

THE REGIONAL TRANSITION TO A CIRCULAR ECONOMY

Insight into assessing the transition process to a circular
economy at the regional level in the Netherlands

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Summary

The concept of a circular has gained increasing attention as a means to address high consumption levels, material scarcity and unequal access to natural resources. This shift from a linear to a circular economy is a complex transition. Understanding and steering this transition requires insight into the transition process. This research aims to contribute to this understanding by providing insight into assessing the CE transition process at the regional level in the Netherlands.

The first part of this research analysing the suitability of several CE indicator frameworks for assessing the CE transition at the regional level and classifying them using the policy evaluation tool used by the Dutch government to guide the CE transition process. It was found that in the formative phase, which is the early stage of the transition, the use of a transition indicator framework can be most suitable to assess the transition process. This resulted in the choice of one transition indicator framework, the mission-oriented innovation framework (MIS). In this framework, several functions are proposed that are identified as boundary conditions in the transition process. These functions are measured in the second part of the research where the framework is applied to a regional case study.

In the second part, the mission-oriented innovation framework is applied to the Food Valley region in the Netherlands. This was achieved by structured interviews of thirteen stakeholders within the region. The results give a in depth insight into the local circular ecosystem by identifying the weaknesses, strengths, and possible improvement related to each function. Furthermore, several interactions between functions were observed, supporting the dynamic system of functions. The framework provided a systematic overview of the state of the circular ecosystem and the role of different stakeholders within the Food Valley Region.

The research shows that using a transition framework can contribute to the assessment of the CE transition at the regional level, especially in the early phase of the transition. However, the use of a transition framework is no silver bullet and should be considered in the context of the transition phase because it doesn't take into account the outcomes of the transition. Overall, more research is needed to further develop transition frameworks as well as transition dynamics to better understand the transition process and help steering the transition in the right direction.

Preface

Before you lies the product of my master program Sustainable Development at the Utrecht University. The process of writing this thesis has been both a challenge as well as a great learning experience. When writing this master thesis, I have also been working as an intern at Royal HaskoningDHV (RHDHV). I am grateful to have been able to work on several projects and apply my knowledge to real world issues.

There are several people which I would like to thank. First, I want to thank Jesus Rosales Carreon, my UU supervisor, and Eva Herrewijnen from RHDHV for their continuing feedback and support during all phases of the research. Our discussions have been a driving factor in bringing this thesis to where it is now. Second, I would like to thank Carolien Huisman-Zilverentant from the Food Valley region for her enthusiasm and feedback as well as helping me reach the stakeholders in the region. Third, I would like to thank all my colleagues at the sustainability team within RHDHV for all the help with my thesis or my internship activities. Furthermore, I would like to thank all the professionals that I have been able to talk to and who have shared their knowledge with that form the main body of this thesis. Lastly, I would like to thank my parents and girlfriend for their continues support during the whole process.

It is time to close a chapter, but at the same time the start of a new chapter to bring the learned knowledge and experience into practice by hopefully contributing to a better world.

Pieter van Bommel

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1 Introduction

1.1 Background

According to the International Institute for Sustainable Development, the global economy has doubled since the beginning of the century, currently being worth around 80 trillion US dollar (IISD, 2017). Forecast from the United Nations on population growth predicts that it will keep increasing to almost 11 billion at the end of the century (UN, 2019). These developments will likely lead to even higher production and consumption levels compared to today, which will put pressure on the current economic model. Additionally, they can lead to material scarcity, unequal access to natural resources and other social, geopolitical, and environmental concerns (IISD, 2017).

To respond to these concerns, the concept of the circular economy (CE) has been proposed as a replacement to the current linear economic model. In a circular economy the use of materials is maximized to keep their value as long as possible. This is achieved by using product services as well as improving the durability, repairability, reusability and recyclability of products to retain their worth in the value chain (Avdiushchenko, 2018). This transition to a circular economy also has multiple benefits as mentioned by the European Environment Agency (EEA). It can reduce environmental pressures in Europe and beyond as well as decrease the dependence on imports from other regions. Furthermore, the transition could result in cost savings and the creation of new job opportunities in Europe (EEA, 2016).

To implement this new paradigm, developing circular policies will be necessary. Steps for implementation of CE at European level have already been taken. An example of this is the 'new circular economy action plan' by the European Commission providing a future-oriented agenda for achieving a cleaner and more competitive Europe. (EC, 2020). At the national level, the implementation of the CE has received increased attention which has led to action plans for different countries in the EU. An example of this is the ambition by the Netherlands to have a fully circular economy in 2050 with a first milestone of having 50% less raw materials in 2030 compared to 2014 (DMoE, 2016). Related to these national action plans, plans for implementing CE at regional and city level have also been introduced. Examples of these are CE strategy plans for Amsterdam, London, and the Catalonia region (Avdiushchenko & Zajac, 2019). To achieve the goals that are proposed in these CE strategies, assessing the transition to a CE will be key (Alaerts et al., 2019).

1.2 Problem Definition

Assessing the transition to a CE is crucial to determine if the transition is progressing as planned. To measure the progress of the CE transition, a monitoring framework is necessary. An example of this is the monitoring framework developed by the European Commission. This framework focuses on monitoring the progress of CE implementation on the national level focusing on four monitoring areas: production and consumption, waste management, secondary raw materials, and innovations (EC, 2018).

However, as this framework is focused on national level, there is limited attention for monitoring the transition to a CE at region level (Avdiushchenko & Zajac., 2019). Having a monitoring framework at the regional level is becoming increasingly important as regions play a significant role in EU development policy and financing. Funds coming from the European Regional Development Fund (ERDF) and the European social Fund (ESF) are both focused on stimulating the transition to an environmentally friendly economy, create business opportunities and support innovation at the regional level (EC, 2022). These developments are all closely related to the concept of CE.

Another argument for the focus on regional level is the increased attention for CE issues at regional and local level because of the European focus on circularity. This has led to new CE strategies and CE initiatives at regional and local government level (Avdiushchenko, 2018). Focusing on the Netherlands, the importance of developing regional CE policies is stated by the Dutch Government in their updated Circular Economy Implementation Programme. It is argued that regions have a key role in supporting stakeholders to develop circular initiatives, innovations, and networks (IenW, 2021). Furthermore, these stakeholders, especially decentral governments and network organisations have an important role to play in speeding up the transition. However, it is noted that one of the challenges related to CE at the regional level is the lack of information needed to give stakeholders clarity about in what direction the transition should be developed (IenW, 2021)

In the light of this increasing focus on transitioning to CE at the regional level and a lack of direction in this transition, information for understanding the current direction and speed of the transition is required. This information can then be used to identify where steering is necessary. A functional regional monitoring framework for this purpose is currently lacking, as is recognized by the academic field (Avdiushchenko & Zajac, 2019; Alaerts et al., 2019; Silvestri et al., 2020).

1.3 State of the art

There have been several studies in the literature discussing frameworks for monitoring CE at the regional level. Avdiushchenko (2018) developed a framework for CE monitoring by proposing focus areas, pillars and evaluation aspects that are key for regional CE development in Europe. A follow up article by the same author further developed this framework by proposing a system of possible indicators for assessing CE at the region level in European states and applying these indicators in multiple case studies in Poland. With these case studies, barriers related to data availability and the need for additional indicators are discussed (Avdiushchenko & Zajac, 2019). The importance of data management is also emphasized by Alaerts et al. (2019) that argues for the development of meso indicators, which focuses on the business level, to deliver more direct feedback for policy makers. Furthermore, the authors outline the development of a monitoring framework for the regional level. Bianchi et al. (2022) take the indicators developed by Avdiushchenko (2018) and combines them with the CE framework from the EC. This framework is applied to three different case regions in Europe. The study stresses the importance of taking the local context into account when discussing regional CE strategies.

These studies conducted on CE monitoring are all aimed to develop indicators for monitoring the effects of the CE transition on material use, the environment, or social economic factors. However, as the transition to a circular economy is in its early stages, these effects can sometimes only become visible at a later stage. Therefore, it is relevant to also assess the transition process itself. Assessment of the transition process can be characterized as measuring systematic changes that occur in a system before the effect of these changes take shape. Assessing the transition process can provide information to see if transition effects are being achieved or that changes in direction are necessary (Potting et al., 2018). In the “Integrale Circulaire Economie Rapportage” (ICER) from the Dutch knowledge institute “Planbureau voor de Leefomgeving” (PBL) the importance of looking at this transition process is highlighted. Furthermore, in this report, a start for measuring the CE transition is made by developing transition-indicators and applying them to the national level (Hanemaaijer et al., 2021). A start for assessing this transition process at the regional level has been made by Roemers et al. (2018) that incorporated some transition indicators in their framework for monitoring CE for the Amsterdam Metropolitan Area. However, this study highlights that these indicators are underdeveloped, and more research is needed into understanding the concept of the transition process as well as new ways of measuring these indicators.

1.4 Research aim and research question

The Netherlands has a clear ambition with their ambition to have a fully circular economy in 2050 with a target of 50% virgin material reduction by 2030, taking 2014 as base year (DMoE, 2016). To reach this goal, this national ambition needs to be translated into CE strategies at the regional level. To get insight into the state of the CE transition at the regional level, assessing this transition process is necessary. This study aims to get insight in how the CE transition process can be assessed at the regional level. Following this, the research question of this study is:

How can the transition process to a circular economy be assessed at the regional level?

To answer the main research question, the following two sub questions are identified:

What CE indicator frameworks are suitable for assessing the CE transition process at the regional level?

The suitability of each framework will be discussed by categorization of the different indicators within the frameworks and their suitability to assess the CE transition. The aim is to build an argument for using a transition framework to assess the CE transition at the regional level.

How does a transition framework perform in assessing the CE transition at the regional level?

This sub question aims to measure the performance of the selected indicator framework by applying it to a regional case study in the Netherlands. This gives insight into the practical application of the indicator framework. Furthermore, it gives insight in the theoretical implications of using the framework at the regional level.

1.5 Outline

The remainder of this research is structured in the following way: The second section will outline the theoretical concepts that are used within the research. The third section discusses the research design and elaborates on the different methods that are used to answer the research question. The fourth section presents the results of this study. In the fifth section, the results will be discussed in relation to the existing literature. Furthermore, limitations of the study and directions for future research are discussed. Finally, section 6 provides a conclusion in which the main research question is answered.

2 Theoretical Framework

To understand the assessment of the transition process to a circular economy there are some key concepts that form the base of this research. First, the concept of the circular economy will be explored as well as its application to the regional level. Secondly, the transition theory that is related to the transition process will be analysed. Lastly, monitoring of CE will be discussed.

2.1 Circular Economy

2.1.1 Concept of a Circular Economy

The concept of a circular economy is an approach to develop an economy with responsible and cyclical use of resources. This shift from a linear to a circular approach has been introduced into policy to decrease the environmental impact as well as stimulating the economy (Moraga et al., 2019). CE is an umbrella concept, meaning that it incorporates multiple meanings and has blurred boundaries (Homrich et al., 2018). In the early stages, the concept of CE has been mostly focused on resource efficiency, waste management and energy efficiency. This made it a useful policy tool to deal with environmental challenges such as air pollution or resource inefficiency (Avdiushchenko, 2018). This approach has been used extensively in China characterized by their national CE strategy focusing on the previously mentioned environmental challenges (Geng et al., 2012).

In the European context, the concept of CE has changed from 2014 onwards into a new area of CE development. This change has been shaped by reports from the Ellen MacArthur Foundation (EMF) focusing on the potential for CE in EU countries (Avdiushchenko, 2018). This has led to the development of the EU circular economy Action Plan in 2015. This plan focused on a broad range of actions, covering the whole life cycle: product design, production and consumption, waste management and the market for secondary raw materials. Furthermore, it looked at innovation and investments in the transition to a CE (EC, 2015). Comparing to China, which is focused on environmental problems and pollution, the European approach focuses on materials, resource efficiency, waste management, new business models, new jobs, social and eco-innovations (Parchomenko et al., 2019). Connected to this, the following definition of the concept of the circular economy has been developed by the European Commission (2015):

“In a circular economy the value of products and materials is maintained for as long as possible; waste and resource use are minimised, and resources are kept within the economy when a product has reached the end of its life, to be used again and again to create further value.” (p. 1)

This definition will be used in the rest of the research. It was chosen because it provides clear boundaries for applying the CE concept. Furthermore, this definition is also integrated into the national ambition of CE in the Netherlands, which makes it suitable to use as this research is focused on the regional level in the Netherlands.

This research specifically focuses on CE at the regional level. It is thus important to better understand the playing field of CE at this level. Analysing the regional context, regional authorities play a key role in developing and accelerating the CE transition. Firstly, they are responsible for the key sectors that are related to the CE such as transport and solid waste. Furthermore, regions can be seen as laboratories for innovation and experimentation with CE concepts (Romano, 2018) This can be achieved by having a clear framework that supports local and regional stakeholders.

