoroughly and pinpoint certain overlaps, contradictions and possible ideas for development.

After having conducted the interviews, they were all transcribed accurately. Deliberate permission of each respondent was asked and granted to audio-record each interview, for a

better quality transcription. In the transcription process it is important to also capture any emotional outbursts a respondent may have during the interview, given that this could very well help explain something they address and how they feel about it. Hereafter, the most important aspects of the interview that are relevant to the research questions need to be filtered out. The application ATLAS.ti was used to manually code the interviews openly at first, followed by axial coding. Open coding helps identify certain overlapping themes across different interviews, which helps sort them into categories (Creswell, 2013). Axial coding helps to further break down and specify themes within larger categories, which also helps to illustrate possible interconnections between themes (Creswell, 2013). The codes used were categorised into code 'families'. Each family encompasses a different core topic (such as 'policy' or 'barriers') and includes various sub-codes (also referred to as 'sub-families') (Creswell, 2013). Sub-codes allow a more in-depth analysis of the interviews and help identify possible interconnections between core themes and between interviews. Code themes were chosen based on the research questions posed in chapter 1 (depicted in appendix D).

3.5 Validity and reliability

Within research, it is important to pay attention to validity and reliability and ensure both are as high as they can possibly be. The validity of the research is made up of an external and an internal aspect. The external validity of a research determines the degree of which the results of the research are able to be generalised to a larger population or situation (Fischer & Julsing, 2014). The internal validity refers to the degree of certainty of the causal relationship which is being researched is true and not influenced by other external factors or variables (Fischer & Julsing, 2014). This can be very sensitive as variables within the research context can suddenly change during the course of the research itself. There are five main factors that could have an impact on the internal validity of a research: (1) a third variable, (2) history, (3) selection of respondents, (4) morality of drop-outs, and (5) ambiguity of the direction of research (Fischer & Julsing, 2014). Certain external variables (such as barriers) have been adapted into the conceptual model already in the hope to eradicate most of the risk of losing (partial) validity. However, it could be that there are other external variables that have an influence on the monitoring status of the CE in RvN. In order to maintain the best possible internal validity, the obtained results were checked continuously over time and possibly confirmed various findings with the respondents in an iterative manner.

Reliability refers to the degree of which the research results can be reproduced if the research were to be carried out again, also if the research were supposedly carried out by another

researcher (Fischer & Julsing, 2014). With qualitative research, this may be more challenging than with quantitative research, given that qualitative research is more subjective and better captures people's opinions and feelings, whereas quantitative research is more factual and based on concrete figures (Vennix, 2011). By choosing an existing framework as a guide for this research, it acts as a guide for the results and allows the researcher to fall back on the methods and line of thinking applied for that framework, decreasing levels of unclarity or uncertainty. Hence, keeping the risk of unreliability to a minimum.

4 Results

In this chapter the findings of the carried-out literature study and interviews will be presented in order to answer the research question – '*what indicators and factors contribute to a better monitoring towards a more circular economy in Rijk van Nijmegen (RvN) and what recommendations can be given to RvN to further stimulate the monitoring of the transition towards a more circular economy?'*. The chapter will be structured according to each sub-question, as outlined in chapter 1, with exception to the first sub-question – '*what monitoring frameworks and tools are available in the literature?'* – which has been answered in chapter 2. First, the status of monitoring of primary indicators (section 4.1) will be presented, followed by the status of monitoring of the dashboard indicators (section 4.2) and transition indicators (section 4.3). Hereafter, the external factors are identified that are of influence on the indicators and hence overall status of monitoring of CE (section 4.4). Finally, the possible opportunities or other trains of thought for RvN suggested by respondents is explained (section 4.5).

It is important to note that sections 4.1 and 4.2 explaining the data availability of the primary and dashboard indicators remains an indication of data availability and is not fixed. Currently, there is research being carried out on key performance indicators (KPIs) by the municipality of Nijmegen, as a result of the letter of state, mentioning the indicators used for monitoring the CE in the province of Gelderland (Provincie Gelderland, 2020).

4.1 Primary indicators

The second sub-question – '*what is the current state of monitoring of primary indicators?'* – analyses three indicators, namely: primary material input and overall use, and the growth in net assets.

4.1.1 Primary material input and overall use

Roemers, Galle, & Kennedy (2019) published a circular regional vision and implementation report for the city of Nijmegen – also highlighted in section 4.3 – and uses a methodology developed by Metabolic, namely the Regional Metabolism Analysis (Roemers et al., 2019). This measures – amongst other things – the volumes of the main material flows in the region in four sectors: the health sector, the construction sector, the manufacturing industry and the waste and bio-based industry. For the health sector, the in- and outflows of materials is evident

for the hospital RadboudUMC. The influx of materials is based on already manufactured materials (such as: textiles, cleaning products and medical equipment) and less so on primary raw materials (such as: plastics, various metals and glass). Data for other health institutions within RvN, like the Canisius Wilhelmina Ziekenhuis (CWZ), are not (yet) available.

As mentioned before, the Regiotool aims to help regional and local initiatives take off in their development towards a more CE (Royal HaskoningDHV, 2021). Amongst other things, the Regiotool gives an insight on material flows at city-level, municipal-level and/or for a region. The advantage of this tool is that material flows of all the municipalities of RvN are able to be viewed and are able to be compared with one another. However, the Regiotool uses key figures, not specific numbers for each municipality. Key figures based on averages may give a skewed image of the flows in the region, as one outlier can significantly change the value of the key figures.

Moreover, the primary material use indicator is especially dependent on data from the dashboard indicators materials and energy. Hence, when material and energy indicator data is missing for RvN, the more difficult it becomes to gain an overview of the primary material use indicator. The data availability on the material and energy dashboard indicators will be elaborated on later.

4.1.2 Growth in net assets

In the online platform Madaster, buildings are registered including the materials and products they contain (Madaster, 2021). This registry also works with a Madaster Circularity Indicator (CI) for buildings, which measures the degree of circularity in the construction phase, the utilisation phase and the end-of-life phase of the building, scored from 0-100% (Madaster, 2021). The score is appointed to a building on the basis of the material it is built from (i.e. whether the used materials are virgin or recycled, reused or renewable) and the buildings' functional lifecycle (Madaster, 2021). This way of measuring is ideal for monitoring the growth net assets indicator but is not (yet) binding in any way, so data for this indicator is currently only available on organisations or other parties that self-willingly have their building analysed by Madaster, and not per se for buildings in the RvN region.

Furthermore, stored materials also include electronic devices and apparatus citizens of RvN have in their possession. There is no data available for this, but a good alternative would be to make an estimate of the possessions for all citizens in the municipalities of RvN.

4.2 Dashboard indicators

The third sub-question – '*what is the current state of monitoring of dashboard indicators?*' – analyses five indicators, namely: materials, energy, health and well-being, natural capital and economy. There is no central database for RvN for all the mentioned indicators (yet). The municipality of Nijmegen monitors certain statistics like population density figures and housing market figures (Gemeente Nijmegen, 2021; 2020), and keeps track of their waste figures. Still, certain dashboard indicators are being monitored – even if it is not in too great detail, it is a start.

4.2.1 Materials

The materials indicator encompasses the recycling rate, loss of material, toxic waste use, loss of material value through downcycling and use of critical materials. The municipalities within RvN measure their waste flows, predominantly of domestic waste (respondent 8, personal communication, June 23, 2021). Domestic waste is differentiated into different categories and for most of the municipalities of RvN, data dates back as far as 2001 (CBS, 2020a). However, the rate of recycling, loss of material and loss of material value are not included specifically in these statistics for the region RvN, nor for the separate municipalities of RvN. Variations of these indicators are presented for different scales. Waste treatment and preparation for recycling is measured for the region Arnhem-Nijmegen and for the province of Gelderland (CBS, 2013). Small toxic domestic waste is also measured for the municipalities pertaining to RvN, as well as for the region Arnhem-Nijmegen, but does not include toxic waste from other sources like businesses or other organisations per municipality of RvN (CBS, 2013).

The Landelijk Meldpunt Afvalstoffen (LMA) (translated: National Reporting Centre for Waste) manages data on primary and secondary waste of businesses of the Netherlands, including that of the municipalities of RvN, including various types of materials (respondent 9, personal communication, July 9, 2021). Examples include: mixed municipal waste, biodegradable waste, grease and oil mixture from oil, asbestos-containing construction material, lead-acid batteries and waste paints and varnish containing organic solvents or other dangerous substances (respondent 9, personal communication, July 7, 2021). Practically all toxic waste is registered at the LMA, but a lot of other material data is missing, like glass or paper waste.

The degree of recycled material and degree of material loss through downcycling, is not known at the LMA. Information on these indicators reside with the waste processing companies (respondent 9, personal communication, July 7, 2020).

4.2.2 Energy

The energy indicator encompasses total use of energy, renewable energy use and CO_2 emissions. Total use of gas and electricity per municipality of RvN is available per sector, for example the large retail industry, agriculture and transportation (StatLine, 2020). Data on the amount of energy produced using renewable energy sources is available on provincial scale only. However, there are multiple policy documents indicating future energy plans or plans already in motion to promote and improve renewable energy sources. For example: Movements Group, a unique ICT company from Beuningen (one of the municipalities of RvN), looks to demonstrate and install a hybrid heat system (RvN@, n.d.). The demo set-up can be used by relevant market parties from the region to show how to make homes, business premises and neighbourhoods more sustainable. The demo set-up hereby contributes to the gas transition and is already set in motion (RvN@, n.d.).

In addition, the circular regional vision and implementation report for the city of Nijmegen shows the energy use across four sectors, for the hospital RadboudUMC (health sector), the construction sector, the road construction sector and waste and bio-based industry (Roemers et al., 2019). The different types of input energy source used is also mentioned, such as (natural) gas, diesel oil and electricity (Roemers et al., 2019). The same goes for the manufacturing industry. However, the waste and bio-based industry does not have defined energy sources as an input, nor does it specify the total amount for waste processing, yet it does specify the total energy used for wastewater treatment (Roemers et al., 2019). On the output side of the waste and bio-based sector, it is known how much energy is generated in terms of green gas, electricity generation and how much rest warmth goes to the heat grid (Roemers et al., 2019). In addition, the amount of energy that originates from incineration is known, including the amount of incinerated waste that generates no energy at all, and the CO_2 emissions produced (Roemers et al., 2019). For the remaining three sectors, the amount of CO_2 emissions is known, and the amount of energy generated from incineration of waste.