Another important aspect is the difference in geographic, environmental, economic, and social factors at the regional level. These differences between regions will translate into different opportunities and needs for each region. This should be considered when implementing a CE approach (Bačová et al., 2016). Development of CE strategies has increased over the years. Salvatori et al. (2019) shows an exponential increase of circular economy strategies between the period of 2014 and 2019. Of these strategies, most of them are related to the national level. However, there have been several CE strategies that are related to the regional level. Examples of this are the development of a CE strategy in Catalanian region, Brussel region and Scotland. Furthermore, examples of CE strategies on the city level have been developed for Paris, Amsterdam, and London (Avdiushchenko & Zajac, 2019; Roemers et al., 2018). Zooming in on the Netherlands, there have been several CE strategy plans developed for different provinces such as Brabant, Utrecht, and Rotterdam. Furthermore, an example of a regional organisation is the Food Valley Region that developed a strategic agenda focusing on several sustainability issues including the CE transition (Food Valley, 2019). These developments show the increased awareness of CE at the regional level

2.2 Transition Theory

2.2.1 Transition process

To assess the transition process to a circular economy, it is important to understand the theory related to this transition process. A transition, as defined by Rotmans et al (2001, p. 16) is a “gradual, continuing process of change where the structural character of a society transforms”. This transition process can be characterized by different phases. In this research, the simplified version that takes together the first and last two phases will be used as shown in figure 1 as proposed by Potting et al. (2018). The first phase is

the formative phase in which the conditions for later growth are created. This can be related to experimentation with new products and services, new business models or changes to existing organizations. The second phase is the growth phase. This phase is characterized by fast growth of circular products and services. The boundary between the two phases coming from the literature is 2.5% of potential market share of circular products and services (Bento & Wilson, 2016). It is argued that we are currently in the formative phase of the transition. These phases are the base for assessing the process that has been made in the transition (Potting et al., 2018).

Degree of circularity of the economy

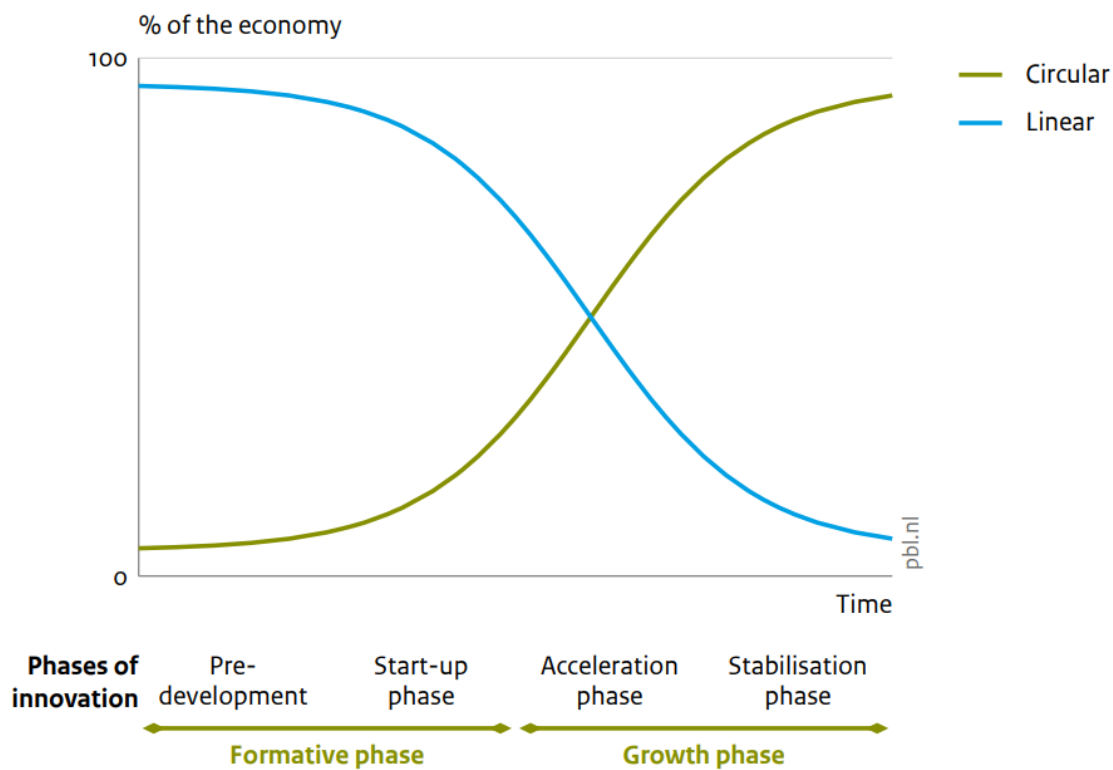


Figure 1: X-Curve-Model adapted by PBL (Potting et al., 2018)

2.2.2 Transition assessment

Measuring the progress in the transition to a circular economy can be difficult depending on the phase of the transition. Measuring the effects of circular actions are often not measurable in the formative stage and are more useful in the growth stage. However, assessing the transition process in the formative phase can help understanding the transition process and open opportunities to manage and steer the transition in the right direction (Potting et al., 2018) To assess the process of the transition to a circular economy, information is needed on the transition process.

The Dutch knowledge institute “Planbureau voor de leefomgeving” (PBL) has made a start in developing a framework for gathering this information. They make a distinction between three processes that are important for steering the transition. The first area are processes that support capacity. Examples are the mobilisation of human capital, financial means, and knowledge for innovation. The second area are processes that support motivation. This is related to the creation of markets and the development of circular product chains. The last processes are focused on supporting permission. This is about laws and regulation that support the implementation of CE (Hekkert et al., 2007; Potting et al., 2018). For each of these processes, indicators are proposed. These are categorized into means, activities, and output indicators. Means are input variables such as investment in research or number of circular advisers. Activities are throughput variables such as the number of circular projects and awareness campaigns. The last category is the output variable that is related to achievements, examples of this are number of new circular products or the number of publications on CE (Potting et al., 2018).

Another approach proposed by PBL in the “Integrale Circulaire Economie Rapportage” (ICER) for assessing the transition is based on evaluating key processes related to a transition within an innovation system (Hanemaaijer et al., 2021). This approach is based on a Technical Innovation Systems (TIS) approach. A TIS is focused on a specific technological transition and consists of the network of actors involved as well as the institutional structure, which are the rules of the game that determine the actions of network actors (Hekkert et al., 2007). If a TIS functions well, this is a sign for fast innovation and with that a smooth transition progress. The degree to which a TIS functions well is determined by the key processes in the innovation system.

The CE transition is not solely a technological transition, but a societal transition in which social and technical aspects come together (Elzinga et al., 2020a). To deal with this societal transition, the key processes used for TIS were revised to fit this societal transition. This theory assumes that there is a causal link between the fulfilment of the function and the speed, risks, and costs of the transition (Hanemaaijer et al., 2021). The specific framework related to this approach will be further discussed in this research.

3 Methodology

This part elaborates on the methodology and data that have been used in this research. Section 3.1 shows the research design. Section 3.2 discusses the first phase of the research, giving an overview of CE indicator frameworks. Section 3.3 discusses the second phase of the research, the regional case study.

3.1 Research design

The aim of this research was to get insight in how the CE transition process can be assessed at the regional level. The research was divided into two phases. In phase one, the current literature on assessing the CE transition was explored to give an overview of the different indicator frameworks that are available. After this, the suitability of each framework to assess the CE transition process at the regional level was evaluated and one framework was chosen to be applied in phase two. In this phase, the research applies a transition framework, the mission-oriented innovation system monitoring framework, to a regional case study in the Netherlands. The research process is visualized in figure 2.

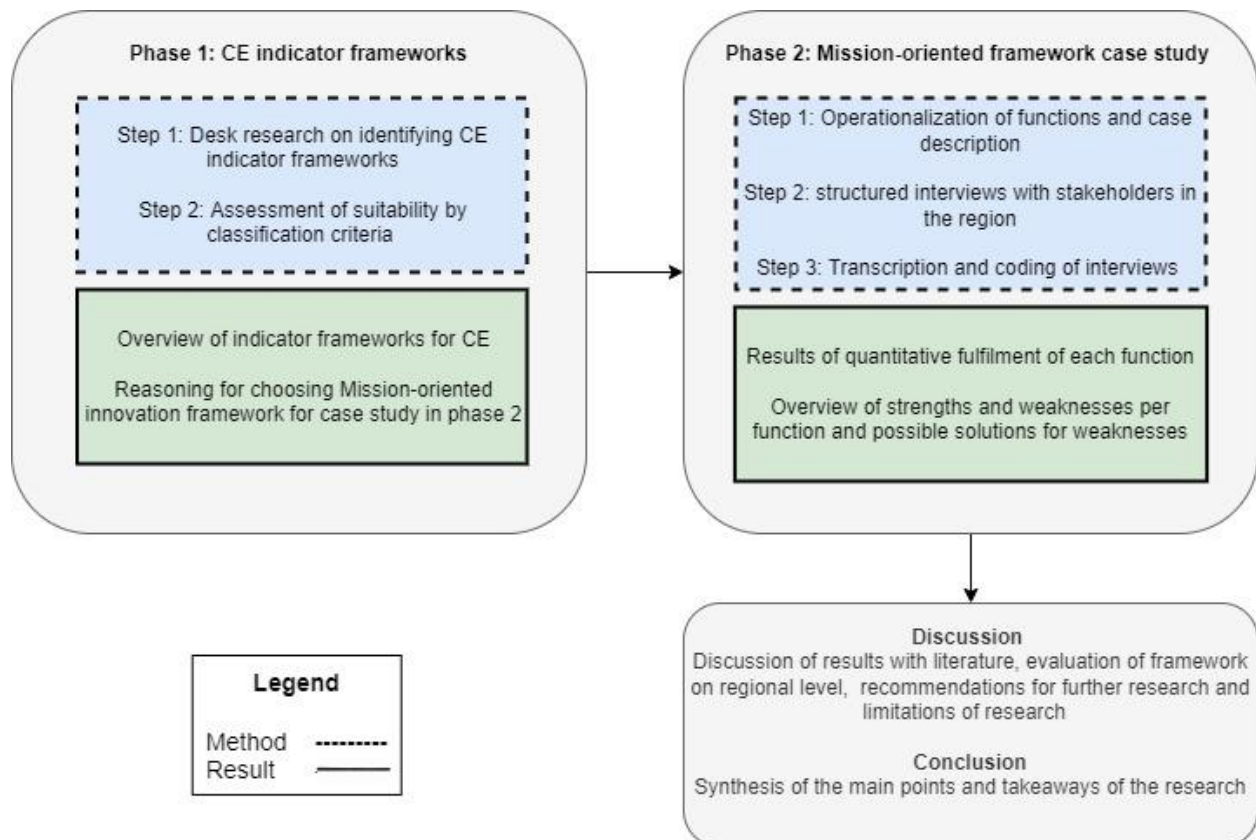


Figure 2: Research Design (Own design)

3.2 Phase one: Overview CE indicators

This phase explored the existing literature on indicator frameworks for assessing the CE transition. This was achieved by doing desk-research, looking at scientific literature as well as policy documents. To give more insight into the indicators that are used within the frameworks, classification criteria were used to categorize them. The result is an overview of the indicator frameworks related to assessing the CE transition from the literature

To limit the scope of indicator frameworks that were discussed in this research, the scale of implementation was used as boundary criteria. As this research focuses on CE at the regional level, only macro-level indicator frameworks were discussed. Macro-indicator frameworks are defined in this research as indicators related to cities, regions, provinces, nations or beyond countries (Kirchherr et al., 2017).

The CE indicators within these frameworks were classified using the policy evaluation framework proposed by PBL. This framework was chosen because it is used as tool by the Dutch government to guide the CE transition process. Thus, it makes sense to use it to classify the suitability of these frameworks with this framework. In the framework, a distinction is made between indicators that measure the transition process and those that measure effects of this transition process (Potting et al., 2018). The transition process indicators are further divided into input, throughput, and output indicators. Input indicators are related to the resources that are needed to create circular activities. Throughput indicators focus on measuring these circular activities and output indicators are in turn about measuring the results of these activities. The other group of indicators are effect indicators. These are focused on the effects, which are the outcomes of the circular actions (Potting et al., 2018). The classification scheme is visualized in figure 3.

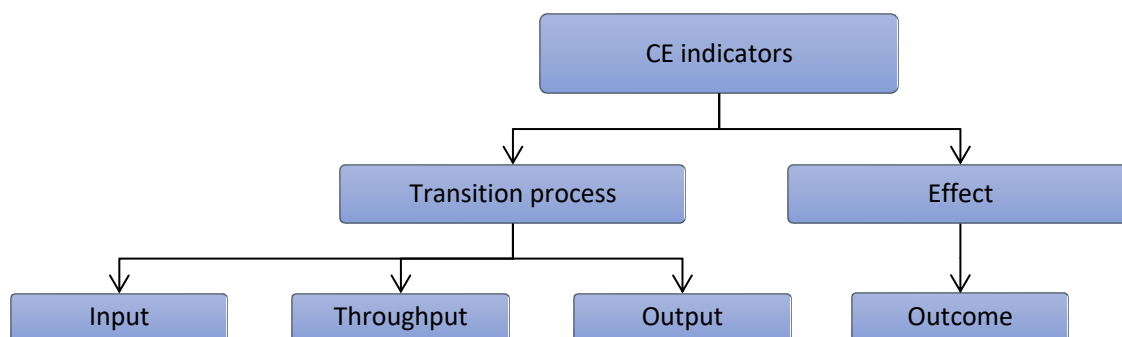


Figure 3: Classification scheme based on Potting et al. (2018, p. 23). (Own design)

Based on the classification scheme together with arguments from the literature, the suitability of each framework is discussed to assess the CE transition at the regional level. Based on this suitability assessment, the argument is built for applying the mission-oriented innovation framework that is used in phase two of the research.

3.3 Phase two: Regional case study

In this phase, the Mission-oriented innovation system monitoring framework was applied in the Food Valley region in the Netherlands. The first step was the operationalization of the functions by translating them into diagnostic questions and develop an interview guide. In the second step the interview guide was used to conduct interviews with stakeholder groups in the case region. The last step entailed the transcription of the interviews and the process of analysing the gathered data.

3.3.1 Operationalization & interviews

The first step was the operationalization of the theoretical concepts by translating the abstracts functions of the mission-oriented innovation framework into measurable concepts (Vennix, 2011). This was achieved by developing diagnostic questions that address each of the functions. A starting point for this is provided by Wesseling & Meijerhof (2021) & Scheulderman (2021) that contributed to the framework. They proposed a range of diagnostic questions that capture the fulfilment of each function.

The questions by Scheulderman (2021) were used as baseline for the interview guide used in this research. They were modified to make it fit the regional context as well the introduction of a new question for each function where the interviewees were asked if they have other comments on a function. For each of the functions it started with a closed question where the interviewee answered through a Likert scale (1-5). This question gave a quantitative interpretation of the fulfilment of the function from the perspective of the interviewee's organisation. After this, several open questions are asked to get more in-depth information on the argumentation behind the choice for fulfilment of a function. The interview used in this research can be found in appendix C

A few steps were taken before the interviews were conducted. First an introduction email was sent explaining the research and the goal of the interview and invite the interviewee. Attached to this email was a document with a short description of different system functions based on the work of Elzinga et al., (2020). This has been done to familiarize the interviewee with the characteristics of each of the functions. Second, an informed consent form was sent out to the respondent after the interview was planned. This form can be found in appendix D. Before conducting the interview, each of the interviewees was asked if

they agreed with recording the interview audio. Furthermore, each interviewee was asked if they had a clear understanding of the system functions. If concepts were unclear, these were further explained to give the interviewee a good understanding of each of the functions. If during the interview the interviewee indicated that he/she didn't have the knowledge to assess a certain function, this function was not discussed.

After this, structured interviews were conducted to get insight into each of the functions of the framework. These are characterized by having a predetermined topic and order which connects well to the structured indicator framework that is used in the research (Vennix, 2011). All interviews except one were conducted in an online setting. All interviews were conducted in Dutch as this is the native language of both the researcher as well as the interviewee. This helped the interviewees expressing their thoughts as well as limiting errors related to misinterpretation. The conducted interviews were transcribed to translate the verbal research material in writing Flick (2013).

3.3.2 Case study sample

A generic purposive sampling strategy was used to establish a sample for the interviews. This strategy allows to specifically select your sample based on criteria (Bryman, 2016). These criteria were the stakeholder groups that are involved in shaping the CE ecosystem in the Food Valley Region as presented in table 1. The interview sample contains at least two of each actor group. Table 1 gives an overview of the different stakeholder groups as well as the amount sample size of each group (N). The actor groups were identified by using policy documents, project descriptions as well as a contact person within a network organisation in the region. An overview of the full interview sample is found in appendix A

Table 1: Overview stakeholder groups and sample size (N)

<i>Interview sample (N)</i>	<i>Stakeholder groups</i>
3	Companies
2	Financial institutions
2	Education institutes
3	Governments
3	Network organizations

3.3.3 Analysing

The next step in the research was analysing the gathered data. The categorizing strategy for the data is coding. In this strategy data segments are labelled and grouped by category. The specific coding category that is used are theoretical categories. This is described by Flick (2013) as categories that place the coded data into a theoretical framework. This strategy was chosen as this research focuses on applying a specific framework. To achieve this, two steps were performed. In the first step, the interviews were analysed one by one to assign the data segments that relate to a specific function with the code of that function. If a data segment was related to multiple function, it was labelled for each function. In the second and final step, the previously assigned codes were analysed separately per function. The goal here was to group similar codes together to make sense of the fulfilment of each of the functions. The categories that were used are based on Scheulderman (2021) that proposed the following categories:

- Strengths
- Weaknesses
- Solutions for weaknesses and/or root causes

These categories were chosen as they reflect the structure that was used in the interview guide. The strengths and weaknesses in this case reflect good of bad fulfilment of a function. Solutions for weaknesses as well as root causes reflect the ways that a function could be improved according to the interviewees.

During the analysis it was decided that the quantitative interpretation of fulfilment for each function by the interviewees will not be used in discussing the results of the case study. An overview of the average score of each function can still be found in appendix B. There were several reasons for this decision. First, not every function was rated by each interviewee, this made it difficult to compare between different stakeholder groups as there were gaps in some of the functions. Second, when comparing the averages of each function, it is difficult to give meaning to the small differences as it doesn't show the range or individual values. Furthermore, the values represent an interpretation of the interviewee of a specific function, this makes it very susceptible to interpretation errors. Concluding, it is undesirable to take the average scores into account when discussing the fulfilment of the functions. These shortcomings will be further addressed in the discussion.

3.4 Validity and Reliability

Two important criteria that are used to assess the quality of research are validity and reliability. *Reliability* is related to the repeatability of the research, ensuring transparency of what steps were taken to conduct the research and whether the research methods can reproduce the same result multiple times (Bryman, 2016). To ensure *reliability* within this study, the steps taken in this study are well-documented in the method section. Justification for each of these steps can be found in the argumentation of decisions regarding the research design.

The second criterium is validity. As described by Vennix (2011), this concept consists of two components. The first is *internal validity* which discusses the degree to which the research methods are suitable to measure the concept that the researcher aims to measure. This can be ensured by controlling every step in the operationalization process. In this study, the gathered data is supported by the structured interview guide which in turn is based on the theoretical concept derived from the framework used in the case study. Because of this, reliable data can be gathered to make valid conclusions. The second concept is *external validity* which concerns the generalizability of the research to other social settings. The case study design of this research makes it difficult to generalize the findings because it is a representation of a unique social context. However, generalizing the result of the case study was no specific goal of this research. Instead, the theoretical implications of using the framework to discuss its suitability were the main goal. This relates to the role of using a case study in qualitative research. The primary role of using a case study in this research was to explore, test and refine the ideas of existing theories. This application of a case study has been discussed by Silverman (1984) which argues that in this situation the validity of the research doesn't depend on the generalizability of the research to other populations but instead that the research findings represent a general theoretical principle. In this study, this can be characterized by the expected workings and dynamics of a transition within an innovation system.

4 Phase 1: Overview indicator frameworks CE

This part gives an overview of the existing indicator frameworks for assessing the transition to a circular economy. This is achieved by using the classification criteria as discussed in section 3.2. It discusses the most important frameworks and the different indicators that are included in them. Furthermore, it will evaluate the suitability of each framework for assessing the CE transition at the regional level.

4.1 Indicator frameworks

4.1.1 CE monitoring European Union

The European commission has proposed a framework to measure CE progress in the EU and its member states. It consists of four elements: production and consumption, waste management, secondary raw materials, and competitiveness and innovation. For these topics, a total of 10 different indicators are proposed. Furthermore, for some of the indicators, sub-indicators are proposed, which will not be considered to keep a clear overview (EC, 2018). The framework is related to the national/global level as it gives information for the EU as well as for each of its member states.

Table 2: Indicators EC monitoring framework (EC, 2018)

Indicator	Indicator type
Self-sufficiency for raw materials	Output
Green public procurement	Output
Waste generation	Outcome
Food waste	Outcome
Recycling rates	Outcome
Recycling / recovery for specific waste streams	Outcome
Contribution of recycled materials to raw materials demand	Outcome
Trade in recyclable raw materials	Output
Private investments, jobs and gross value added	Input
Patents related to recycling and secondary raw materials	Output

Looking at the classification of the different indicators from the EC framework it as presented in table 2, it can be noted that half of the indicators are effect indicators. These effect indicators are mostly related to material flows and waste production. This makes sense as the CE definition that the EU has taken has a material focus (EC, 2015). For transition progress indicators there is less material focus as these

indicators measure more ancillary aspect of CE. One example of this is the indicator: “patents related recycling and secondary raw materials”. This indicator does not measure a quantitative value or effect. Instead, the indicator is a proxy for technological progress that is assumed to support the CE transition (EC, 2018).

Concluding, most indicators focus on the preservation of materials and recycling. This is also recognized by the European Economic and Social Committee (EESC, 2018) that argues that it is partly the result of the reliability on waste data and lack of other options. This results in a framework that only explores a specific part of CE and neglects other aspects of CE such as multifunctionality or product sharing. Furthermore, because of this focus on data availability, it is difficult to translate these indicators the regional level.

4.1.2 CE-eco-innovation

Another proposed framework that is related to regional policy is the CE-eco-innovation framework by Smol et al. (2017). It explores the link between CE and eco-innovation. The term eco-innovation is defined by Kemp and Pearson (2007) as the following:

“It is the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organisation (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts on resources used (including energy use) compared to the relevant alternatives.” (p. 4)

The concept of eco-innovation has been taken up by the European Union in their “Europe 2020” strategy which focuses on goals in employment, innovation, poverty reduction, and climate/energy. With the current ambitious European goals on CE, the authors argue that taking a circular economy perspective on eco-innovation can be a fruitful approach (Smol et al., 2017). The CE-eco-innovation framework proposed by the authors has its roots in the indicator framework that is used to create the eco-innovation scoreboard developed by the EU. This scoreboard measures the performance of EU Member States on environmental innovations (EC, 2020).

Table 3: indicators regional CE-eco-innovation framework (Smol et al., 2017)

indicator	Indicator type
Regional authorities environmental and energy R&D for CE	Input
Regional total value of green early-stage investments	Input
Firms having implemented CE–eco-innovation activities aiming at a reduction of material input per unit output	Output
Firms having implemented CE–eco-innovation activities aiming at an increase of material recycling	Output
Generated industrial waste	Outcome
Generated municipal waste	Outcome
Recycled industrial waste	Outcome
Recycled municipal waste	Outcome
Life cycle assessment of enterprises activity (Amount of companies with LCA reports per region)	Output
Number of companies with "zero waste" program	Output
Material productivity	Outcome
Water productivity	Outcome
Energy productivity	Outcome
GHG emissions intensity	Outcome
Employment in eco-industries and circular economy	Input
Revenue in eco-industries and circular economy	Output

These indicators together give insight into the CE-eco innovation at the regional level. Table 3 shows that the framework consists of both effect indicators as well as transition indicators. These frameworks take a broad definition of CE by including GHG emission and energy productivity. One advantage using this framework is that the indicators are based on eco-innovation indicators for which databases are already available (Smol et al., 2017). Furthermore, the indicators are universal and can be used for assessing different regions and compare these. However, similar to the EC network, translating the effect indicators within the framework to the regional level can be difficult due to data availability limitations.

4.1.3 Mission-oriented innovation system monitoring framework

Section 2.2.2 described the theory related to transition assessment. It was noted that the transition to a CE is not only a technological transition. Instead, it can be seen as a societal transition consisting out of technological as well as social changes. To deal with this, the key processes as proposed for the TIS framework are adjusted by Elzinga et al. (2020) to fit this societal transition. The result is a mission-oriented innovation system (MIS) monitoring framework. In the framework, key functions are identified as boundary condition for making the transition to a circular economy. If these key functions are not sufficiently fulfilled it can slow down the transition process (Elzinga et al., 2020a).

To measure the key functions, indicators are proposed for each of the functions. However, for this framework, a range of possible indicators are proposed. To give insight in how each of the different key functions can be measured these will be summarized to preserve the overall picture. Table 4 gives an overview of the different functions.

Table 4: Functions and indicators MIS framework (based on Elzinga et al., 2020a)

Function	Indicators	Indicator type
Entrepreneurship	Amount of Circulair businesses experimenting with CE	Output
	Amount of started or stopped CE projects	Throughput
Knowledge development	Amount of new scientific research on CE	Output
	Amount of knowledge CE projects	Throughput
Knowledge diffusion	Amount of CE knowledge activities between businesses, consumers, knowledge institutes, and governments (seminars and conferences)	Throughput
Challenge directionality	Degree of priority for the CE challenge in media, stakeholders, and other relevant organisations	Throughput
Solution directionality	Stimulating laws and regulations for specific CE solution	Throughput
	Naming expectations around CE solution pathways	Throughput
Market formation	Subsidies to stimulate demand for CE solutions	Throughput
	Laws and regulation to force the use of CE solutions	Output
Resources mobilisation	Available financial resources for research, innovation, pilots and investments on CE.	Input
	Available human capital and education on CE	Input

Creation of legitimacy	Balance in lobby activities for and against CE solution pathways	Throughput
Change in regime practices	Laws and regulation to phase out regime activities	Output
	Phasing out subsidies for regime activities	Throughput
	Voluntary agreements in the industry to change practices	Output
Coordination	Developments of leading organisations that bring CE actors together	Output
	forming of coalitions between actors in the system	Throughput
	Development of coherent visions on the transition	Output

This framework is developed to measure the CE transition process. This results in indicators that measure the input, throughput, and output in an innovation system. They can be used to map the corresponding functions to see how well each of the parts of the innovation system is doing. Furthermore, the functions influence each other within the system. This framework assumes that the better the functions are fulfilled, the bigger the positive effect on the innovation process. This in turn will increase speed, reduce risk, and lower cost of the transition (Hanemaaijer et al., 2021).