4.2.3 Health and well-being

The health and well-being indicator encompasses human health, satisfaction and social cohesiveness. For the latter two, data is limited available for RvN. For the municipal area of Nijmegen, satisfaction and social cohesiveness are split out in great detail (CBS, 2020). For social cohesion for example, the degree of how at home citizens feel is included, as well as how close contact citizens have with their neighbours (CBS, 2020). In total, the social cohesive score assigned to Nijmegen is 5.9/10 (CBS, 2020). Satisfaction is measured with a combination of whether citizens have a good feeling about the place they live and the degree of dissatisfaction in their place of residence. Essentially, it can be assumed that the less dissatisfaction there is in a region, the more satisfied a citizen is in their place of residence. In addition, the report by Boon et al. (2020) shows the extent of a healthy community for the municipal region of Nijmegen. For the remainder of the municipalities pertaining to RvN, there is no specific data available.

As for the human health indicator, CBS (2021a) indicates the experienced health of citizens, with the age eighteen or older, registered at the GGD-Gelderland Zuid. In the report by Boon et al. (2020), Nijmegen is listed above average measurement as a stress-relief place to be. This is also relevant for the human health indicator. As for the aforementioned satisfaction and social cohesiveness indicators, this data is limitedly available, mainly for the municipal area of Nijmegen or for the provincial region. This is also the case for data registered by the GGD-Gelderland Zuid, as opposed to the other municipal regions of RvN.

4.2.4 Natural capital

The natural capital indicator encompasses greenery, air quality, water consumption and ecosystem service value. As for the greenery in RvN, the municipalities of RvN have the number of trees registered (Overheid.nl, 2021), as well as the percentage of overall greenery in the region, displayed by the ‘Green map’ (Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2021). Moreover, the report by Boon et al. (2020) shows an above average measurement of greenery for the Nijmegen municipal area, compared to 19 other Dutch cities.

Exact measurements of air quality for all municipalities of RvN is also not readily available, only for larger municipal regions like Amsterdam and Utrecht (Overheid.nl, 2021). Other data sets on air quality are mainly focussed on livestock farm areas, measuring levels of nitrogen (di)oxide (Overheid.nl, 2021). Having said that, a study carried out measuring the air quality in nine Dutch cities, concludes that Nijmegen has the second worst (after Amsterdam) air quality

of the Netherlands (de Gelderlander, 2021). This ranking is mainly based on measuring the amount of fine matter (PM_{10}) and nitrogen dioxide (NO_2) in the air (de Gelderlander). The reports by Boon et al. (2020) and Gemeente Nijmegen (2020) confirm the higher levels of PM_{10} and NO_2 in Nijmegen. Factors that contribute to the poor air quality are from nautical transport on the river Waal and due to the amount of domestic heating of natural gas and wood-burning stoves (Gemeente Nijmegen, 2020). For the remaining municipalities that make up RvN, there is no concrete data available concerning air quality. Currently, the national government is carrying out research on air quality, using cheap sensors to measure PM_{10} and NO_2 in the air (RIVM, 2021). However, the sensing apparatus is not yet specific enough such that it does not comply with the EU standards of air quality measurements and so cannot be measured as official, national data for air quality (RIVM, 2021).

The use of water in the construction and road sector, in the hospital RadboudUMC and in the waste and bio-based industry is estimated in the report circular regional vision and implementation for the city of Nijmegen (Roemers et al., 2019). Furthermore, for each industry in the Netherlands, water consumption is known, as well as the average per capita consumption, but not specified to one region like RvN (Rijksoverheid, 2019; Foekema & Van Thiel, 2011). Measurements of water consumption are done by measuring three main flows: water that flows from nature into the economy, water that flows within the economy, and water that flows from the economy into nature (CBS, 2016). Each water authority monitors the water quality for their region, but not necessarily the amount of water consumed (Ruimte voor de Rivier, 2021).

In 2020, CBS and Wageningen University & Research (WUR) carried out a first attempt of monetising the ecosystem value in the Netherlands. Examples of what kind of value nature gives to the economy are: fields and grasslands that are used to grow crops and feed livestock, bees pollinate crops, and forests store CO_2 and produce oxygen (CBS & WUR, 2020). Important to note is that only the economic value of benefit to humans was considered in this study, leaving out all non-economic (such as aesthetics of greenery) and non-human (such as animal welfare) benefits (CBS & WUR, 2020). As is the case with water consumption, indicator data for ecosystem service value remains at national level.

4.2.5 Economy

The economy indicator encompasses circular employment and circular domestic product. This indicator is partly available, in that platforms stimulating the transition towards CE showcase

multiple circular jobs and projects. For example, RvN@ is a platform that aims to bring businesses together to work on circular solutions, in multiple sectors like the construction, housing and health sector. Within these sectors, RvN@ focuses on four themes: smart & IT, circularity, health & food, and entrepreneurship (RvN@, 2019). According to CBS (2020), there has been a slow increase in the amount of circular jobs over the past 20 years. On the one hand, this signifies a positive trend in that circular practices are becoming more dominant and valued. On the other hand, this increase could also mean that there is an increase in waste reuse or recycling jobs due to an increase in domestic waste (CBS, 2020). In this sense, an increase in domestic waste is exactly the opposite of what a more CE encompasses. Moreover, this data portrays an average of the existing circular jobs and so excludes potential areas for circular employment (CBS, 2020). Also, important to note is that this data is measured on a national level, and hence, it is not exactly known what percentage of circular jobs or circular GDP attributes to RvN, nor is it known what the degree of circularity is of those circular jobs, merely that they are in some way circular (Roemers et al., 2019).

4.3 Transition indicators

The fourth sub-question – '*what is the current state of monitoring of transition indicators?*' – analyses four indicators, namely: optimisation and destabilisation, build up (of a more CE), the breakdown (of the linear economy), and institutionalisation. As mentioned before (section 2.2), the transition indicators are identified by different phases, in which change takes place structurally, culturally and/or practically (Roemers et al., 2018). To identify these changes, policy documents were analysed and the degree of responsibility and awareness on the topic was identified. Important to note is that the structural, cultural and practical transitions appear within these two aspects interchangeably. There are of course more structural changes portrayed in policy, as there are more culturally related changes identified in awareness, for example, but they are not set to hard boundaries and so are not categorised in this way.

4.3.1 Circular policy

The circular policy relevant to RvN is summarised in table 2 below. As mentioned before, this list results from the interviews and the desk research carried out. Although (inter)national and EU circular policy (such as the EU Green Deal and the national ICER) is also of influence on RvN, it says little about the region itself or their specific actions or goals. For example, which indicators they are monitoring and which they are not. Hence, it has been left out of the short list of circular policies to be analysed for RvN. However, (inter)national and EU circular policy

remains relevant for the bigger picture, as it could possibly be an explanation as to why a certain region has an ambitious CE policy or whether it lacks diligence. Hence, (inter)national and EU policy has still been used throughout this research (chapters 1 and 2).

Each policy document in the table below has been categorised according to the scale it relates to (i.e. local, regional, national, so on). Although policy 1D is officially a nationally set up and controlled circular policy, it is categorised under the local scale because it is an administrative agreement that was signed by RvN and contains specific information about the region. In addition, it gives an indication for the second and third sub-questions that relate to waste indicators and data availability for RvN.

Table 2: Circular policy on different levels relating to RvN (own publication).

Code	Document title	Scale
1A	**Economische Visie 2020-2025** *(Gemeente Nijmegen, 2020)*	Local (municipal)
1B	**Inkoop- & aanbestedingsbeleid** *(Gemeente Nijmegen, 2019)*	Local (municipal)
1C	**Notitie Rijk van Nijmegen Circulair** *(Roemers, Galle & Kennedy, 2019)*	Local (municipal)
1D	**Van Afval Naar Grondstof (VANG) Bestuursakkoord** *(VANG-HHA, 2016)*	Local (municipal)
2A	**Circulaire Kansen regio Arnhem-Nijmegen** *(Hendriksen et al., 2017)*	Regional (Arnhem-Nijmegen)
2B	**Woondeal Arnhem-Nijmegen** *(Rijksoverheid, 2020)*	Regional (Arnhem-Nijmegen)
2C	**Manifest 'Maak werk van CIRCULAIRE ECONOMIE in de bouw en GWW-sector'** *(Wethouders Economische Zaken Regio Arnhem-Nijmegen, 2020)*	Regional (Arnhem-Nijmegen)
3A	**Rapportage Circulaire Atlas Gelderland** *(RHDHV, 2019)*	Provincial
3B	**Van ketens naar kringlopen: Uitvoeringsprogramma Circulaire Economie 2021-2023** *(Provincie Gelderland, 2019)*	Provincial
3C	**Gaaf Gelderland: Omgevingsvisie** *(Provincie Gelderland, 2018)*	Provincial

Local

In 2019, the municipality of Nijmegen set out their economic vision for the period 2020-2025 (policy 1A); the result of a collaboration between the municipality, multiple entrepreneurs, knowledge institutions, councillors and civil servants (Gemeente Nijmegen, 2019). The economic vision consists of six main themes, one of which includes circularity. The overall aim within the circularity theme is to encourage sustainable entrepreneurship, by stimulating the reuse of goods, and connecting entrepreneurs and providing them with an environment to develop themselves. In addition to this, Nijmegen aims to reduce the pressure on the living environment and to decrease the use of natural resources, by stimulating the reuse of used resources and thereby closing the loop (Gemeente Nijmegen, 2019). An example of this is the introduction of the 'House of the Inner City', a foundation that aims to improve the engagement in and aesthetics of the inner city, by reducing waste on the streets of the city centre (Gemeente Nijmegen, 2019). Considering the previous, the municipality highlights the importance of creating job opportunities. Having been European Green Capital, the municipality believes that Nijmegen has an exceptional starting position and potential to excel in this field (Gemeente Nijmegen, 2019). These aims are broken down into concrete actions, categorised in three key aspects: stimulating sustainable measures, providing a stage for circular businesses and working towards the last mile.

In addition to this, policy 1B focuses on the procurement process whilst considering the areas of circularity, mobility, vitality, climate change and the energy transition (Gemeente Nijmegen, 2019). These five themes are based on the SDGs and with each procurement, attention is paid to people, planet and profit (Gemeente Nijmegen, 2019). In the procurement process, a certain prioritisation is stuck to, that relates to the R-framework, for example, starting with the refusal of procurement if it is deemed unnecessary in any sort of way, firstly resorting to existing products (Gemeente Nijmegen, 2019). Attention for the procurement process is also paid in demolition and rebuilding works in the construction sector (Gemeente Nijmegen, 2019).

As mentioned before (section 4.1), policy 1C focuses on four sectors, namely: health sector, construction sector, manufacturing industry and waste and bio-based industry. This analysis shows the volumes of the main material, water, and energy flows, as well as the effects, impacts and inefficiencies in the chain in these sectors. On the basis of this analysis, the most important bottlenecks and opportunities for the economy for RvN are mapped out for each sector. More specifically, they propose nine key circular projects across the four sectors for RvN (Roemers, Galle, & Kennedy, 2019).

Policy 1D is aimed at municipalities decreasing their overall waste production to a maximum of 100kg per capita (VANG-HHA, 2016). Together with other municipal regions across the Netherlands, RvN is one of the regions that signed the agreement to adhere to minimising waste in their municipal region. Not only does committing to this agreement contribute to a higher transition indicator value, it also contributes to the materials dashboard indicator (reducing waste).

Overall, there is more local policy focussed on the municipality of Nijmegen, as opposed to all municipalities pertaining to RvN. This is because Nijmegen is the biggest and most prominent city for the region of RvN, and also pertains to the larger network of Arnhem-Nijmegen.

Regional

Policy 2A lays out various circular opportunities for the region Arnhem-Nijmegen, mainly aimed at businesses in the industrial sector, health sector, trade, transport and storage sector, and in construction and property (Hendriksen et al., 2017). The regional opportunities scan, carried out by the three local Rabobank's in the Arnhem-Nijmegen region, also reveals the economic characteristics of the region, the most important raw material flows and the various opportunities for partnerships to develop circular ideas into business cases (Hendriksen et al., 2017). Examples include: the refurbishment of medical equipment, alternative fuels for heavy transport, independent smart grids and the reshoring of operational activities (Hendriksen et al., 2017).

Policy 2B is aimed at the construction sector and aspires to (1) increase the use of circular building materials to a minimum of 10% in existing housing construction plans that are situated within the boundaries of the policy's geographic area, and (2) in new housing construction plans, incorporate at least 25% circular construction (Rijksoverheid, 2020). Eventually, the region Arnhem-Nijmegen aims at achieving 50% circularity in construction by 2030 and full-scale circularity in 2050 (Rijksoverheid, 2020).

Policy 2C acts as an extra stimulant for policy 2B and for further circularisation in the construction sector. It is said that the Netherlands is already well underway in the construction sector when looking at the transition towards more circularity, However, there remains a difference between the high- and low-grade reuse of materials within this sector (Wethouders Economische Zaken Regio Arnhem-Nijmegen, 2020). High-grade reuse is encouraged most, and general awareness of the CE throughout the chain is encouraged, especially at the design phase of the chain (Wethouders Economische Zaken Regio Arnhem-Nijmegen, 2020). This

policy also refers to the provincial policy 3A (described below) and the two main national governmental goals set for 2030 and 2050.

Provincial

Policy 3A focuses on monitoring five key aspects: (1) the reuse of materials in the construction sector, (2) the reuse of materials in road construction, (3) food waste, (4) the number of circular jobs, and (5) volume of waste (Jutte, Euler-Van Hulst, & Roos, 2019; respondent 7, personal communication, February 5, 2021). These indicators are to give an image of all sectors and their progress, and are supposed to be measured periodically, without adding new indicators (respondent 7, personal communication, February 5, 2021).

Similar to the aforementioned local policy, policy 3B focuses on agri-food, construction and infrastructure, the manufacturing industry, and consumers and waste (Provincie Gelderland, 2019). The focus of this policy document matches that of policy 3A, policy 3C and the goals set up by the national Dutch government for reducing primary material use. For the four aforementioned sectors, possible circular measures were mapped out, and the market was scanned for initiatives from the business community and the public sector to cash in on these opportunities (Provincie Gelderland, 2019). An example of this is the introduction of 'true pricing', where the true (environmental) costs are reflected in the purchasing price of foods (Provincie Gelderland, 2019).

Policy 3C focuses on goals nestled in the provincial field of the energy transition, climate adaptation, CE, biodiversity, accessibility, economic climate, and the residential and living climate (Provincie Gelderland, 2018). Within the CE field, the main focus is to (1) drastically reduce waste and become the first waste-free province in the Netherlands, and (2) decrease the use of primary material to the national goal of 50% in 2030 (Provincie Gelderland, 2018). The former goal relates especially to local policy 1D on waste reduction. Policy 3C further extends its goal to the food sector and the recycling of plastics and consumer goods. In addition, the Province of Gelderland seeks to make the regions and businesses within the province more circular (Provincie Gelderland, 2018).

Overall, there is a lot of policy written that is of relevance to RvN and the transition towards a more CE, each highlighting a different focus and/or sector. For example, policy 1D on waste in municipalities per capita, policy 3A and 3B focussing on indicators to be monitored at provincial level, and policy 2B and 2C focussing on stimulating circularity in the road and construction sector. Noteworthy is that policy is mostly directed at a particular sector and stems from existing (inter)national policy and goals related to the CE, such as the SDGs and

the Dutch national governments' goals to decrease raw material input and waste. Little local policy stems from the policy set out by the province.

4.3.2 Responsibility and awareness

As mentioned before, a part of the transition indicators stems from cultural change, which is fed by the awareness of actors and willingness to take action and responsibility in-house. There are four main bodies of actors that the respondents look to, to take more responsibility in order to further the transition towards a more CE. These include: businesses, the national government, the municipality of Nijmegen and educational institutions; especially Radboud University (RU), the University of Applied Sciences in Arnhem and Nijmegen (HAN) and Wageningen University of Research (WUR) (respondent 4, personal communication, November 11 2020; respondent 5, personal communication, December 1 2020; respondent 6, personal communication, January 21 2021; respondent 7, personal communication, February 5 2021).

Firstly, businesses should take more responsibility in leading the transition and taking action (respondent 5, personal communication, December 1, 2020). Before this is possible, the mind-set of profit in the business world needs to change. Rather, the focus should be established on how to make their business processes and strategic decisions more sustainable, and eventually more circular. Businesses – especially manufacturing businesses – not only have a great influence and responsibility concerning products, but they also have an exemplary role for consumers. When there is a shift in mind-set and organisational strategy, consumers and other businesses that look up to one another will most likely change their attitude too.

Secondly, respondent 6 (personal communication, January 21, 2021) notes that innovations and transition towards a more sustainable world are stimulated by top-down authority, in this case by the national government. As mentioned before, market players are focussed on other interests (such as profitability) and will rarely adapt on their own, without an incentive or 'push from above' (respondent 6, personal communication, January 21, 2021). This relates to RvN in that actors not only look for guidance to the national government, but also for incentives like subsidies or concrete plans to carry out and coordinate the CE monitoring process (respondent 7, personal communication, February 5, 2021).

Thirdly, the municipalities of RvN (especially of Nijmegen) are expected to take responsibility for identifying any barriers and work towards removing them or facilitating the situation

regarding monitoring the CE (respondent 6, personal communication, January 21, 2021). In addition, the municipalities are expected to take a more communicative role in signalling circular chances and/or barriers in the region for businesses, so they can latch on, and communicate this to the province, so that they can act upon it as well (respondent 7, personal communication, February 5, 2021). Municipalities are situated closer to and have a more personal connection with its citizens and businesses, and naturally they are more aware of what is going on locally, and hence have a better idea of what circular activities and actions have a chance to work well in their region.

Finally, the educational institutions RU, HAN and WUR should take an even bigger role than they already do in the transition to monitoring CE (respondent 7, personal communication, February 5, 2021). They have in-house knowledge of how to set up monitoring frameworks and tools. Moreover, they have students eager to carry out research to further expand knowledge on the topic of monitoring frameworks which could greatly help to further the transition and the development of indicators to monitor.

As for the current awareness for monitoring CE, respondent 6 (personal communication, January 21, 2021) comments on the fact that society as we know it is not set up in a way that a transition can suddenly take place. For this to be possible, a healthy and strong relationship between citizens and actors in general is necessary. A concrete example of citizen initiatives is the platform ‘mijnbuurtje.nl’. This platform aims to connect citizens in order to eventually be able to bring about change, like the transition towards a more CE. Mijnbuurtje.nl achieves this by training citizens but also civil servants to become so-called ‘community connectors’ (Mijnbuurtje.nl, 2021). Only a part of RvN partakes in this initiative, including: Nijmegen and Wijchen. On each platform, citizens can find news items, vacancies for (volunteer) jobs and join or help organise activities in their municipal region (Nijmegen-oost.nl, 2021; Wijwijchen.nl, 2021).

4.4 Barriers

Although there is great overlap, it is important to note that most publications describing ‘barriers to CE’ refer to CE barriers of the CE in general and the implementation thereof, and not specifically applied to monitoring. Additionally, although the interviews were specific to the concept of monitoring the CE on a local scale, many barriers mentioned by respondents hinder both monitoring as well as CE in general, on different scales. Nevertheless, when proven relevant to monitoring the CE on a local scale, the barriers were considered. These are

summarised in table 3. The relationships between these barriers is shown in figure 9. When reading the figure, the reader should start with the most recurring barrier that has been enlarged in the figure, and work their way through the relationships from there onwards.

Definition

The first barrier of monitoring the CE was mentioned by more than half of the respondents and is highlighted often in literature, namely: a lack of a clear definition. Each definition produces different sets of indicators to measure and focus on, which then causes discrepancies between local and regional authorities, for example, as is the case with RvN and the province of Gelderland (respondent 7, personal communication, February 5, 2020).

A lack of definition also leads to a lack of prioritisation of goals and visions. Problems such as waste management are being tackled when actually one of the main causes of increased waste flows is overpopulation. Hence, the prioritisation of the problem is unclear and not focussed around the very source of the problem but rather at the stage where the problem has already had a negative impact (respondent 5, personal communication, December 1, 2020). This also makes it difficult to further operationalise and quantify indicators to monitor.