Complexity can be a barrier for using this framework to measure the transition process. It requires excessive insight into the system that is assessed to get the required information on each of the functions. Furthermore, the mostly quantitative indicators that are proposed can be insufficient in measuring the functions. Another approach used by Wesseling & Meijerhof (2020) could be using diagnostic questions to map the different functions. This more qualitative approach can provide deeper insight into the innovation systems around CE. However, to give a representative overview of the system, all important actor groups have to be taken into account. This can be useful for assessing smaller innovation systems, for example at the regional level. Advantages of using this method on a smaller scale is the richness of information that is gathered while mapping the innovation system. Furthermore, this information can provide intervention points by proposing actions that aim to improve weak functions.

4.1.4 Discussion CE frameworks

In this section, different frameworks were discussed that are aimed at assessing the CE transition. There are significant differences between the frameworks with each having a different focus. The EC framework (section 4.2.1) is a very broad indicator framework mostly focused on measuring the material effects of the CE transition on national and European level. The CE-eco-innovation framework (section 4.2.2) takes a different perspective by focusing on the regional level and combining eco-innovation with the concepts of a circular economy. Effect indicators play a major role in this framework, but transition indicators are also included. The Mission-oriented innovation system framework (section 4.2.3) is a novel approach that takes an innovation system perspective. This makes it a promising tool to measure the transition process, but it doesn't consider the effects of the CE transition.

This research aims to assess the CE transition at the regional level. Looking back at the X-curve model in section 2.2.1 it is noted that the transition to CE is currently still in the formative phase. As a result, the effects of the transition are often not yet measurable. This would strengthen the argument for using transition indicators for assessing the CE transition process. Furthermore, as seen in the European Commission framework, data availability is often a problem and a limiting factor for the effect indicators (EESC, 2018). This problem of data availability at the regional level is also recognized by Avdiushchenko & Zajac (2019) as an important barrier for assessing the transition process at the regional level. This barrier is less limiting when looking at transition indicators because these indicators are often measured at a higher level and are proxies based on a cause-effect relationship between the indicator and progress in the CE transition.

In the formative phase of the transition it is difficult to use effect indicators to give insight of the progress of the CE transition, especially at the regional level. The use of a framework specifically focusing on assessing the transition progress can overcome these problems by giving insight into the transition process. This can open opportunities for steering the transition. It is important to note that both effect and transition indicators are necessary to assess the CE transition over time. However, in the current phase of the transition it can be fruitful to further explore the use of a transition indicator framework to assess CE at the regional level. To further explore the suitability of a transition indicator framework, the mission-oriented innovation framework that is discussed in this section will be applied to a regional case study. Specifically, the qualitative approach as suggested by Wesseling & Meijerhof (2021) will be applied as this approach fits the smaller regional level scale by providing a deep insight into the local innovation system. The next chapter will give a deeper insight into the functions within the framework.

4.2 Phase 2: Case study Food Valley region

This section presents the results of the case study in the Food Valley region. It starts with giving an overview of the different elements within the mission-oriented innovation framework that was chosen in the previous section. Next, an introduction of the Food Valley region and the role of circularity within the region will be given. Lastly, an overview of the fulfilment of each function within the region based on the results of the interviews.

4.2.1 Mission oriented innovation framework

Section 4.1.3 discussed the characteristics of the Mission-oriented innovation framework based on the indicators proposed by Elzinga et al. (2020a). To add to that description, Figure 4 gives an overview of the key functions as visualized by PBL. The functions are presented as gears that work together as a system. This means that if one gear changes, this will influence other gears. This shows the importance of not just measuring one gear but look at the connection between different processes (Elzinga et al., 2020a). The next section will give a short description of each of the functions.



Figure 4: Key processes CE transition (Hanemaaijer et al., 2021)

Entrepreneurship

Entrepreneurs are key actors in an innovation system and with that essential for a well-functioning innovation system. The main role of entrepreneurs is to identify the potential of new knowledge, networks and markets and turn this into actions to explore new business cases. This can be done by new entrepreneurs that enter the market, but also by incumbent companies that are changing their business strategy to adapt to these new developments (Hekkert et al., 2007). These new business cases are often experimental and risky from a business perspective. However, this experimentation is key to collect knowledge about the functioning of these new business cases under different circumstances. Furthermore, it gives insight into the reaction of other actors such as the consumers, governments, and competitors to these new innovations.

Knowledge development

Knowledge development is key in an innovation system and closely related to learning. Lundvall (1992) emphasizes that in the modern economy, knowledge is the most important resource and learning is the most important process. Knowledge development in an innovation system is related to new technologies, products, legislation, and market development. Examples of activities related to this knowledge development are R&D actions and market research.

Knowledge diffusion

Knowledge diffusion is related to the accessibility of knowledge by networks. To fulfil this function, knowledge should be shared by the different actors that are in the network. This can be private companies and governments, but also NGO's, knowledge institutes and civilians. This function can be measured by looking at the amount of knowledge activities such as conferences and workshops. Furthermore, mapping the size and intensity of the network of actors inside the innovation system can provide insight in this function (Hekkert et al., 2007).

Guidance of the search

At the start of a transition there often is uncertainty and insecurity about the direction of the transition. To deal with this, it is important to give direction to the search. According to Elzinga et al. (2020a), there are two types of sub-functions that are important for this function. The first is challenge-directionality, which focuses on the perception and priority of the challenge that must be solved in the transition. The more uniform this perception is, the better (Elzinga et al., 2020a).

The second sub-function is solution-directionality. For societal transition, there are often more solution paths that can be pursued. It is important that there is consensus on which solution path should be pursued. If this is not achieved, financial and human capital will flow to each of the different solution paths which can lead to insufficient development of both solution pathways (Elzinga et al., 2020a).

Market formation

New innovations often don't fit into the current socio-technical system. They are inefficient and often badly adapted to the existing system which makes it difficult to compete with the embedded technologies (Rosenberg, 1976). To deal with these difficulties, it is important to create a protected space for these innovations. This can be done by creating temporary niche markets where actors can learn and further develop. Another way to achieve this is create a competitive advantage through tax regimes that are favourable for the new innovations (Hekkert et al., 2007). To fulfil this function, it is important to create market demand for these new innovations.

Resources mobilization

Resources are a necessary input to all activities in the innovation system. This can be financial capital as well as human capital. This function is closely related to knowledge development function as financial resources serve as input for activities such as R&D programs and subsidies for innovations. Human capital is related to well educated workers and the integration of the transition challenge in education programs. This function can be difficult to measure as the impact of financial and human capital input can be difficult to assess. Another way to measure this could be to investigate if financial and human capital are a constraint to actors in the innovation system which would mean that the function is not fulfilled (Hekkert et al., 2007).

Counteract resistance to change

A transition often creates tension between the desired and existing system. This is because there will be a breakdown of the current structures of the system while the new system is implemented. This can lead to resistance from the existing system by opposition from parties with vested interests. Furthermore, the existing system is based on rules, norms, views, and habits that can limit the transition to a new system (Hekkert et al., 2007). To overcome these limitations, lobbying networks are key as they put the new system on the agenda and lobby for resources and favourable legislation (Elzinga, 2020a).

Coordination

The last function is coordination. As discussed in section 2.2.2, in a societal transition there are social as well as technological changes. This results in different social and technological paths that together lead to the transition. Coordination between these different paths is essential to achieve the transition. This coordination role can be fulfilled by the different actors that are active in the system. An example of coordination would be identifying the overlap or limitations between different transition paths. This mapping can help identifying what action from the governments or businesses can be used to stimulate certain transition paths (Elzinga et al., 2020a).

4.2.2 Case description

The Regio Foodvalley is a partnership of eight different municipalities in the Netherlands. It is located in the provinces of Utrecht and Gelderland. The region is home to a population of around 350 thousand people as well as more than 30.000 companies. The region is active in the agrifood sector and has a long history of working together on agrifood related topics. Governments, education institutes and entrepreneurs are actively working together to bring research and entrepreneurship into new innovations (Food Valley, 2020). In their strategic agenda for the period 2020-2025 they focus on tackling global challenges and applying solutions at the regional level. Their vision, translated from Dutch, as mentioned in their strategic agenda is:



Figure 5: Food valley region within the Netherlands (Foodvalley, n.d.)

‘Region Foodvalley is a top region in the field of agriculture and food embedded in an environment where it is good to live, work and do business. Based on experience and knowledge, innovative power, involvement, and mutual connection, we focus on the sustainable realization of broad welfare. We are proud of our region and we are an example in combining and connecting economic prosperity, pleasant living conditions, health, natural values and contributing to global food solutions.’ (Food Valley, 2020, p. 11)

One of the key challenges tackled within the strategic agenda is the transition to a circular economy. With its Living Lab: Foodvalley Circular, the region has joined the national circularity goals. This is a network organization founded by businesses that has around fifty businesses working together on projects related to circularity. They are committed to having a fully circular economy in 2050 and a 50% reduction of primary materials in 2030 compared to 2014 (Living Lab, 2019).

To accelerate the transition to a circular economy, three strategic goals are proposed: sustainable usage of raw materials, more competitive power, and an innovative knowledge region. Sustainable usage of raw materials is related to long and effective use of these materials by circular product design as well as closing cycles. The second goal, more competitive power, is related to the contribution of the Living Lab to help the Food Valley Region to compete as an economical top region. The last goal is about being an innovative knowledge region. This is a region where stakeholders innovate together in the agrifood as well as other sectors to create circular chains. The Living Lab aims at inspiring businesses, education and knowledge institutes, and governments to work on circularity within the region. The regional transition to a circular economy is connected to other transitions such as the energy transition and the protein transition. The living lab works in close collaboration with these programs to seize joint opportunities (Living Lab, 2019).

4.2.3 Results per function

As mentioned in the method section, structured interviews were conducted to get insight into the different functions within the mission-oriented innovation framework. Thirteen stakeholders from different stakeholder groups within the region were interviewed. An overview of these groups can be found in appendix A. This section explains the argumentation for the fulfilment of each function, discussing the strong and weak points as well as underlying root causes and possible solutions for better fulfilment as mentioned by the interviewees.

4.2.3.1 Entrepreneurship

This is an important function as the region describes itself as an innovative entrepreneurship region in their strategic agenda of the region (Food Valley, 2020). This is confirmed by the interviewees, which mention multiple strengths regarding this function. Seven interviewees argue that entrepreneurship is strong and organized within the region. One interviewee stated:

“People within this region are above average regarding entrepreneurship. That leads to some very big successful companies within the region. This means that you have to be innovative, otherwise you won’t make it. And those companies have also discovered circularity in the last years, I see it everywhere around me, that companies are working on circularity.” (Interview 4, personal communication, 2022).

There are several reasons given to support this statement. Starting with the presence of a physical space for startup companies as mentioned by four interviewees. Examples that are mentioned are a building for startups from Barneveld Tomorrow as well as the startup accelerator StartLife related to the Wageningen University. The importance of physical spaces is emphasized by one interviewee:

“An initiative such as Startlife is an example of an innovation hub where people can find each other and then you see that it speeds up the whole process of innovation.” (Interview 5, Personal communication, 2022)

Another strength mentioned by 4 interviewees is related to the Living Lab and its role within accelerating the circular economy. Another event that is mentioned is the circularity challenge by the Rabobank that was organized in 2018 and is seen as a starting point for the Living Lab. Within this initiative, regional entrepreneurs worked together to think about a business case for circularity. However, as mentioned by one interviewee, also outside the Living Lab there are businesses that have discovered circularity in the last years:

“There are around fifty businesses active within the living lab. However, also outside the living lab, companies are active within the circular economy. If you ask around, there are more and more businesses busy with circularity, this gives strength to circularity within the region.” (Interview 12, personal communication, 2022)

There were also several weaknesses mentioned by interviewees regarding entrepreneurship. The first, which is mentioned by six interviewees, is the big differences between frontrunner companies and others. It is said that that the bulk of companies within the region are not yet actively applying circularity in their businesses. This specifically applies to smaller companies within the region. Another weakness mentioned by two interviewees is that circularity within businesses is often only focused on educating about what circularity is instead of applying these concepts in their businesses. Related to these weaknesses, some root causes are mentioned that could limit the fulfillment of this function within the region. It is mentioned by five interviewees that it is difficult to reach a big group of businesses to work on circularity, one interviewee stated:

“The group that has inherent interest in circularity is easy to reach. But it is very difficult to reach the group for which circularity is too vague or the priority isn’t high enough. Although those companies could do a lot around circularity.” (Interview 11, personal communication, 2022)

Several reasons are mentioned by interviewees for limited engagement with circularity from businesses within the region:

- Lack of knowledge or examples (**knowledge development and diffusion**)

“Yeah, there is quite a big group of companies that would like to work on circularity, but they don’t know how to, so help them with knowledge and examples.” (Interview 10, personal communication, 2022)

- Lack of capacity (time) or resources, especially in smaller businesses (**Mobilisation of resources**)

“Companies within the region are mostly small businesses with few employees. Every entrepreneur has to ask: What is in it for me? For these smaller companies, working on circularity is difficult because time and capacity are very limited.” (Interview 13, personal communication, 2022)

- Lack of priority (**problem directionality**)

“The first companies are easy to reach, but how do you reach the big group of companies that are busy with their daily business. How do you create priority for these companies? I think that is a real issue.” (Interview 11, personal communication, 2022)

- Lack of viable business models (**Market formation**)

“I think that circular entrepreneurship could be stimulated. I currently see a lot of entrepreneurs, but not that many new circular business models. It is mostly an improvement of the current business model.” (Interview 11, personal communication, 2022)

These reasons are connected to other functions within the framework as mentioned above. Better fulfilment of these functions could increase the fulfilment of this function. This supports the argument that the entrepreneurship function has a central role within the framework because fulfilment of other functions serves as input for fulfilment of this function. This will be further elaborated on in the discussion.