Additionally, a lack of definition also encompasses a lack of scope. Although this research is specified to the local scale, it remains difficult to differentiate the exact aspects that should be considered, and which should not. For example, when developers in housing construction are given the task to build new housing that is at least 20% circular, one developer may interpret this as 20% of materials used must be of circular origin, while another developer may interpret this as 20% of the construction process as a whole has to be carried out in a circular way (respondent 6, personal communication, January 21, 2020). The question then remains whether the housing built by the beliefs of the first interpretation meets the requirements of the brief of being 20% circular.

Data and knowledge

Moreover, not only is monitoring the CE a relatively upcoming concept, it remains a complex one because – among other things – it concerns multiple areas of society and is still (at least partly) in its experimental phase (respondent 6, personal communication, January 21, 2020). This entails that new methods of monitoring are still being tested, and knowledge and literature on the topic is still being developed and explored. Hence, there is a huge lack of data and knowledge. Moreover, jobs across different sectors have to deal with issues that exceed their knowledge. For example, a civil servant in charge of bus stops can no longer simply order new bus shelters like they did before, when the requirements state that it must be a circular bus

shelter. In other words, the new bus shelters must be made from circular materials and manufactured in a completely circular way (respondent 4, personal communication, November 9, 2020). This then hinders the civil servant in completing their work tasks, given that they are not specialised in that field.

Another problem related to the lack of data and knowledge barrier is that it remains unknown what material reserves exist. When a raw material gets manufactured into a product and remains there for a longer period of time before being disposed of (for example: the metal material used for a car), material reserves are built up (respondent 1, personal communication, June 5, 2020). In the framework by Roemers et al. (2018), this would refer to the indicator growth in net assets. How much material is stored, which materials could potentially be repaired, what the effects are of remanufacturing or reparation and so on, are all still relatively unknown aspects.

Operationalisation of goals

A lack of data leads to yet another barrier, namely the difficulty of operationalising goals and hence determining the exact status of progress in the CE transition we are in. Some goals are not yet measurable because of the way they are operationalised (respondent 2, personal communication, August 20, 2020). Additionally, multiple goals need to be set up to be monitored, because the main goal is often achieved quite quickly within the year, but not constantly being monitored as it should, which then defeats the purpose of the initial goal (respondent 2, personal communication, August 20, 2020). Moreover, prioritisation of goals is very important. For example, the national government should implement taxes on material use instead of labour in packaging for example, so that the problem is addressed at the source and not at the end of the chain (respondent 4, personal communication, November 9, 2020).

Transparency

A part of the reason why there is a lack of data availability is because of a lack of transparency, especially when it comes to businesses and governments (on multiple scales). Businesses are often reserved in revealing the product chain, their circular strategies or waste flows because it puts their competitive advantage at risk. The same goes for governmental officials; sharing all data on waste management and material flows for example, may influence voters and present a potentially worse image of that particular region than expected (respondent 5, personal communication, December 1, 2020).

Uniform method

The topic of monitoring the transition to a more CE is currently trending, and a wide array of actors are engaging themselves in it in some way (Galvão et al., 2018). Initially, this would be a positive trend, but it also leads to multiple approaches to the same issue at hand due to a lack of a uniform method of monitoring. To that respect, data output can vary greatly when measuring the same aspect, when monitoring the transition towards a more CE. At this stage of the transition, one method of monitoring cannot be considered better or more correct than the other, so various results are presented for the same issue.

Contradictory methods

Moreover, current methods that are used to monitor the CE can contradict themselves (respondent 5, personal communication, December 1, 2020). For example, the back-casting method is commonly used to outline in what situation we find ourselves now, where we would like to be and how to get there. However, what is left out of this method is the cause of why we got where we are and why we need to change this situation into a better one in the first place (respondent 5, personal communication, December 1, 2020). The model should rather focus on identifying mistakes, learn from them and work towards a better solution or situation, as well as highlighting what in the past has been successful and continue to build on those methods (respondent 5, personal communication, December 1, 2020).

Law and regulations

Current law and regulations – and certain policy to that extent – stand in the way of the monitoring and transition towards a more CE. Having said that, efforts have already been put into motion to overcome this barrier and is a trend seeming to be ‘unstoppable’ according to respondent 6 (personal communication, January 21, 2020).

Transboundary

CE is a transboundary phenomenon, which makes monitoring its progress (for one region) particularly difficult (respondent 1, personal communication, June 5, 2020; respondent 2, personal communication, August 20, 2020). Materials, goods and waste are all part of a certain region, but certain flows do not necessarily pertain to that region. Resource extraction and waste management are two examples of activities which are specific to one region and exported to other regions. Determining where the measurements are made for such flows remains difficult and can sometimes lead to double measurements (respondent 1, personal communication, June 5, 2020).

Customisation per region

In addition to the previous, monitoring the CE transition progress in regions remains bespoke

work. This is because each region has its own set of indicators which they prioritise, that is aligned to their policy and goals (respondent 2, personal communication, August 20, 2020). Having said that, current estimates and/or broader measurements, such as that of raw material flows on a national scale can often provide a reasonable image of the current trends, without needing to narrow it down to much detail (respondent 2, personal communication, August 20, 2020).

Multi-stakeholder and -scale

Given the fact that monitoring is a transboundary phenomenon, it includes multiple stakeholders (respondent 4, personal communication, November 9, 2020). Additionally, stakeholders across sectors are involved, for different reasons and levels of involvement. For example, monitoring the CE concerns the minister for sustainability for setting out an implementation programme, entrepreneurs that are willing to contribute, and the national government in general to grant subsidies, for example (respondent 4, personal communication, November 9, 2020). Additionally, it must be approached from various scales, given that it concerns all levels of society and the economy. This complicates the concept greatly.

Resources and leadership

Dependency on others is another problem that resides in the fact that there is a sense of lack of leadership from 'higher powers'. In other words, the local municipality looks to the province for leadership, as the province looks to the NEAA and the national government for leadership and clarity (respondent 3, personal communication, September 7, 2020; respondent 4, personal communication, November 9, 2020; respondent 7, personal communication, February 5, 2020). Additionally, local institutions and governmental bodies look to higher scales for resources in various fields like financial, legal and social. Other local governmental bodies simply do not have the political power or general authority to implement certain circular solutions or obligate businesses to deliver data for monitoring (respondent 4, personal communication, November 9, 2020).

Cooperation between scales

Communication is vital, especially when it comes to the alignment of indicators and goals on circularity between municipal and provincial governmental bodies. At the time of writing, the Province of Gelderland and the municipality of Nijmegen for example, have little to no contact on their views and goals for monitoring CE, while they are both working on it (respondent 4, personal communication, November 9, 2020; respondent 7, personal communication, February 5, 2020). The Province of Gelderland is working on five indicators to monitor for the

CE, which does not match the efforts in the same field for the municipality of Nijmegen, for example (respondent 4, personal communication, November 9, 2020; respondent 7, personal communication, February 5, 2020). Provincial data rests a great deal upon municipal data, so for a good monitoring system, cooperation between these two scales is vital (respondent 7, personal communication, February 5, 2020).

Adaptive capacity

A recurring issue concerning circularity is the reluctance to adapt to a new concept and essentially, a new lifestyle. Also, in the working field, people find it difficult to adjust and expand their job portfolio or task package, essentially doing 'more than is expected' to include more circular ways of working (respondent 4, personal communication, November 9, 2020). In addition, certain systems and ways of working are required to fully change to become even the slightest bit more circular. Whole business strategies for example, or whole machinery in factories sometimes needs to be replaced, which can be difficult. Above all, circular change is often seen as expensive which is a big incentive for people or businesses not to adjust, or delay the investment (respondent 4, personal communication, November 9, 2020).

Long-term vision

A barrier also relevant on multiple scales, but especially locally, is that there is a lack of long-term vision within governments. With each new councillor that comes, new policies, goals and plans are set up instead of working on long term goals and ensuring the continuation of previous efforts (respondent 6, personal communication, January 21, 2020). Also, a lack of focus on the important aspects of such a plan are overlooked, because councillors and politicians are too focussed on gaining votes and increasing their popularity.

Overall, it is difficult to monitor the exact progress of transition towards a CE. We remain in the experimentation phase instead of taking bigger steps (respondent 6, personal communication, January 21, 2020). Problems like overconsumption and overpopulation need to be addressed radically, but officials are hesitant in taking such radical action. Instead, we are focussing on issues like recycling of waste, but only a fraction of this is properly reused, giving a somewhat skewed image of current efforts and progress. This is mainly because there is a lack of long-term vision (as mentioned before) and especially a lack of urgency for the matter (respondent 5, personal communication, December 1, 2020). The national government should, for example, focus more on taxing products made of plastic or that require more packaging instead of taxing jobs (respondent 4, personal communication, November 9, 2020).

Table 3: Overview of barriers mentioned in interviews (own publication).

Barrier	Respondent								
	1	2	3	4	5	6	7	8	9
Lack of definition	X			X	X	X	X	X	
Lack of data and knowledge	X			X				X	X
Lack of operationalisation of goals		X		X			X	X	
Lack of transparency	X				X			X	X
Lack of uniform method	X						X		
Contradictory methods					X	X			
Law and regulations	X					X			
Transboundary phenomenon	X	X							X
Customisation per region		X							
Multi-stakeholder and -scale				X					
Lack of resources and leadership			X	X			X		
Lack of cooperation between scales			X				X	X	
Lack of adaptive capacity				X		X			
Lack of long-term vision						X			
Lack of overall progress						X			

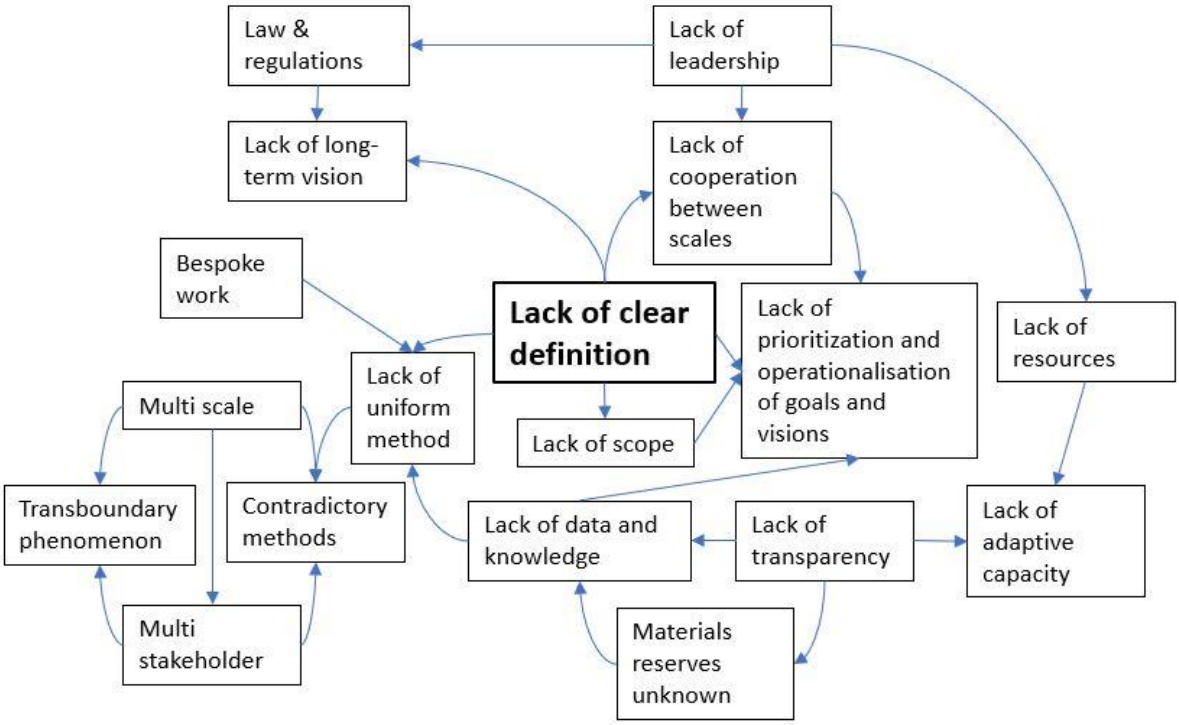


Figure 9: Relationships between barriers (own publication).

4.5 Opportunities

After having examined the main barriers, certain opportunities can be identified to improve the monitoring. Ideally, each external factor should be linked to an opportunity, and while this may be true and available in the literature, not all opportunities match the exact barriers presented above, nor do they all refer directly to the improvement of monitoring, but rather to CE in general. For this reason, opportunities specifically mentioned by respondents, and opportunities that relate directly to the most prominent barrier, lack of definition, are discussed. These opportunities ultimately form the most prominent recommendations for RvN to act upon to improve monitoring, as proposed in the sixth sub-question.

Indicators definition and alignment

The choice of indicators to monitor should be more aligned between local and regional governments for a more effective monitoring. At the moment, the Province of Gelderland is focussed on a set of 5 indicators, for which they (may) require local information to be able to measure those indicators (respondent 7, personal communication, February 5, 2020). However, little to no coordination of these indicators takes place right now which is a huge miss for both governmental bodies. Open communication and alignment of the indicators to

monitor, visions, policy and approach for monitoring present a huge opportunity. This would greatly increase the access to resources for monitoring, monitoring efficiency, data accuracy and the carrying capacity of the region as a whole to continue monitoring and perhaps expand into measuring other indicators as well.

Once indicators are aligned and agreed upon across scales, more attention can be paid to the content of the indicators. At the moment, it is difficult to measure CO_2 emissions that are stored in materials and products (respondent 4, personal communication, November 9, 2020), which may cause a skewed image of the CO_2 emissions (dashboard) indicator. When this information becomes known, the awareness of producers and consumers – respectively, in the way products are made, and in what and how often certain products are bought – could increase and hence change for the better (respondent 4, personal communication, November 9, 2020). Furthermore, the process of product manufacturing needs to happen in a smart way. An example in new housing construction is that materials should be used that let air naturally circulate through the material instead of needing to implement a separate air circulation system in the house (respondent 6, personal communication, January 21, 2021).

Actor responsibility and overall viability of CE

Also, it should be socially accepted on all scales that monitoring the CE remains a difficult task and that there will be blind spots which are perhaps too difficult or intangible to resolve. We should embrace this as part of the challenge to monitor the transition towards a more CE and should rather focus on creating concrete and workable solutions and opportunities (respondent 4, personal communication, November 9, 2020; respondent 5, personal communication, December 1, 2020). Having said that, society finds itself in the beginning phase of the transition towards a more CE and this may be too early a time to call out that we should accept certain gaps in the transition, when all the aspects of CE have not yet fully been explored or researched properly.

Furthermore, there is no use in (aimlessly) trying to motivate all levels of society to contribute to the transition of CE and the monitoring thereof, with the same level of expectations from each actor (respondent 5; personal communication, December 1, 2020; respondent 6, personal communication, January 21, 2021). Rather, ‘communities of practice’ (CoP) (respondent 5, personal communication, December 1, 2020) and ‘coalition of the willing’ (CoW) should be identified and focussed on (respondent 6, personal communication, January 21, 2020). CoP should be set up based on vision and urgency of a particular aspect and should largely be driven by businesses, and CoW should be created across sectors, also not only targeting frontrunners. Whilst creating such CoP and CoW, it should still be a goal to address

and include a broad audience, specific actors should be targeted in particular to pull the weight such as entrepreneurs and businesses in general. Respondent 5 (personal communication, December 1, 2020) states that this process is already being undertaken by the Economic Boards in the Netherlands. In addition to this, educational institutions and knowledge centres should take a more dominant role in the monitoring of the CE, which could greatly be facilitated by the national government by providing more subsidies for research and development in this field. In this sense, the aim should be to create circular opportunities that create a 'win-win-win' situation for government, businesses and educational institutions (respondent 6, personal communication, January 21, 2020), also known as the triple helix concept (Leydesdorff, 2012). In drawing up plans based on this concept, the aim is to create a commercial pulling power so that businesses themselves get involved (respondent 6, personal communication, January 21, 2020). For this to have most effect, it would be best to allocate the chairman position of such concepts to create CoP and CoW to a manufacturer or legislator, who find themselves at the start of most value chains, instead of say, a waste disposal company who mostly have a role in the end phase of a value chain (respondent 5, personal communication, December 1, 2020).

Entrepreneurs and their businesses most notably have the potential to initiate change and a faster transition towards a more CE (respondent 5, personal communication, December 1, 2020). They have a large responsibility concerning the production process of goods and services and currently influence consumers with initiatives like Black Friday, which stimulates fast fashion – an example of a linear economy driven initiative. Moreover, a change in thought and attitude needs to occur in which it should be less about making profit and more about how to proceed to a more sustainable and circular society (respondent 5, personal communication, December 1, 2020). For this to be achieved, businesses also need to be more transparent of their actions against and in favour of a CE. In this way, it becomes much easier to identify areas they need to work on, but also areas they already excel in. Moreover, business strategies should be aligned and focussed on achieving the lowest possible R-strategy (see figures 3 and 4).

Consumer attitude and behaviour

Attitude and behaviour of consumers/citizens is not yet apparent in the NEAA's CE monitoring work programme as a separate indicator to be measured (respondent 2, personal communication, August 20, 2020). This potential indicator is described in the ICER but not quantified or fully operationalised to be measured. The goal of the NEAA is to have a (complete) monitoring system by 2023 (PBL, 2021). When this is realised, this indicator should be included. For RvN it would be interesting to include this indicator so that the progress of the transition indicator can further be specified. Inspiration could be taken from Camacho-

Otero, Boks & Pettersen (2018), who portray the main factors influencing the perception and acceptance of circular solutions.

5 Discussion

This chapter will discuss the limitations encountered throughout the research and other relevant discussion points that originate from the results presented in the previous chapter.

5.1 Definition

Defining the term ‘circular economy’ is an ongoing discussion. What the term encompasses exactly varies from region to region, organisation to organisation, (local or national) government to government, and so on. While this could be seen as beneficial for each region alone – in the sense that each region can focus on their goals which are most important to them – it causes a problem for unity in achieving a common goal; that of achieving full-scale circularity in the Netherlands by 2050. In turn, this has an effect on the focus and interest of actors. Given that each actor has its own idea of how to contribute to increased circularity, efforts may miss each other in points of interest or collaboration opportunities. Furthermore, this aspect makes it difficult to accurately measure and compare to other regions to get a glimpse of the overall progress and leave actors to wonder how much they *actually* contribute. Respondent 6 illustrates this idea with an example from the construction sector. Policy 2B (see Table 2) aims to construct housing in a completely circular way; one may interpret this as constructing using only circular materials, whereas the other may interpret this as all processes and flows relating to the construction process and materials must be circular and carried out in a circular way. The question remains which reasoning is correct and who is fit to settle such a point of discussion. Following the former reasoning, one may question how much of the housing construction is *actually* circular, and hence if the aimed goal is then achieved in minimum circularity percentage. As respondent 6 validly points out: the most important aspects to a monitoring framework is to have a clear definition and a clear zero measurement (respondent 6, January 21, 2020, personal communication).

5.2 Knowledge and awareness

Lack of knowledge and awareness on the topic highlights the next point of discussion. In the interviews it became clear that actors and certain organisations are motivated to contribute to the transition of circularity but that a lot is still unknown about the topic or how to act. “That is a very good question but I do not know the answer” or “I do not know who supposedly does know the answer” is something I get a lot of in interviews from respondents (respondents 2, 3,

6, 7). Following on from this idea, respondents are also very hesitant in commenting on indicators they see fit for a framework. Simply because they do not have the knowledge of what exactly would best suit the RvN when monitoring CE.

5.3 Tracking progress and scope of project

The fact that there is no universal method (yet) for measuring and monitoring the circular economy and the exact progress of transition, makes it difficult to determine which regions are lagging behind and which are ahead of their own targets. It remains a very subjective matter in which actors are free to contribute to CE as they see fit. Moreover, the scope of this research can both be seen as a strength and a weakness of this research. On the one hand, not narrowing it down to a single sector or indicator to monitor the progress of the CE, helps create an overview for the overall progress made – or not made – in the region of RvN. This then informs municipalities of RvN and officials from the province of Gelderland how to further specify their policy and actions to improve the monitoring. It is then expected that the transition towards a more CE is sped up. On the other hand, embracing such a large scope means that a lot of aspects and areas of monitoring are brushed upon, not in great detail. For example, in the previous chapter, barriers for monitoring are analysed but not fully examined and reviewed in great detail from the literature and categorised into the various fields.