4.2.3.2 Knowledge development

Starting with the strengths related to this function. Seven interviewees mentioned the important role of education institutes within and around the border of the region. Specifically, the Wageningen University was mentioned as playing a key role in developing theoretical knowledge around circularity. Furthermore, it is mentioned that other education institutes inside and around the region are developing practical knowledge around circularity, focusing on circular entrepreneurship and innovation, as stated by one interviewee:

“We have the Wageningen University within our border, that is a real knowledge factory. It is a place where a lot of knowledge is developed around all relevant themes for circularity. But also more practical universities in the region are working on circularity in relation with the Living Lab.” (Interview 11, personal communication, 2022)

Another strength mentioned by three interviewees is the role of the Living Lab in knowledge development in their “workshops”. In these workshops stakeholders work together on a specific topic within circularity. Other initiatives such as the circularity challenge that was discussed in the previous function is also pointed out by two interviewees. This has inspired businesses to think about how to make a business case for circularity and as a result created new knowledge on applying circularity within their companies. The importance of the circularity challenge is stated by one interviewee:

“Rabobank has organised that challenge around four years ago. I can mention several companies that would call circularity nonsense before that time. But if you look at them now, you see that each of them has found a way to incorporate circularity into their company, so I think that such challenges definitely help.” (Interview 1, personal communication, 2022)

Several weaknesses related to knowledge development are also mentioned by interviewees. The first one is related to theoretical knowledge development at university level. It is mentioned by four interviewees that this knowledge often stays at a higher level of abstractness and is centralized within the region at the Wageningen University. This can make it difficult to get access to this knowledge. Furthermore, this theoretical knowledge is mostly focused on fundamental knowledge about circularity and because of that difficult to translate to company level. One interviewee stated:

“There has been a lot of effort to develop knowledge about circularity, but it is mostly limited to abstract questions such as: What is circularity? and statements such as the importance of saving raw materials. It will be important to translate this knowledge to be able to apply it in businesses.” (Interview 1, personal communication, 2022)

Another weakness mentioned by three interviewees is that knowledge development at the practical level is still at its infancy. It is currently limited to lectures or presentations about circularity. Developing practical knowledge by doing circular projects by market participant and local governments hasn’t been explored as much. This learning by doing approach can speed up the development of practical knowledge significantly. To improve this function, four interviewees argued that governments can take a central role in knowledge development by doing an invitation to tender with specific circularity demands. This will

speed up the process of learning by doing for governments and other market participants. This proposed solution is related to the function *market formation*. Another action to improve knowledge development within the region is proposed by two interviewees. They suggest a systematic plan around knowledge development that aims to understand the role that each stakeholder has within the region regarding knowledge development as well as which knowledge should be developed by which actor. This should be combined with a focus on knowledge diffusion, which is the next function that will be discussed.

4.2.3.3 Knowledge diffusion

Multiple strengths related to this function are mentioned by the interviewees. Four interviewees mentioned the “workshops” within the living lab that were also discussed in the previous function. They function as networks for knowledge development and sharing experiences as stated by one interviewee. It supports developing a network between entrepreneur and researchers and creates a space for conversation as mentioned by one interviewee:

“There are already a lot of things going on related to knowledge diffusion. Especially within the workshops, those are the perfect places to facilitate this.” (Interview 6, personal communication, 2022)

Outside the Living lab there also is knowledge diffusion in networks of businesses as mentioned by two interviewees. This is organized by businesses themselves and involves local governments and other stakeholders such as housing association that are involved in the market. An example of this is a building company in the region that is organising their own knowledge sessions with their clients about circular procurement.

“We want to discuss topics around circularity that are of interest for our clients. Examples of this are discussing circular procurement with municipalities and reusing existing real estate with housing associations. In this way we want to contribute to knowledge diffusion for our clients on different topics related to circularity.” (Interview 2, personal communication, 2022)

One of the weaknesses mentioned by three interviewees is the limited knowledge diffusion between education and businesses. Knowledge diffusion on this level is often limited to student projects or internships at companies. However, students often don’t have the knowledge to embed this circular knowledge into an existing business. Another weakness mentioned by four interviewees is that knowledge diffusions is mostly based on voluntary agreements between program managers and other parties, lacking a structural approach for diffusion of knowledge as stated by one interviewee:

“The regional deal has been going on now for two years with two more years to go, so we are already halfway. Yes, you see that there are some projects started, however, a structured approach is missing to make the knowledge spread to a bigger group of people” (Interview 11, personal communication, 2022)

The living lab provides knowledge for businesses on circularity and point them to places with where they can find further information. However, this often doesn't lead to specific action by businesses. Furthermore, only companies that are familiar with the Living Lab, which are often already frontrunners, will see this information. It is therefore difficult to get the knowledge to all actors within the region. When discussing solutions, four interviewees mentioned that for increasing knowledge diffusion between companies, it is important to get more companies to work together on projects. The Living Lab can play a role in this by facilitating initiatives between companies and showcase examples. This also works for municipalities that could share knowledge and experiences regarding circular procurement or other circular practices. An example in which this knowledge sharing was missing was stated by one interviewee:

“There was one example within the region where a municipality was experimenting with circular procurement. But this circular procurement tender has never been shared with other municipalities within the region. In this example we should aim to distribute and exchange these experiences and knowledge between municipalities.” (Interview, 12, personal communication, 2022)

4.2.3.4 *Guidance of search*

As mentioned in section 2.2.2, this function is divided into two different sub-functions, each of these functions were separately discussed with the interviewees.

Challenge directionality

Most of the interviewees agree that priority for circularity has been increasing over the years. There are several reasons mentioned. First, five interviewees mention higher material costs and lower security of supply as external factors that have a positive influence on the priority for circularity. Secondly, the increasing priority for circularity within the region is characterized by the introduction of a strategic agenda around circularity, the Rabobank circularity challenge, and the start of the Living lab and its circular counsel. Lastly, a factor mentioned by three interviewees is the role of individual leadership in prioritizing circular action within organisations. Examples of leadership within government as well as companies were given, one interviewee stated:

“It is very important that there is someone that wants to work on circularity on an individual level, trying to bring it further. It shows the need for frontrunners that want to put effort into bringing the issues to the table.” (Interview 9, personal communication, 2022)

Multiple weaknesses are mentioned by the interviewees. Three interviewees mentioned that priority for circularity is undervalued compared to the energy transition. Higher priority for the energy transition can lead to lower capacity and resources for working on circularity. One interviewee stated:

“The cause for lower priority for circularity is that it is overshadowed by, in the public opinion, more important business, which is the energy story, this draws all the attention from businesses.” (Interview 1, personal communication, 2022)

Another weakness mentioned by three interviewees is that working on circularity is currently without obligation. This means that motivation is often based on non-financial incentives, such as intrinsic or PR-value. These motivations are often only related to frontrunners that want to work on circular issues and not to other companies. Looking at companies, there are several reasons mentioned for a lack of priority for circularity as mentioned by three interviewees:

- **There is no direct trigger to change**

“Everyone recognizes the problems around circularity, but there is no direct impact on businesses, yes, everything is getting more expensive, but the trigger to change is not there as it does not directly impact them.” (Interview 13, personal communication, 2022)

- **Negative market conditions**

“An even bigger challenge is that there maybe will be a new crisis. In that situation, there will be less financial space for businesses and other parties to work on issues such as circularity, because in the end, working in these issues will cost extra money, labour and energy, which are often the first ones to disappear in times of crisis.” (Interview 2, personal communication, 2022)

As stated in the interviews, it can be difficult to increase priority on circularity for businesses. If circularity would be more embedded into laws and regulation, which is currently happening in the energy transition, it could steer companies to have a higher priority for circularity in their businesses. However, it is difficult or impossible to influence laws and regulation directly on a regional level, influencing this comes back when discussing the function *Counteract resistance to change*.

Solution directionality

There are several strengths mentioned with this function. As in some of the other functions, the role of the Living Lab and their “workshops” are mentioned by three interviewees. These workshops are places where stakeholders come together to discuss challenge and solutions related to a specific topic. This structure helps achieving solution directionality as different solutions and experiences of these solutions are shared. This can help to find the most effective solutions.

“I think the structure of the living lab with its workshops is a very good initiative to provide structure to the different solutions. I think we are well on our way on that within the region, it is now important to keep putting energy and effort to get the next phase.” (Interview 2, personal communication, 2022)

Another strength mentioned by three interviewees is that on a higher level, solutions for achieving circularity in the region are visible, the proposed solutions are: creating market demand, creating material hubs and chain integration across the supply chain. Having this consensus at a higher level can provide direction for financial and human capital flows into these solution paths. However, specific solutions for circularity are not clear yet and there are significant differences between sectors. As mentioned by four interviewees, this lack of specific solutions is necessary in this phase of the transition. One interviewee stated:

“It is important to keep different solution pathways open. You have to put a spot on the horizon of what you want to achieve and let the ideas come and go. There can be solutions in five years that we don’t know about right now, but we shouldn’t exclude those ideas.” (Interview 13, personal communication, 2022)

They argue that there shouldn’t be a lock-in for specific solutions because there is no certainty that those solutions will be sufficient in the long term. This is in contradiction with the definition of good fulfilment of these functions, which is discussed in the Section 5.

A weakness mentioned by two interviewees is that there is a fragmented future view by stakeholders of a circular region. One interviewee stated:

“We did a session about the future view of the Food Valley region, and you notice that there are very different views of how the region will look in twenty years regarding circularity.” (Interview 11, personal communication, 2022)

These different views can have a negative impact on consensus on the solution paths that should be pursued. This is also related to the comments of one of the interviewees that argued that social solutions

are neglected within the circular transition. Current solution pathways are focused on technological fixes. However, for a fully circular society, social changes and changes in attitude are important aspects that should be considered.

Discussing ways to improve this function, three interviewees mentioned that more specific goals regarding circularity at the national level could help provide more solution directionality. From a regional perspective this will give a role to local government to translate this to specific goals that give direction at the regional level.

“I think the government can help to give direction to the circular transition by specifying their goals. We currently talk to much in umbrella terms that are vague. When the government will implement specific goals regarding CO2 emissions or material standards, stakeholders will better understand which direction they need to go.” (Interview 2, personal communication, 2022)

4.2.3.5 Market formation

There are some strengths mentioned by the interviewees regarding this function. Starting with three interviewees mentioning that circular procurement is gaining traction in local governments. One interviewee stated:

“When looking at the regional governments you see that circular procurement is becoming an increasingly important aspect. The municipalities are aware of their role in creating circular demand. However, I doubt of this is already happening fully within the region” (Interview 6, personal communication, 2022)

This is important as it created market demand for circular products and innovations. Another strength mentioned by two interviewees are that frontrunners, specifically in the building sector, are creating their own market demand by creating circular opportunities and working together on these with their partners in the supply chain. This makes circular practices be shared along the supply chain and increases awareness of circularity within the whole chain.

“If you look at the private market within the region you see that building companies are helping each other. You have a company that wins a circular tender, which in turn takes other companies within the sector with them to work on this. This makes companies work together to create market demand for themselves.” (Interview 12, personal communication, 2022)

Regarding weaknesses, seven interviewees mentioned that there is no structural approach regarding circular procurement within local governments. In contrast, there are several purchasing agreements between local governments within the Netherlands, but not in the Food Valley region (PIANO, 2022).

Instead, there are big differences in circular procurement between municipalities within the region. Most of them are in an experimental phase and some are not doing anything related to circular procurement. The importance of circular procurement is emphasized by companies that argue that governments and clients have a key role in steering market. One interviewee stated:

“It is key that circularity is included into tenders. If it is not included, it limits the integration of circularity within these tenders because of the strong market competition in which cost plays a major role. This means that the responsibility to ask these circular requirements is with the client.” (Interview 12, personal communication, 2022)

Suggestions by interviewees to improve this function are mostly related to increasing circular procurement within governments. Two interviewees suggested that local governments could work together on public procurement. This could have economies of scale benefits when purchasing products as well as increased *knowledge diffusion* between governments. Another suggestion that was discussed was the introduction of a certification norm related to circularity at the regional level as stated by one interviewee:

“You could introduce a circular certification scheme within the Food Valley region in which companies must have this certification to bid on a tender. This will introduce an incentive for companies to work on circularity. However, it would be the question if this should be introduced at the regional level, or if this is more suitable for the national level.” (Interview 6, personal communication, 2022)

4.2.3.6 Mobilisation of resources

Starting with strengths. Most interviewees agreed that financial capital isn't a constraint within the region. There are sufficient funds and subsidies available around circular innovations. An example of this is the Living lab that has financial resources to focus specifically on accelerating the circular transition within the region. These financial resources are based on contributions from governmental organisation, entrepreneurs, and educational institutes. When discussing human capital, it is mentioned by three interviewees that there are specific programs within and around the region focused on education people on circular topics and skills needed to tackle the circular transition.