6 Conclusion

In this final chapter the research results are concluded, considering the discussion points from the previous chapter. In doing this, the research question – *'what indicators and factors contribute to a better monitoring towards a more circular economy in Rijk van Nijmegen (RvN) and what recommendations can be given to RvN to further stimulate the monitoring of the transition towards a more circular economy?'* – is answered with respect to the six sub-questions (section 6.1). The first five sub-questions answer the first half of the main question, with respect to the current status of monitoring the CE in RvN. The last sub-question provides an answer to the second half of the main question regarding recommendations for RvN to further improve the monitoring of the transition towards a more CE. Hereafter, recommendations for future research are proposed (section 6.2) and a reflection of the whole research process is given (section 6.3).

6.1 Conclusion of findings

6.1.1 Sub-question 1

The first sub-question reads: '*what monitoring frameworks and tools are available in the literature?'*. This question was answered through a literature review and showed different monitoring frameworks and tools that are already developed and planned to be or already implemented in practice. The literature review revealed monitoring frameworks and tools mostly on (inter)national and regional scales, set up by the EU, the Dutch national government and provinces, amongst others. Each framework and tool is developed to a different level of detail; some presenting indicators to be measured at country or city level, and others developed to measure company progress and material flows. The advantage of using a broad set of indicators is that it provides an overview of the total progress towards a more CE, and allows simple comparison to other regions, cities or countries. However, it can also provide a very skewed image, because the average scores practically erase the image of anomalies that may be present in the region, city or country. For example, the dashboard indicator air quality scores especially poorly in Nijmegen, whereas the natural capital and energy indicators score well. When an average score is given for the dashboard indicators, it may be that the air quality outlier is evened out due to other dashboard indicators scoring positively. On the other hand, using a more detailed framework or tool on a smaller scale (such as: business or local level), provides a better overview of progress and areas to improve, but says less about the overall situation and may cause overlap of data and efforts. For this research, the

monitoring framework by Roemers et al. (2018) was chosen, because of its clarity and inclusion of indicators. In addition, it has been applied to a similar geographic region (the MRA) and so deemed appropriate for this research too.

6.1.2 Sub-question 2

The second sub-question reads: *'what is the current state of monitoring of primary indicators?'*. One can conclude that for primary material input and primary material use, there is basic data available that give an estimate. Tools like the Regiotool, and reports like the circular regional vision and implementation report for the city of Nijmegen, give an example of material flows within different municipalities and sectors, respectively. However, the Regiotool is based on key figures, so it misses in accuracy for the region RvN, and the report is limited to certain sectors or single institutions within that sector. This is the case with the health sector, for example, in which only RadboudUMC is analysed, leaving out the CWZ hospital which also pertains to RvN. This gives a somewhat skewed image and requires further research and development. Moreover, primary indicator data is very reliant on the availability of dashboard indicator data, especially for primary material use, which in this case leads to gaps in data for the primary indicators. The growth of net assets indicator has great potential to be monitored within the region by creating material passports. However, it remains difficult to monitor the exact amount of stored materials in products, given that the number of possessions owned by citizens, kept over a longer period of time is not known.

6.1.3 Sub-question 3

The third sub-question reads: *'what is the current state of monitoring of dashboard indicators?'*. The five dashboard indicators – materials, energy, health and well-being, natural capital and economy – are arguably the most tangible and operationalised indicators of the whole framework. For RvN, data for the above-mentioned dashboard indicators is partly available, especially key figures on materials, energy, and natural capital. For the materials indicator for example, the LMA contains data for both primary and secondary material use for each municipality of RvN. However, it is not complete, given that not all materials are collected (and hence measured), and the materials that are measured, are collected along a route of waste collection, with no reference to the exact pick-up point. Evidently, not all data pertaining to these indicators are clearly available for RvN. A lot of indicators have data for the municipal region of Nijmegen, but no or limited data on the other municipalities of RvN, as is the case with air quality, for example. In addition, despite the fact that data is available to measure the

economy indicator in terms of circular jobs and circular domestic product, it remains difficult to pinpoint the degree of circularity within jobs as well as (future) opportunities for circular employment. This would suggest that the measurement for this indicator is also incomplete.

6.1.4 Sub-question 4

The fourth sub-question reads: '*what is the current state of monitoring of transition indicators?'*, and shows the progress made in terms of structural, cultural and practical change. RvN has many policy documents, with diverse themes relating to the CE, such as energy, waste, economy and construction. For example, the economic vision (policy 1A) illustrated the goals and existing initiatives the municipality of Nijmegen has towards circularity. The action-based strategies indicate a proactive attitude towards booking progress relating to circularity. The House of the Inner City and the corresponding fund is a great example of how to encourage a great deal of entrepreneurs to go about their practices more sustainably and how to work together in order to achieve this. Having said that, the vision lacks ideas about possible monitoring, including relevant indicators and in almost all pieces of policy, it is not mentioned at all. This may imply that there have not been many developments in this area and thus that this may need to become more of a priority for the municipalities pertaining to RvN. Circular awareness is difficult to quantify and measure at all to that extent, due to the subjective nature of this indicator. However, attempts are being made to contribute to this indicator in the form of community platforms for citizens to connect with each other and eventually encourage action amongst citizens in the domain of CE.

6.1.5 Sub-question 5

The fifth sub-question reads: *'what main external factors can be identified that influence the indicators for monitoring?'*. First of all, there are a number of different barriers to be identified in different fields that arose from the literature as well as the interviews. Although a lot of barriers apply to the general concept of implementing CE on any scale, many also apply to the monitoring status of the CE on a local scale. One can say it hinders the monitoring in the various fields that are specified. The most frequently mentioned barrier refers to the lack of definition for monitoring CE and CE in general. Discussions are held on end about what aspects of the CE should be monitored and which should not, while the real solution should be to agree on a broad principle with whom the majority of actors can identify themselves with and pursue action. This will then provide further clarification for indicators and help define actor responsibility for monitoring.

6.1.6 Sub-question 6

The sixth sub-question reads: *'what recommendations can be given for improving monitoring?'*. While there are many opportunities that arise from the literature and from the interviews carried out for this research (as discussed in section 4.5), there are two main opportunities that relate directly to the improvement of monitoring the CE transition for RvN, which was also repeatedly mentioned by respondents. The first opportunity is to define the concept of monitoring CE and what exactly this entails and in doing so, define who is responsible for what aspect of the monitoring process. This saves double efforts and a more efficient way of working towards a more CE and a more accurate monitoring thereof. It would be best to clearly state what the region RvN (as a whole) understands by the term 'CE'.

The second opportunity is to achieve a better indicator definition and alignment across scales. The communication between scales and hence the alignment of indicators is not very strong at the moment, especially from the Province of Gelderland towards the municipalities of RvN, in particular the municipality of Nijmegen (top-down). Municipalities look up to higher forms of authority for guidance and for an indication of the approach to monitoring CE. Once this is achieved, a database for data sharing between the Province of Gelderland and the municipalities of RvN is necessary so a digital dashboard can be created, containing both top-down and bottom-up data.

Finally, it goes without saying that RvN should look for workable solutions for all barriers that were identified in this research, and possibly other barriers that they encounter relating to monitoring.

6.2 Recommendations for future research

This research provides an overview of the progress of monitoring the transition towards a more CE in RvN, including the barriers and opportunities related to this. There are various aspects that are interesting to explore in more detail in future research and also for the municipalities pertaining to RvN to act upon. Not to confuse, in the previous section (6.1.6), recommendations were given to RvN, content wise, whereas this section highlights potential further academic research.

The first recommendation is to carry out a comparative study, so that regions can be compared to one another. Applying the same framework is also strongly recommended so that the research criteria and forms of measurement are kept the same. As mentioned before (section 1.3.1), Roemers et al. (2018) encourages the application of this framework on other regions for comparison. For there to be a continuation on the topic of monitoring the CE, this recommendation is very important to be followed up.

Secondly, each aspect of the framework should be concentrated on separately and explored in more depth. The framework by Roemers et al. (2018) focuses on primary indicators, dashboard indicators and transition indicators, and this research adds the aspect of barriers and opportunities for monitoring CE. Future research could focus on one of the five aforementioned aspects and merge them for a complete overview of the progress of monitoring the CE. Not only can such future research focus on the data availability of the indicators, but it could also focus on the possibility of adding or removing certain indicators for improvement. Similarly, for the barriers, focus can be laid on finding causes for barriers and workable solutions. As for the final aspect, major opportunities, such as better communication between municipal and provincial efforts and policy, could be explored in more detail.

Finally, this research has highlighted many different actors and their levels of involvement in monitoring the CE. It would be interesting to investigate the levels of influence actors have across the three institutional perspectives: state, market and civil society. In this way, discoveries could be made as to the goals, discourses and level of awareness at each institutional perspective. From this, opportunities can be identified to match similar or differing perspectives that could further improve the process of monitoring the CE.

6.3 Reflection

Throughout my thesis, I encountered various interesting moments which have taught me a lot about the topic of monitoring CE and doing scientific research in general. In this section, a reflection is given on the use of theories and methods, and on the overall process of conducting this research.

6.3.1 Method and approach

First and foremost, this project has reminded me to keep an open mind but at the same time be critical when necessary. As mentioned in this research, the topic of CE is extremely broad

and contains an array of different aspects. Naturally, this made it difficult to pinpoint an exact research question that was relevant and added to current knowledge. In addition, this complicated the operationalisation phase especially, given that too much narrowing of the subject may have led to a decreased reliability of the research, whereas keeping the research too broad may have resulted in vague results. This greatly forced me to filter information as accurately as possible, given that including all information would have been near to impossible.

The COVID-19 pandemic presented many new challenges and opportunities that I did not anticipate upon starting my master thesis. On the one hand, it worked to my advantage; especially in the data collection phase. Conducting interviews became much less time consuming given that I was able to conduct them virtually from home. This provided me with valuable time to invest in my thesis. Contrastingly, being at home so much and not having a separate working environment cost me a lot of my concentration. This had a direct effect on the progress of my master thesis and perhaps in the beginning even the quality of my initial work. Thankfully, I got the opportunity from my internship organisation to extend my contract so that I could potentially contribute to projects and remain a part of the team for a longer period of time than initially agreed on.

Moreover, some of my interviews were carried out with a colleague from my internship organisation. In principle this is useful, because I was able to discuss my interview guide with a colleague and ask for feedback. It also saved the respondent time given that they were able to speak to my colleague and I both at once, instead of at separate times. Having said that, it meant that not all questions were (directly) relevant to my research and perhaps cost me valuable time of the interview in which the respondent could have elaborated their answers relevant to my case.

6.3.2 Generalisability and demarcation of the region

One aspect which this research highlights well is the demarcation of the region chosen for study. RvN was chosen as a region for study because of the existing network of municipalities already working together on this topic. Studies directed at single municipalities or cities for example, in a region that already has a network such as RvN, may cause for double measurements and may provide more blind spots and limitations. Hence, this research approach can serve as an example or source of inspiration for related studies for other regions. A possible critique to demarcating a region as RvN for such a study is that one might argue

that indicators are always chosen subjectively which best fit the region, never really being able to set a rule of thumb when wanting to carry out a similar research to a different region. However, the method and approach used in this research should be adapted for other regions in future research, so that general interpretations of regions can be given and because this point of view is rarely used in research so far.

6.3.3 Framework for monitoring

Finally, the framework by Roemers et al. (2018) serves as a very good basis for analysing the state of monitoring in RvN. The framework allows the researcher to approach a region and form a broad perspective on the progress of monitoring, which should be adapted in future research on other regions. Having said that, some indicators remain difficult to interpret how to measure them exactly. Especially the transition indicator circular awareness is very difficult to quantify and/or measure. This is mostly due to the subjective nature of this indicator which most likely leads to great discrepancies in results of this indicator. Where one region thinks there is a strong sense of circular awareness, another region might have the same level of awareness but discount this as a lower sense of awareness. It would be a great improvement if the framework identified key points to monitor for the transition indicator and in that way further operationalise this indicator. For example, to identify the degree of cultural change amongst citizens that find linear economic practices unacceptable as part of the break-down indicator, a survey could be set up that the researcher can spread amongst citizens. Not only will this give a better image of the level of circular awareness in the region; it will also provide a better basis for comparisons of regions to be made.

Overall, this master thesis presented me with an opportunity to delve into a very current topic that interests me a lot and combine theory with practice. I tried to challenge myself with this project by choosing a very current topic, and sincerely aiming to spark new ideas and entry points with respondents for better monitoring.

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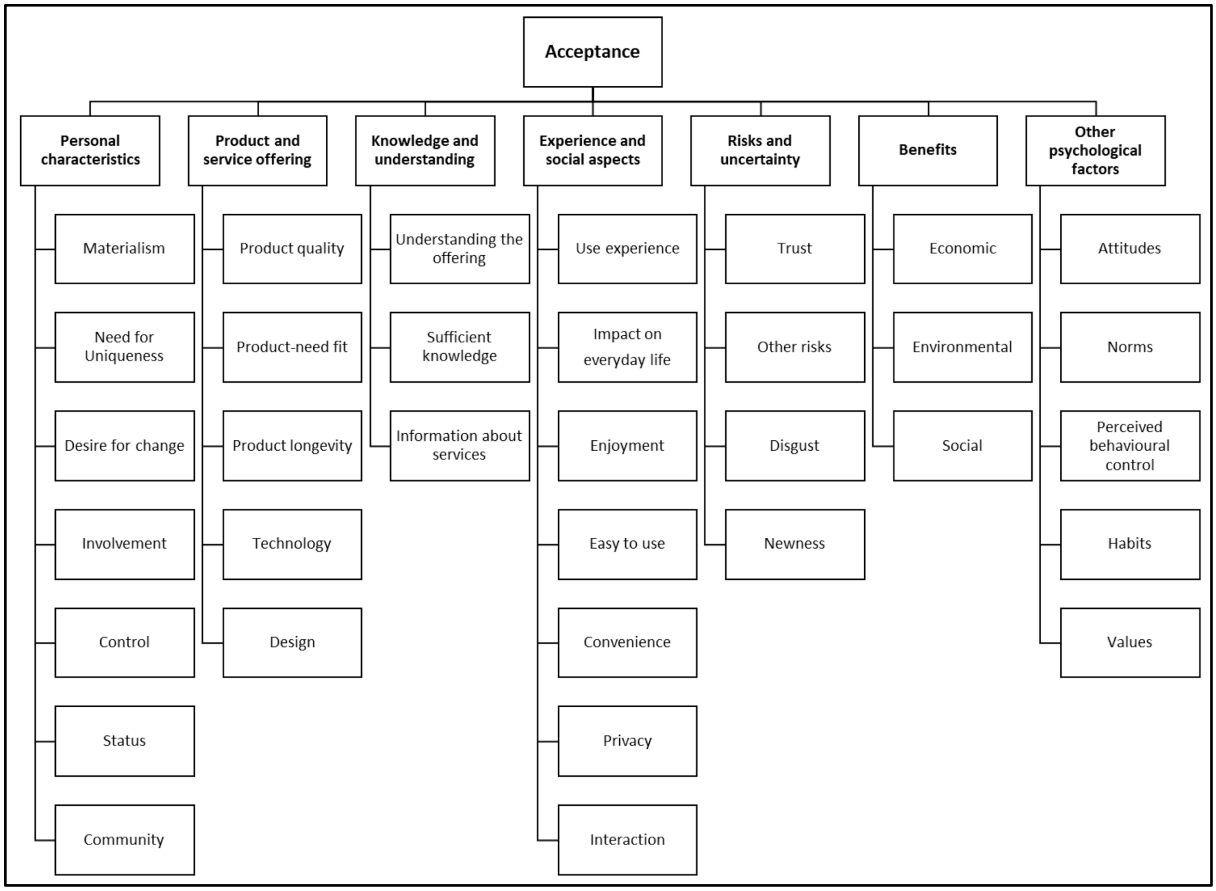
Appendices

Appendix A – Figures

A1. Main factors influencing the perception and acceptance of circular solutions

Source: Camacho-Otero, Boks & Pettersen (2018).



A2. EU-monitoring framework indicators for The Netherlands

Source: own publication, adapted from Eurostat (n.d.).
https://ec.europa.eu/eurostat/web/circular-economy/indicators/monitoring-framework

Indicator	**Value [year]**
Production and consumption	
EU self-sufficient for raw materials (%)	N/A
Green public procurement	N/A

Waste generation - Generation of municipal waste per capita (kg per capita) - Generation of waste excluding major mineral wastes per GDP unit (kg per thousand euro, chain linked volumes (2010)) - Generation of waste excluding major mineral wastes per domestic material consumption (%)	 492 [2018] 66 [2018] 12.8 [2016]
Food waste (million tonne)	70 [2016]
Waste management	
Recycling rates - Recycling rate of municipal waste (%) - Recycling rate of all waste excluding major mineral waste (%)	 47.4 [2018] 56 [2016]
Recycling/recovery for specific waste streams - Recycling rate of overall packaging (%) - Recycling rate of plastic packaging (%) - Recycling rate of wooden packaging (%) - Recycling rate of e-waste (%) - Recycling rate of bio-waste (kg per capita) - Recovery rate of construction and demolition waste (%)	 67.5 [2017] 41.7 [2017] 41.2 [2017] 34.8 [2018] 83 [2018] 88 [2018]
Secondary raw materials	
Contribution of recycled materials to raw materials demand - End-of-life recycling input rates (EOL-RIR) (%) - Circular material use rate (%)	 N/A 11.2 [2017]
Trade in recyclable raw materials (tonne) - Imports from non-EU countries - Exports to non-EU countries - Intra EU trade	 8,877,945 [2019] 25,467,976 [2019] 47,905,897 [2019]
Competitiveness and innovation	
Private investment, jobs and gross added related to circular economy sectors - Gross investment in tangible goods	 0.12 [2017]

(% of GDP at current prices) - Persons employed (% of total employment) - Value added at factor cost (% of GDP at current prices)	 1.72 [2017] 0.96 [2017]
Number of patents related to recycling and secondary raw materials	337.74 [2015]

Appendix B – Interview guides

B1. Expert interview guide

Introductie

- Zelf voorstellen en korte introductie over thesis geven en doel van dit interview.
- Toestemming vragen voor het opnemen van het interview voor verdere uitwerking.

~start opname~

Algemene Informatie

Datum interview	
Naam respondent	
Organisatie	
Functieomschrijving	
Hoe lang werkzaam in deze functie	

De circulaire economie op het nationale level

1. Welke definitie hanteert het Rijk met betrekking tot de circulaire economie?
2. Hoe beschrijft het Rijk haar eigen rol in deze transitie?
3. Wat voor CE-aanpak/strategie heeft het Rijk?
4. Wat zijn belemmeringen bij de aanpak van een CE-strategie?

De rol van de regionale en lokale overheid

5. Welk takenpakket zou, volgens u, de regionale overheden op zich moeten nemen met betrekking tot de transitie naar een circulaire economie?
    a. En als we dit toespitsen op gemeentelijk niveau: wat is hun rol hierin?
    b. Voorbeelden van taken/rollen?
    c. Wat verwacht u van gemeenten in de transitie naar een CE?
6. Hoe verhoudt dit zich tot de nationale overheid?

Monitoring van de circulaire economie

(Zoals je zelf al aan het begin zei) Het Rijk heeft ambitieuze doelstellingen waaronder: circulair willen zijn in 2050 en 50% minder primaire input in 2030. Om te kijken hoe dicht we bij deze doelstellingen gaan komen, moet er worden gemonitord:

7. Zijn er voor circulair in 2050 al duidelijke indicatoren beschikbaar?
8. Wordt er gefocust op effect indicatoren of transitie indicatoren of beide?
9. Het PBL werkt momenteel aan een monitoringssysteem, wat is de status hiervan?
10. Denkt u dat een landelijk monitoringssysteem ook te gebruiken is op het regionale/lokale level? Of hoe verhoudt dit landelijke systeem zich tot regionale overheden?
    a. Zo nee, heeft u suggesties voor regionale/lokale overheden om hun voortgang te monitoren of anders bij te houden?
11. In hoeverre is het van belang dat burgers worden betrokken in het proces? Is het voldoende om beleid gericht op CE-doelen vanuit gemeentelijk niveau in te voeren?
    a. Welke andere belangrijke actoren zijn niet te missen in dit proces?

(deel collega - niet relevant voor eigen onderzoek)

Evaluatie van beleid

Behalve onderzoek naar hoe we als land vorderen naar het behalen van de doelstellingen van 2030 en 2050 is het ook relevant om te bezien wat het beleid van de overheid en van regionale overheden daaraan heeft bijgedragen:

12. Wordt de inzet van beleidsinstrumenten op nationaal niveau voor de Circulaire Economie op dit moment geëvalueerd? En zo, Ja hoe?
    a. Verschilt dit van evaluatie van niet-CE-beleid?