In contrast to the availability of financial capital, there are several weaknesses mentioned regarding the accessibility of financial capital. First, it is mentioned by five interviewees that is difficult to get access to subsidies, especially for small businesses.

“If you talk about financial resources, there a quite a lot of financial resources available. However, I think that financing and subsidies aren’t always transparent and accessible. Businesses often don’t know where to start or what subsidies are available.” (Interview 5, personal communication, 2022)

“We had a meetup with a group of businesses, and they said: We realise too late that there are subsidies available and there is a lot of competition for the available funds. Yes, you can get a loan with a bank, but I am not sure if every company wants to do that.” (Interview 12, personal communication, 2022)

Second, three interviewees mentioned that financial institutions practices are often still based on a linear system. This means that new innovations with higher risk and lower returns are difficult to finance. This makes it difficult for circular innovations to get funding. Regarding human capital, a limitation that is mentioned by six interviewees is the current shortage of skilled labour. This external factor, which was already mentioned in the *problem directionality* function, has been mentioned as bottleneck because it limits companies to think about circular strategies and work on innovation projects.

“Human capital, that is difficult on two sides, on one side, the knowledge about circularity is logically not yet widespread available in the workforce, so this needs to be higher. On the other side, the lack of human capital on itself is a challenge that needs to be addressed.” (Interview 13, personal communication, 2022)

When discussing action to improve this function, three interviewees mentioned the importance of incorporating circularity into existing education programs such as entrepreneurship and introducing further education for the working force regarding circularity.

“Specific skills are required when dealing with circularity. I see a lot of younger people with a lot of understanding about circularity. However, companies often don’t know yet what circularity will mean for the future and often don’t incorporate further training for employees regarding circularity topics. This could be a place for improvement.” (Interview 11, personal communication, 2022)

4.2.3.7 Counteract resistance to change

Looking at resistance from vested interest, most of the interviewees agree that circularity is well accepted within the region. One interviewee stated:

“With circularity, I have the idea that there is nobody really against it. It is always accepted with a lot of goodwill and seen as a positive development.” (Interview 11, personal communication, 2022)

However, three interviewees argue that the reason for this is that resistance to change is not yet relevant. Circularity is a voluntary practice based on bilateral willingness to work on circularity. As a result of this,

we are currently not yet in a phase where there is a lot of resistance against new practices. This makes sense as the transition to a circular economy is currently still in its formative phase as presented by the X-curve figure in 2.2.1. In contrast, three interviewees do mention resistance from the existing system related to laws and regulation as a negative impact on circular innovation in the region. It is argued that current laws and regulation are based on a linear system. One example stated by an interviewee:

“One limitation regarding laws and regulation is the still traditional focused waste policies. As a result of this, new circular materials can’t get into the picture when this is exactly what should be stimulated to get to more circular products.” (Interview 3, personal communication, 2022)

However, two interviewees mentioned that it is difficult to influence the implementation of laws and regulation at the regional level. Actions are limited to lobbying and putting circularity on the agenda at the national level. One interviewee stated:

“You see that existing laws and regulation in some cases limit the implementation of a circular economy. We need to rethink the relationship between new products, markets, and solutions to make laws and regulations circular.” (Interview 10, personal communication, 2022)

When discussing the functions, five interviewees mentioned that focusing on removing resistance isn’t the best approach because resistance has a negative connotation and doesn’t focus on changing the resistance. It is argued that instead the focus should be on understanding the willingness to change. This means looking at the triggers for actors to work on circularity within the region. Together with this, interviewees mentioned the importance of taking a positive approach in dealing with this willingness to change to create more effective change.

“I think the word resistance has per definition a negative connotation when it is actually very important to learn from this resistance. The key is understanding where the pain and desires are and use these insights to understand the triggers to work or not work on circularity.” (Interview 7, personal communication, 2022)

“I personally don’t believe in resistance. I always look at a willingness to change, and that is what you should focus on. Everyone wants to change but has their own trigger to not do that in the end. I think there should be more attention on the people that are willing to change instead of people that are not willing to change. If you invest in the people that want to change, the rest will follow eventually.” (Interview 13, personal communication, 2022)

4.2.3.8 Coordination

Discussing the strengths of this function, three interviewees mentioned the strategic program for circular economy within the Regio Foodvalley. They argue that together with the Living lab there is clear coordination on how to tackle the transition to a circular economy from a regional level perspective. Another strength related to the role of the Living lab and mentioned by six interviewees are the role of their “workshops” that have been discussed in other functions. They have a key role in coordination between different circularity topics. There is an overarching structure in place that focuses on collaboration between different topics of circularity and their problems and solutions.

“I think it is good that there is a joint initiative with the Living Lab involving governments, businesses, and education institutes so it will be important to keep that structure. In there, collaboration between different sectors and topics of circularity can form. So, I think it is important that an initiative such as the Living Lab is embraced by the whole region.” (Interview 2, personal communication, 2022)

However, there are several weaknesses mentioned with this function. First, it is mentioned by five interviewees that stakeholders in the region are still searching for their role within the transition to a circular economy. As a result, it is unclear who should take responsibility for solutions, leading to fragmented actions of coordination as stated by one interviewee:

“One of the problems is that nobody wants to take responsibility for the solutions, nobody wants to take that task. When nobody takes responsibility, people look at the government. However, the government has no budget and don’t have a task to work on circularity outside of circular procurement.” (Interview 12, personal communication, 2022)

Second, it is stated that there is insufficient attention for discussing expectations about the direction and goals within the region. There is a lot of enthusiasm and energy coming from stakeholders within the region to start new initiatives. However, the questions regarding the specific goals of these initiatives and how this fit in the broader circularity goals in the region are often not asked.

“What in my opinion is still missing within the region is the conversation about the role of each stakeholder and the reasons for pursuing circular goals. The why, what for, and what to, is currently very vaguely defined. Speaking out expectations and thinking about the long-term result could be improved.” (Interview 7, personal communication, 2022)

When discussing actions to improve this function, three interviewees proposed to take a more systematic approach around circularity within the region. One example of this could be introducing an area director

for circularity that is appointed by a regional government or network organisation as mentioned by one interviewee:

“It is very difficult for entrepreneurs to have a systematic view of the circular possibilities within a region. Yes, they can work together with their neighbour companies to for example exchange waste streams, but you can’t expect more from a business. If you want to systematically tackle circularity at the regional level, you need an area director that is focused on identifying circular opportunities and bringing stakeholders together.” (Interview 4, personal communication, 2022)

5 Discussion

This section discusses the results of case study of the Regio Food Valley using the mission-oriented innovation framework. It starts with an overview of the key results and its relation to the literature. Next, the theoretical implications of the framework and suggestions for improvement are discussed. It ends with a discussion of limitations and suggestion for future research.

5.1 Key results relation to literature

Table 5 gives an overview of each function as explained in the mission-oriented innovation frameworks. It discusses the key points as well as proposed solutions to improve for each function. This is a summary of the results discussed in the previous chapter.

Table 5: Key points and proposed solutions

Function	Key points	Proposed solutions
Entrepreneurship	<ul style="list-style-type: none"> • Entrepreneurship is strong and organized within the region • Physical space available for start-ups within the region • Living Lab as accelerator for circularity within the region • Big differences between frontrunner companies and big bulk of companies regarding CE involvement • Difficult to reach this big bulk of companies 	<ul style="list-style-type: none"> • Limited engagement of companies to work on circularity for several reasons: <ul style="list-style-type: none"> ○ Lack of knowledge ○ Lack of capacity ○ Lack of priority ○ Lack of viable business models • Improving these functions can help improving fulfilment of this function
Knowledge development	<ul style="list-style-type: none"> • Wageningen University has a key role in theoretical knowledge development • Other educational institutes are developing practical knowledge around CE • The “workshops” within the Living Lab contribute to developing practical knowledge for companies • Practical knowledge development is still in its infancy • Valorisation of theoretical knowledge to company level is difficult 	<ul style="list-style-type: none"> • Central role for governments to stimulate learning by doing through using circularity demands in their tenders • Creating a systematic plan around knowledge development within the region, discussing the role of each stakeholder in developing knowledge
Knowledge diffusion	<ul style="list-style-type: none"> • The “workshops” within the Living Lab function as networks for knowledge diffusion • Businesses are organizing their own networks around CE, diffusing knowledge between stakeholders 	<ul style="list-style-type: none"> • Get companies to work more on projects together, can be facilitated and showcased by the Living Lab. • Sharing knowledge and experiences regarding circular procurement

	<ul style="list-style-type: none"> Limited knowledge diffusion between education and businesses 	between municipalities within the region
Guidance of search	<p><i>Challenge directionality</i></p> <ul style="list-style-type: none"> Priority for circularity has increased over the years External factor of higher material costs and security of supply have a positive effect on priority for CE Priority for CE is undervalued compared to the energy transition Circularity is without obligation, leading to lower priority. 	<p><i>Challenge directionality</i></p> <ul style="list-style-type: none"> Difficult to increase priority of circularity for businesses If circularity would be more embedded into laws and regulation, it could steer companies to higher priority for circularity
	<p><i>Solution directionality</i></p> <ul style="list-style-type: none"> Role of “workshops” within the Living Lab to discuss challenges and solutions Solutions are clear at a higher level Lack of specific solutions necessary in current transition phase Social solutions neglected in CE discussion 	<p><i>Solution directionality</i></p> <ul style="list-style-type: none"> More specific goals regarding circularity could provide more directionality Difficult to influence specification of goals because this starts on the national level
Market formation	<ul style="list-style-type: none"> Circular procurement is gaining traction in local governments Frontrunners are creating their own market demand No structural approach for circular procurement Importance of circular procurement for market formation is emphasized by companies 	<ul style="list-style-type: none"> Cooperation between local governments regarding circular procurement could have economies of scale benefits and increase <i>knowledge diffusion</i> between governments
Mobilisation of resources	<ul style="list-style-type: none"> Financial capital is no limitation within the region Specific programs available focused on educating people on circular topics Accessibility of financial capital is difficult for companies Shortage of labour is bottleneck limiting companies to work on CE 	<ul style="list-style-type: none"> Increase attention for circularity in practical education programs Provide education programs for workers that are working on topics related to circularity

Counteract resistance to change	<ul style="list-style-type: none"> • Circularity well accepted within the region • Resistance is not yet relevant due to the voluntary practices around circularity • Existing laws and regulation limit circular innovation within the region 	<ul style="list-style-type: none"> • Focus should be on understanding willingness to change • Understanding triggers of stakeholder to work on circularity • Share success stories and benefits of working on CE
Coordination	<ul style="list-style-type: none"> • Strategic plan around circularity within the region • Coordination between different CE topics within the “workshops” in the Living lab • Stakeholders are searching for their role within the CE transition • Insufficient attention for discussing expectations and directionality 	<ul style="list-style-type: none"> • Taking a systematic approach around circularity within the region • Introducing an area director around circularity • Increased coordination between governments

These functions are part of a system in which they influence each other. Better fulfilment of one function can lead to better fulfilment of other functions and vice versa. There were several examples of these interactions observed related to the *entrepreneurship* function. The first observed interaction was between *knowledge development* and *knowledge diffusion* and *entrepreneurship* in which a lack of knowledge or examples regarding circularity can lead to less circular entrepreneurship. A Second example is the interaction between *market formation* and *entrepreneurship* in which increasing market formation by circular procurement can lead to more circular entrepreneurship. Lastly, several other functions that are related to the entrepreneurship function are *mobilisation of resources* and *problem directionality* as discussed in section 4.2.3. For each of these interactions, these functions are a prerequisite for the fulfilment of the *entrepreneurship* function in which better fulfilment of these functions could lead to an improvement in circular entrepreneurship within the region. These positive feedbacks show the importance of taking these interactions into account when developing CE policies.

One other interaction observed was the relation between *knowledge development* and *market formation*. It is argued that increasing circular procurement by municipalities will accelerate knowledge development through learning by doing. However, the other way around, increased knowledge development around circular procurement can steer governments to increase circular procurement, and with that improve market formation. Another interaction observed in the results is between *knowledge development* and *mobilisation of resources*. It is argued that improving knowledge development, especially on the practical level, helps improving the human capital side by improving the skill of workers within the region. The

function *counteract resistance to change* relates to several other functions such a *problem directionality*. This relates to functions in which fulfilment is dependent on factors that are difficult or impossible to improve from inside the region. Examples of these are the overarching circular goals at national level or the embeddedness of circularity in laws and regulation. In both cases it is argued that lobbying and putting circularity on the national agenda is the only possible action from a regional perspective.

Using the mission-oriented framework at the regional level gives insight in the building blocks of the transition. The success of this approach is related to the fact that the transition is in a formative phase in which effect indicators can't be measured yet. Section 2.2.2 assumed that we are currently in the formative phase. To evaluate this claim based on the result of the case study, Berget et al. (2008) provides several indicators that can be used to assess if a transition is in a formative stage. The first is the duration of the transition, in which it argued that transitions at least stay in the formative phase for around a decade. This is in line with the results in which working on the circular transition has only been done for several years. The next indicator are large uncertainties regarding technologies and markets. This corresponds with the results that show a lack of market formation and experimentation with circularity by companies and other stakeholders. The last indicator is that the number of economic activities is only a small part of the estimated potential (Berget et al. 2008). This is characterized in the results by the voluntary actions on circularity as well as the small number of stakeholders and circular activities in relation to the whole region.

There is no specific literature available on interactions between functions when applying a mission-oriented innovation framework. However, there are several studies looking at the same functions that are applied to a technical innovation system (TIS). Hekkert & Negro (2009) bring several of these case studies together to evaluate the role of each function and how they influence each other. In these studies, a "historical event analysis" method was used. This approach focuses on developing a narrative of the development of a technical innovation system over time by mapping and rating the different events that have occurred within the innovation system. The authors found that high fulfilment of the functions *market formation* and *guidance of search* occurs with a rise in entrepreneurial activities. This corresponds to the results in which these functions are mentioned as limitations for entrepreneurs to work on circularity. Another finding from the literature is the key role of *market formation* in transitioning to the next phase in the transition. Forming a market gives companies and investors a long-term perspective of growth (Hekkert & Negro, 2009). This is also shown in the result in which the need for market formation

by governments or clients through incorporating circular demands is mentioned as important step to increase circular innovation within the region.

The results show that the Living Lab is mentioned in almost all the functions. Actions related to the Living Lab contribute to a significant part of the strengths of different functions. This makes sense as the specific role of the living lab is to stimulate and empower the regional transition to a circular economy. This positive role of a well-organized organisation is also recognized by Hekkert & Negro (2009) as crucial for building expectations and influencing the governments to align with their own interests. Furthermore, Cramer (2020) argues that these so called 'transition brokers' play a key role in orchestrating the different functions within an innovation system. The role of these transition brokers is described by Cramer (2020) as:

"They can enhance processes of change, build alliances, help create the necessary preconditions, and develop impactful circular initiatives from a neutral standpoint. In a multi-stakeholder setting, transition brokers fulfil a variety of roles, depending on time period, content, and context." (p. 1)

This role is reflected in the goals and activities performed by the Living Lab as organisation within the Regio Foodvalley. Furthermore, it shows the importance of this network organisation in the regional transition to a circular economy.

5.2 Theoretical implications

Looking at the theoretical implications of using the mission-oriented innovation framework approach for a regional case study, there are several insights related to the framework and its applicability at the regional level.

This study took a qualitative approach to the mission-oriented innovation. This approach was expected to be suitable at this level because it would give in depth insight into the local circular innovation system. The results show that the use of the frameworks gives an in-depth structured overview of the circular ecosystem within the region. However, it should be noted that this overview is solely based on the views of the stakeholders within the region. On the one side, this can help as understanding the views of different stakeholders can help in developing tailored actions for enhancing circularity in the region. This corresponds with the argument from Bačová et al. (2016) that argues that the specific context for opportunities and needs for each region should be considered when implementing a CE approach. On the other hand, this isolated view is susceptible to misinterpretations and biases which will be further elaborated on in the limitations of this study.

For the function *solution directionally*, interviewees had different interpretations of what good fulfilment meant for this function. Some interviewees labelled having all the solutions in place to tackle the problem as positive while others argued that picking solutions should be avoided in the early phase of the transition to avoid a lock-in. Causes for this difference in interpretation could be the broad term of *solutions* in the framework. Depending on the context, having clear solutions for broad circular problems are important as they provide direction and clarity. However, it can be argued that specifying solutions for specific problems should be avoided to keep room for the market to develop new solutions. This dynamic in relation to the transition should be further explored in future research.

Another insight is related to the function *counteract to resistance*. Several interviewees argued that this function has a negative view on how change happens within an innovation system. They argued that instead of dealing with resistance, the focus should be on understanding the willingness to change of a certain party. This implies taking the perspective of the other party and try to understand the triggers that causes the action of this party. Furthermore, framing this function as willingness to change could open effective intervention action by identifying and responding to specific triggers of stakeholders. Another advantage of taking this perspective is that it can also be applied if there is no specific resistance yet as was mentioned in the results. In that case, looking at willingness to change from different stakeholders within the region can help reduce resistance before it starts to develop.

Lastly, one suggestion for improving the framework is related to the *knowledge development* and *knowledge diffusion* functions. It was often argued that the functions are directly connected to each other. Taking these functions together at the regional level could help simplifying the measurement of the framework. This could be done similarly to the *guidance of search* function by including the *knowledge development* and *knowledge diffusions* as sub-functions of a broader knowledge function. This gives it a better structure to measure and analyse these functions.

5.3 Limitations and recommendations

This section explores some limitations regarding this study and provides recommendations for further research, starting with limitations of the research.

First, In the first phase of the research, the CE indicator assessment, three CE frameworks with different characteristics were analysed in depth to help building the argument for using the mission-oriented framework in the next phase of the research. However, more frameworks with similar characteristics

could have been selected to increase the validity of the results by preventing the risk of cherry picking specific frameworks.

Second, there are some limitations related to the sample of the interviews. To bring together the different perspectives on the circular ecosystem within the region, there were different stakeholder groups identified. Because there were five different groups, the sample size of each group was only two or three. This is especially limiting for the company group as this group can be very diverse in different activities. In the sample used for this study, two out of three companies were involved in the building sector. This could make the results related to their statements biased to the building sector. To address this problem, the interviewees were specifically asked to give their perspective on the whole region and not specifically the building sector. However, some bias could remain which could pose a limitation for the validity of the research. Another limitation related to the interview sample is that all stakeholders that were interviewed are involved within the Living Lab in the region. As a result, mostly frontrunner parties are interviewed, which could lead to a more positive picture than reality because they could generalize their experience with circularity to other parties within the region. This is especially relevant for specific functions such as *counteract resistance to change* in which it would have been better to have an outside perspective on the function. Lastly, this research was conducted during the COVID-19 pandemic, which resulted in all interviews except one to be conducted online. This way of interviewing is less preferable in contrast to face-to-face interviews.

Third, this study used a qualitative combined with a quantitative approach for the fulfilment of functions as was used by Scheulderman (2021). However, as mentioned in the method section, it was decided to not take the quantitative values for each function into account when discussing the results due to several limitations. A recommendation to improve the use of this method could be to introduce different labels from bad to good fulfilment for each of the functions by describing what good or bad fulfilment would look like. This could help the interviewees in making unbiased choices and make the values more comparable instead of the approach used in this research in which the interviewees form their own perspective around good or bad fulfilment of a function. However, the difficulty with this method would be deciding on the different labels, which would require extra research on each function. Another way to deal with this limitation could be taking a quantitative approach to measure the fulfilment of different functions. This way of measuring each function has been proposed by Elzinga et al. (2020a). The study proposed quantitative indicators for each function. Combining this approach with the qualitative approach that was used in this study could help improve the validity of the research.

Fourth, this study is based on a single case study exploring a socio-technical system. These two factors make it difficult to generalize the result to other cases, therefore limiting the external validity of the research. However, results related to the theoretical implications of the framework, for example the interactions between different functions, can be generalized and should be considered when doing future research to further strengthen the foundations of the mission-oriented framework.

Fifth, the use of the mission-oriented framework provides multiple benefits for assessing the CE transition at the regional level as mentioned in section 5.2. However, because of the nature of the framework, there is no information gathered on the outcome of the transition or the desirability of this outcome. Using this approach does make sense at the early stages of the transition but is not a silver bullet to tackle the whole transition. Besides having the building blocks for the transition in place, it is thus important to have clear goals, directions, and definitions of what a fully circular economy is. Furthermore, in the growth phase of the transition, effect indicators will play a more significant role as they provide information on the outcomes of the transition and with that possibilities to steer it in the desired direction. It is thus important to consider which framework or indicator is most suitable to use taking into account the phase of the transition as well as other factors such as data availability and geographical scale.

This study explored the use of a transition framework to assess the CE transition process on a regional level. Based on this study, there are some recommendations on future research areas that could be explored. First, the mission-oriented innovation framework could be applied to a specific sector within the region such as the building sector. This could give a more detailed insight into the circular ecosystem around this topic. Furthermore, it gives the opportunity to compare different sectors in ways of transition process.

Another research avenue that is interesting to explore is the role of network organisations in these circular ecosystems. Cramer (2020) made a start with the role of 'transition brokers' in coordinating a transition. New research could link this with the fulfilment of different functions and different stages of the transition. One last recommendation for future research would be taking a temporal perspective to see how the fulfilment of different functions change over time and which functions are most important in which stage of the transition.

6 Conclusion

Challenges such as material scarcity, unequal access to natural resources and environmental concerns pose challenges for societies and have led to the proposition of transitioning to a fully circular economy in which material use and value is maximized. The Dutch government has the ambition of having a fully circular economy in 2050. To reach this goal, CE strategies will need to be developed and translated to the regional level. To better understand how this transition plays out at the regional level requires ways of assessing this transition. This research contributes to this goal by giving insight in how the CE transition process can be assessed at the regional level.

The first sub question answered in this study was: *What CE indicator frameworks are suitable for assessing the CE transition process at the regional level?* This was achieved by discussing the suitability of different CE frameworks. The empirical findings indicate that transition indicator frameworks are most suitable for assessing the CE transition process at the regional level. It is found that the current formative phase of the transition, in which direct effects are not yet visible, provides support for using a transition indicator framework. Another argument that supports the notion of using a transition indicator framework are the difficulties that arise from measuring effect indicators at the regional level. However, both effect and transition indicators have an important role to play in assessing the CE transition over time, but in the current phase, the use of a transition framework can provide information that can be used to steer the transition in the right direction.

The second phase of part of the study was a case study in which the mission-oriented framework was applied to the Food Valley region in the Netherlands. The sub question answered was: *How does a transition framework perform in measuring the CE transition at the regional level?* The results demonstrated that the performance of the framework is good to assess the transition at the regional level. This is shown by the empirical results that map the strengths, weaknesses, and limitations of the circular ecosystem within the region. These findings can provide guidance for interventions with the proposed solutions by stakeholders within the region to accelerate the regional transition to a circular economy. Furthermore, the findings indicate several interactions between functions within the framework. These interactions are consistent with previous research on these positive and negative feedback loops within innovation systems. Lastly, the results provide support for the assumption that the transition is currently in a formative phase. Overall, the use of the framework provided a systematic overview of the state of the circular ecosystem and the role of different stakeholders within the Food Valley Region. This

information can be valuable for network organisation such as the Living Lab to further accelerate the transition to a circular economy.

The main research question answered in this research was: *How can the transition process to a circular economy be assessed at the regional level?* This study argues that a transition framework such as the mission-oriented framework can contribute to the assessment of the CE transition at the regional level by providing insight into the CE innovation system as well as identify opportunities to steer the transition at the regional level. Especially at the early stages of the transition, this transition perspective can give guidance to the CE transition. However, using a transition framework is no silver bullet in tackling the transition because it doesn't provide information on the final outcomes of the transition. The use of the frameworks should thus be considered in the light of the phase of the transition.

This study gives a first insight in the application of the mission-oriented innovation framework to a regional case study in the Netherlands. This application of the mission-oriented framework to a regional case study should be seen as be a starting point for further research. Future studies will be necessary to further develop and test transition frameworks as well as the transition dynamics related to different sustainability transitions. Ultimately, understanding the complex transition to a circular economy is the first step in steering this transition. It can help identifying intervention points to speed up, reduce risk, and lower costs of the transition to a circular economy. This will be key in working towards the ambitious goal of having a fully circular Dutch economy by 2050.

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Appendix A: Overview stakeholder groups interviews

This table gives an overview of the interview sample used in this research. Furthermore, it shows the different stakeholder groups that were identified within the region. The numbers are used when referring to an interview within the research.