Zo nee,

13. Hoe zijn jullie van plan het succes van jullie beleidsinterventies te monitoren? Kan dit ook op soortgelijke manier op regionaal/lokaal niveau?
14. Wat vindt u geschikte/ gewenste indicatoren om CE-beleid te evalueren?

Afsluiting

- Kenbaar maken dat we zijn gekomen tot het einde van het interview
- Vragen of er bepaalde zaken gedurende het interview niet aan bod zijn gekomen, die volgens de respondent wel belangrijk/relevant zijn om te delen
- Vragen of de respondent nog andere contacten heeft die relevant zijn voor dit onderzoek; of die bijvoorbeeld een hele andere kijk hebben hierop (zo ja, contactgegevens vragen)
- Toestemming vragen aan de respondent of ik hun naam in mijn thesis mag noemen, of dat ze liever anoniem blijven (bij de tweede optie wordt bijvoorbeeld alleen functie en instantie genoemd)
- Bedanken voor hun tijd en de waardevolle toevoeging

B2. Case interview guide

Introductie

- Zelf voorstellen en korte introductie over thesis geven en doel van dit interview.
- Toestemming vragen voor het opnemen van het interview voor verdere uitwerking.

~start opname~

Algemene informatie

Datum interview	
Naam respondent	
Organisatie	
Functieomschrijving	
Hoe lang werkzaam in deze functie	

Algemeen

1. Wat verstaat u onder het begrip ‘circulaire economie’?

Verwachtingen omtrent circulariteit

2. Heeft u bepaalde verwachtingen (vanuit de gemeente/het Rijk/etc.) omtrent de transitie naar circulariteit?
3. Ziet u bepaalde knelpunten gerelateerd aan de transitie naar een circulaire economie?
    a. Waar ziet u mogelijke kansen?
4. Met wat voor kritiek komt u weleens in aanraking in uw vakgebied in relatie tot het meten en monitoren van CE?

Rol van de Gemeente Nijmegen

5. Wat is de rol van de Gemeente Nijmegen in dit proces volgens u?
    a. Wat behoort tot hun takenpakket? Voorbeelden?
    b. Welke rol zouden ze in moeten nemen volgens u? Voorbeelden?
6. Welke andere actoren dragen een grote verantwoordelijkheid op het gebied van circulaire economie op lokale schaal?
    a. Welke actoren zouden nog een grotere rol moeten spelen in het transitieproces naar een CE, volgens u, die dat op dit moment nog niet (genoeg) doen? Voorbeelden van taken/verantwoordelijkheden?

Circulair beleid

7. Wat voor beleid is er momenteel gerelateerd aan CE en de transitie daar naartoe (vanuit de gemeente)?
    a. Zijn er bepaalde doelen te identificeren?
        i. Zo ja, wat zijn deze?
        ii. Zo nee, wat zou hiervoor in de plaats voor moeten komen? Wat voor beleid zou er nog geschreven moeten worden? Wat voor doelen zouden er gesteld moeten worden?

Indicatoren

Het Rijk heeft het ambitieuze doel gesteld om in 2050 volledig circulair te zijn, met als tussendoel in 2030 50% minder primaire input gebruiken. Om te kijken hoe dicht we bij deze doelstellingen gaan komen, moet er worden gemonitord:

8. Wordt er al gemonitord op een bepaalde manier?
9. Zijn er bepaalde indicatoren die volgens u noodzakelijk zijn om te monitoren?
10. Zijn er bepaalde indicatoren die volgens u niet meegenomen hoeven te worden in een monitoringssysteem?
11. Van welke indicatoren is al data beschikbaar?
12. Wat ontbreekt er nog?
    a. Wat is daarvoor nodig om dit wel mogelijk te maken?

Heeft u zelf nog advies over de manier van aanpak voor een gemeentelijk monitoringssystematiek?

Afsluiting

- Kenbaar maken dat we zijn gekomen tot het einde van het interview
- Vragen of er bepaalde zaken gedurende het interview niet aan bod zijn gekomen, die volgens de respondent wel belangrijk/relevant zijn om te delen
- Vragen of de respondent nog andere contacten heeft die relevant zijn voor dit onderzoek; of die bijvoorbeeld een hele andere kijk hebben hierop (zo ja, contactgegevens vragen)
- Toestemming vragen aan de respondent of ik hun naam in mijn thesis mag noemen, of dat ze liever anoniem blijven (bij de tweede optie wordt bijvoorbeeld alleen functie en instantie genoemd)
- Bedanken voor hun tijd en de waardevolle toevoeging

Appendix C – List of respondents for interviews

Respondent	Organisation and job title	Date & duration interview
Respondent 1 *(expert)*	**Planbureau van de Leefomgeving** Researcher department sustainable development	20.08.20 *(01:06:12)*
Respondent 2 *(expert)*	**Ministry of Infrastructure and Water** Circular economy policy coordinating officer	20.08.20 *(00:51:59)*
Respondent 3 *(expert)*	**Province of Overijssel** Consultant monitoring	07.09.20 *(00:49:09)*
Respondent 4 *(case)*	**Gemeente Nijmegen** Senior Advisor Sustainability; and **Economic Board Arnhem-Nijmegen** Civic Entrepreneur Sustainability	09.11.20 *(00:48:23)*
Respondent 5 *(expert/case)*	**Radboud University Nijmegen** Assistant professor strategy; and **Circulaire Raad** Member of the board	01.12.20 *(00:56:19)*
Respondent 6 *(case)*	**De Variabele** Executive manager; and **RvN@** Boardmember	21.01.21 *(01:03:09)*
Respondent 7 *(case)*	**Provincie Gelderland** Programme manager circular economy	05.02.21 *(00:40:22)*
Respondent 8 *(case data)*	**Gemeente Nijmegen** Senior consultant public space policy and specialist waste expert	23.06.21 *(00:53:11)*
Respondent 9 *(case data)*	**Landelijk Meldpunt Afvalstoffen** Consultant	09.07.21 *(00:38:00)*

Appendix D – Codebook ATLAS.ti

D1. Codebook ATLAS.ti (exported in Excel)

	A	B	C
1		**Code**	**Code Groups**
2	○	Actor dependency	Actors
3	○	Actor Educational institution	Actors
4	○	Actor Ministry/National Government	
5	○	Actor Province Gelderland	Actors
6	○	Actor relevant for RvN	Actors
7	○	Actor responsibility	Transition indicator Opportunity Actors
8	○	Actor responsibility businesses	
9	○	Actor responsibility Councillor Economy	Actors
10	○	Actor responsibility Councillor Education	Actors
11	○	Actor responsibility Councillor Sustainability	Actors
12	○	Actor responsibility Councillor Waste Materials	Actors
13	○	Actor responsibility educational institution	
14	○	Actor responsibility Ministry	Actors
15	○	Actor responsibility National Government	Actors
16	○	Actor responsibility Province of Gelderland	
17	○	Agro-food sector	Sectors
18	○	Awareness indicator	Transition indicator
19	○	Barrier	Barrier
20	○	Baseline measurement	
21	○	Breakdown of the linear economy indicator	Transition indicator
22	○	Build up of a more CE indicator	Transition indicator
23	○	CE adaptation creates more work	Barrier
24	○	CE as a complex issue	Barrier
25	○	CE as hype	
26	○	CE as upcoming theme	
27	○	CE is new concept	Barrier
28	○	Circular initiative	
29	○	Clear CE definition	Opportunity
30	○	Clear indicators definition and alignment	Opportunity
31	○	Construction sector	Sectors
32	○	Consumer attitude and behaviour	Opportunity
33	○	Consumer waste sector	
34	○	Contradictory methods	Barrier
35	○	Customisation per region	Barrier

Code Manager | Info

	A	B	C
1		**Code**	**Code Groups**
34	○	Contradictory methods	Barrier
35	○	Customisation per region	Barrier
36	○	Dashboard indicator	Dashboard indicator
37	○	Data availability houshold waste	
38	○	Data availability of dangerous/toxic waste	
39	○	Data not available for dangerous/toxic waste	
40	○	Data not available household waste	
41	○	Double measurements monitoring	
42	○	Economy indicator	Dashboard indicator
43	○	Emotional expression: laughing	
44	○	Energy indicator	Dashboard indicator
45	○	Example circular monitoring	
46	○	Example circular project: housing	
47	○	Example circular project: manufacturing	
48	○	Example circular project: provincial initiative	
49	○	Growth in net assests indicator	Primary indicator
50	○	Health and well-being indicator	Dashboard indicator
51	○	Industrial sector	
52	○	Institutionalisation indicator	Transition indicator
53	○	Job function	
54	○	Lack of adaptive capacity	Barrier
55	○	Lack of authority	
56	○	Lack of continuation	
57	○	Lack of cooperation between scales	Barrier
58	○	Lack of data and knowledge	Barrier
59	○	Lack of definition	Barrier
60	○	Lack of long-term vision	Barrier
61	○	Lack of operationalisation of goals	Barrier
62	○	Lack of overall progress	Barrier
63	○	Lack of prioritisation of the CE problem	
64	○	Lack of resources and leadership	Barrier
65	○	Lack of transparency	Barrier
66	○	Lack of uniform method	Barrier
67	○	Law and regulations	Barrier
68	○	Materials indicator	Dashboard indicator
69	○	Monitoring indicator(s)	
70	○	Multi-stakeholder and -scale	Barrier
71	○	Natural capital indicator	Dashboard indicator

Code Manager | Info

	A	B	C
1		**Code**	**Code Groups**
69	○	Monitoring indicator(s)	
70	○	Multi-stakeholder and -scale	Barrier
71	○	Natural capital indicator	Dashboard indicator
72	○	Need for local viewpoint	
73	○	Network creation	Opportunity
74	○	Opportunity	Opportunity
75	○	Optimalisation and destabilisation indicator	Transition indicator
76	○	Overall viability of CE	Opportunity
77	○	Policy indicator	
78	○	Primary indicator	
79	○	Primary material input indicator	Primary indicator
80	○	Primary material use indicator	Primary indicator
81	○	Region	
82	○	Responsibility Municipality of Nijmegen	Actors
83	○	Responsibility of new concept CE	Actors
84	○	Starting phase CE	
85	○	Top-down enforcement	
86	○	Transboundary fenomenon	Barrier
87	○	Transition indicator	
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Code Manager | Info