Table 5: Interview sample & stakeholders groups

Number	Stakeholder group	Stakeholder
1	Companies	BOOT organiserend ingenieursbureau BV
2		Bouwbedrijf Kreeft BV
3		PaperFoam BV
4	Financial institutions	Rabobank Gelderse Vallei
5		Rabobank Vallei en Rijn
6	Education institutes	AERES
7		Wageningen University & Research
8	Governments	Waterschap Vallei en Veluwe
9		Gemeente Barneveld
10		Gemeente Veenendaal
11	Network organizations	Living Lab Food valley Circulair
12		Regio Foodvalley
13		Federatie Ondernemerskringen Valleiregio (FOV)

Appendix B: Quantitative values for each function

Figure 5 gives an overview of the quantitative values that were gathered during the interviews. They represent the average value of all interviews in which a specific function was scored. The number of interviewees that scored a function is mentioned between the brackets

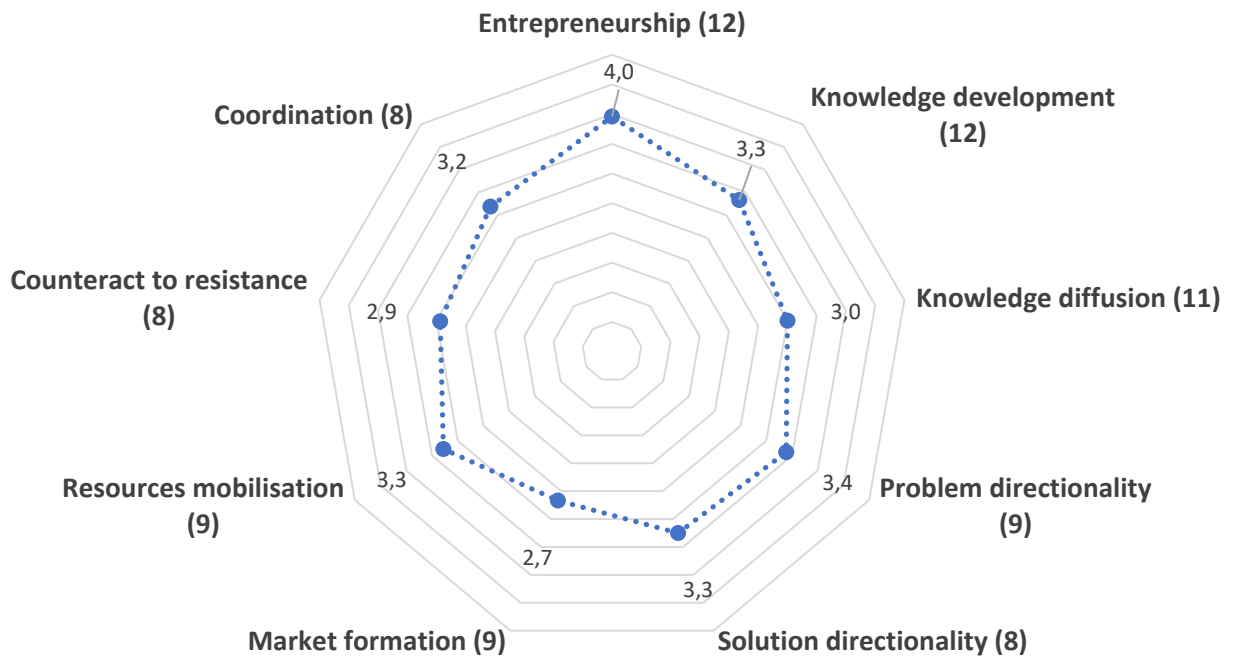


Figure 5: Average scores of fulfilment of each function based on interviews

Appendix C: Interview Guide

Introduction

Can you give a short description of your function?

How does your organisation contribute to the circular ecosystem in the Foodvalley region?

Questions per function

Function - Entrepreneurship

On a scale from 1 to 5, is there sufficient entrepreneurship in the form of start-ups, new business models, and experiments for circular innovation in the region?	1	2	3	4	5
--	---	---	---	---	---

What is the reasoning behind your choice?

(Score of 3 or lower) What causes lead to problems in this area?

How could these problems be solved?

(Score of 4) Why is it no 5?

Is there anything else you want to say on this topic?

Function – Knowledge development

On a scale from 1 to 5, is there sufficient knowledge development in the region around circularity?	1	2	3	4	5
---	---	---	---	---	---

What is the reasoning behind your choice?

(Score of 3 or lower) What causes lead to problems in this area?

How could these problems be solved?

(Score of 4) Why is it no 5?

Is there anything else you want to say on this topic?

Function – Knowledge diffusion

On a scale from 1 to 5, is there sufficient knowledge diffusion around circularity and circular innovation in the region?	1	2	3	4	5
---	---	---	---	---	---

What is the reasoning behind your choice?

(Score of 3 or lower) What causes lead to problems in this area?

How could these problems be solved?

(Score of 4) Why is it no 5?

Is there anything else you want to say on this topic?

Function – Guidance of search (A & B)

A – Problem directionality

On a scale from 1 to 5, to what extent does the region give priority to circularity?	1	2	3	4	5
--	---	---	---	---	---

What is the reasoning behind your choice?

Is there a difference in priority between different stakeholders in the region?

(Score of 3 or lower) What causes lead to problems in this area?

How could these problems be solved?

(Score of 4) Why is it no 5?

Is there anything else you want to say on this topic?

B – Solution directionality

On a scale from 1 to 5, to what extent does the region give sufficient direction to the development of social or technical solutions for achieving circularity?	1	2	3	4	5
---	---	---	---	---	---

What is the reasoning behind your choice?

Are there dominant solution paths?

Is there consensus about the solution pathways between the different stakeholders?

(Score of 3 or lower) What causes lead to problems in this area?

How could these problems be solved?

(Score of 4) Why is it no 5?

Is there anything else you want to say on this topic?

Function – market formation

On a scale from 1 to 5, to what extent is there sufficient action being taken to create market demand for circular innovations within the region?	1	2	3	4	5
---	---	---	---	---	---

What is the reasoning behind your choice?

(Score of 3 or lower) What causes lead to problems in this area?

How could these problems be solved?

(Score of 4) Why is it no 5?

Is there enough attention for phasing out activities that are harmful for achieving circularity?

Is there anything else you want to say on this topic?

Function – Resources mobilisation

On a scale from 1 to 5, are there sufficient resources, human capital as well as financial resources available within the region?	1	2	3	4	5
---	---	---	---	---	---

What is the reasoning behind your choice?

(Score of 3 or lower) What causes lead to problems in this area?

How could these problems be solved?

(Score of 4) Why is it no 5?

Is there anything else you want to say on this topic?

Function – Counteract resistance to change

On a scale from 1 to 5, to what extent is there sufficient attention for creating legitimacy for circularity as well as counteract resistance to change?	1	2	3	4	5
--	---	---	---	---	---

What is the reasoning behind your choice?
 (Score of 3 or lower) What causes lead to problems in this area?
 How could these problems be solved?
 (Score of 4) Why is it no 5?
 Is there anything else you want to say on this topic?

Function - Coordination

On a scale from 1 to 5, is there sufficient coordination between different solution pathways within the region?	1	2	3	4	5
---	---	---	---	---	---

What is the reasoning behind your choice?
 (Score of 3 or lower) What causes lead to problems in this area?
 How could these problems be solved?
 (Score of 4) Why is it no 5?
 Is there anything else you want to say on this topic?

Interview Guide (Dutch)

Introductie vragen

Kunt U kort een beschrijving geven van uw functie?
 Hoe draagt uw organisatie bij aan het circulaire ecosysteem binnen de regio Foodvalley
 Wat zijn uw belangrijkste partners binnen de regio Foodvalley in het bereiken van deze doelstelling?

Vragen per functie

Functie - Ondernemerschap

Op een schaal van 1 tot 5, is er voldoende ondernemerschap (startups, nieuwe verdienmodellen, experimenten met nieuwe technologieën) op het gebied van circulaire innovatie in de regio?	1	2	3	4	5
--	---	---	---	---	---

Wat is de reden van uw keuze?
 (Score van 3 of lager) Welke oorzaken leiden tot problemen op dit gebied?
 Hoe zouden deze problemen opgelost kunnen worden?
 (Score van 4) Waarom is het geen 5?
 Wilt u over dit onderwerp nog iets zeggen?

Functie - Kennisontwikkeling

Op een schaal van 1 tot 5, wordt er voldoende kennis ontwikkeld in de regio rondom circulariteit?	1	2	3	4	5
---	---	---	---	---	---

Wat is de reden van uw keuze?
 (Score van 3 of lager) Welke oorzaken leiden tot problemen op dit gebied?
 Hoe zouden deze problemen opgelost kunnen worden?

(Score van 4) Waarom is het geen 5?
Wilt u over dit onderwerp nog iets zeggen?

Functie - Kennisverspreiding

Op een schaal van 1 tot 5, is er voldoende kennis verspreiding rondom circulariteit en circulaire innovatie in de regio?	1	2	3	4	5
--	---	---	---	---	---

Wat is de reden van uw keuze?
(Score van 3 of lager) Welke oorzaken leiden tot problemen op dit gebied?
Hoe zouden deze problemen opgelost kunnen worden?
(Score van 4) Waarom is het geen 5?
Wilt u over dit onderwerp nog iets zeggen?

Functie - Richting geven aan het zoekproces (A & B)

A - Probleem directionaliteit

Op een schaal van 1 tot 5, is er voldoende prioriteit voor circulariteit binnen de regio?	1	2	3	4	5
---	---	---	---	---	---

Wat is de reden van uw keuze?
Zitten er verschillen tussen prioriteit tussen verschillende stakeholders?
(Score van 3 of lager) Welke oorzaken leiden tot problemen op dit gebied?
Zijn er oplossingen voor deze problemen?
(Score van 4) Waarom is het geen 5?
Wilt u over dit onderwerp nog iets zeggen?

B - Oplossing 's directionaliteit

Op een schaal van 1 tot 5, wordt er voldoende richting gegeven aan het ontwikkelen van (sociale of technische) oplossingen in de regio op het gebied van circulariteit?	1	2	3	4	5
---	---	---	---	---	---

Wat is de reden van uw keuze?
Zijn er dominante oplossingsrichtingen?
Is er overeenstemming tussen verschillende partijen over de oplossingsrichtingen?
(Score van 3 of lager) Welke oorzaken leiden tot problemen op dit gebied?
Hoe zouden deze problemen opgelost kunnen worden?
(Score van 4) Waarom is het geen 5?
Wilt u over dit onderwerp nog iets zeggen?

Functie - markt creatie

Op een schaal van 1 tot 5, wordt er voldoende gewerkt aan het creëren van marktvraag voor circulaire innovaties binnen de regio?	1	2	3	4	5
--	---	---	---	---	---

Wat is de reden van uw keuze?
(Score van 3 of lager) Welke oorzaken leiden tot problemen op dit gebied?
Hoe zouden deze problemen opgelost kunnen worden?

Score van 4) Waarom is het geen 5?

Is er voldoende aandacht voor het uitfaseren van activiteiten die schadelijk zijn voor het behalen van de circulaire ambities?

Wilt u over dit onderwerp nog iets zeggen?

Functie - Mobiliseren van middelen

Op een schaal van 1 tot 5, Zijn er voldoende middelen (menselijk kapitaal en financieel) aanwezig in de regio?	1	2	3	4	5
--	---	---	---	---	---

Wat is de reden van uw keuze?

(Score van 3 of lager) Welke oorzaken leiden tot problemen op dit gebied?

Hoe zouden deze problemen opgelost kunnen worden?

Score van 4) Waarom is het geen 5?

Wilt u over dit onderwerp nog iets zeggen?

Functie - Tegengaan van weerstand

Op een schaal van 1 tot 5, is er voldoende aandacht voor het creëren van legitimiteit voor circulariteit en het tegengaan van weerstand?	1	2	3	4	5
--	---	---	---	---	---

Wat is de reden van uw keuze?

(Score van 3 of lager) Welke oorzaken leiden tot problemen op dit gebied?

Hoe zouden deze problemen opgelost kunnen worden?

Score van 4) Waarom is het geen 5?

Wilt u over dit onderwerp nog iets zeggen?

Functie – Coördinatie

Op een schaal van 1 tot 5, In hoeverre is er voldoende coördinatie tussen de verschillende oplossingsrichtingen in de regio?	1	2	3	4	5
--	---	---	---	---	---

Wat is de reden van uw keuze?

(Score van 3 of lager) Welke oorzaken leiden tot problemen op dit gebied?

Hoe zouden deze problemen opgelost kunnen worden?

Score van 4) Waarom is het geen 5?

Wilt u over dit onderwerp nog iets zeggen?

Appendix D: Informed consent form (Dutch)

Informed Consentformulier



Universiteit Utrecht

Onderzoek:

STUDIE: Master Scriptie Sustainable Development, track Energy & Materials

TITEL: The regional transition to a circular economy: Insight into assessing the transition process to a circular economy on regional level in the Netherlands

Naam onderzoeker: Pieter van Bommel

Doel van het onderzoek:

Dit onderzoek heeft als doel inzicht te krijgen in de bouwstenen van het transitieproces naar een circulaire economie op regionaal level. Het doel van het interview is het in kaart brengen van de verschillende perspectieven van stakeholders in de regio van deze bouwstenen.

Uw medewerking:

De gegevens van dit onderzoek worden verzameld via een-op-een online interviews die ongeveer een half uur duren. Het interview zal worden opgenomen om later uit te schrijven zodat analyse van de gegevens mogelijk is. De gegevens die hiermee worden verzameld zullen zorgvuldig en vertrouwelijk worden behandeld. Tijdens het interview bent u niet verplicht antwoord te geven op de vragen en u heeft ook altijd de mogelijkheid om te stoppen met het interview. De verzamelde gegevens zullen anoniem worden verwerkt, wat betekent dat men hierin op een voor derden onherkenbare wijze wordt beschreven.

Door dit document te ondertekenen, geeft u te kennen dat u akkoord gaat met uw deelname aan dit onderzoek. Ook na ondertekening kunt u altijd afzien van uw medewerking. Uw deelname wordt echter zeer op prijs gesteld.

Ik geef toestemming voor deelname aan dit onderzoek:

Naam:

Handtekening

Plaats:

Datum: