Success and failure factors for grass-fibre innovations

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Abstract

Introduction

Despite several successful pilots, no technological invention, regarding high value application of grass-fibres, has made it to a successful scale-up. For the biowaste sector, it is useful to have insights that can guide them to either invest in ideas that have more potential to become successful or design the innovation process in such a way that the innovation will have a better chance to become successful. Therefore, the following research question was adopted:

What are the drivers and barriers for innovations in extraction and application of roadside grass-fibre, and can patterns be detected?

Theory

Inductive research was used to answer the research question. The Technological Innovation System (TIS) was used as a framework to categorize and analyse processes that hamper or support the scale up.

Methodology

This research used a multi-case study approach and analysed five cases. Using qualitative data, a total of 24 function indicators were developed and assessed. Overall, 18 interviews were conducted among 13 interviewees. Four interviews focused on determining the case studies, seven were held with other relevant actors for general information on grass-fibre innovations, and seven were conducted on the different case studies.

Prior to the case study interviews, interviewees filled out a survey, scoring indicators on a nominal scale. The survey brought insights on relevant indicators and served to design the semi-structured interviews.

Results

For six out of seven TIS functions there was "Room for Improvement". The only function that was not considered a barrier is (Technical) Knowledge Development.

Conclusion

The technical development of innovative products is often not the problem, market penetration is. This research found three prominent barriers that need to be addressed first:

- **Late market engagement:**
  Current grass-fibre innovations are *substitute innovations* but only engage the market late in the innovation process. Consequently, valuable input and buy-in from the market lack in the innovation process making it difficult to build a business case for continued investment.

- **Non-competitiveness of the grass-fibre:**
  The competitiveness of grass-fibre is not significant and varies per end-product, making it a difficult sell to the markets.

- **Difficulty in implementing Organizational change:**
  The requested organizational change from public entities like roadside managers, to also become a resource supplier to the private market is challenging.

The most important drivers include:
- Motivation & perseverance of value-chain partners;
- Smart Management of existing laws and regulations.

This research also calls for refining the TIS theory on two aspects:
- The TIS theory should add the *Organizational Capacity to Change* as an 8th function to the innovation ecosystem.
- The TIS should distinguish between *radical innovation* and *substitute innovation* when it describes the importance of the functions in the different development stages

Executive summary

Introduction

Over the past decade, several grass-fibre innovations have been developed, by a variety of partners, however none of the business cases has reached full scale commercialization. This leads to a considerable loss in the invested finances, resources, and time. While companies can recover financial losses and resources, time can never be recovered, thus delaying the transition to a circular economy.

This research was conducted on the request of the Dutch Association of Biowaste Processors, (BVOR), who wanted to have insights that can guide them and their associates to either invest in ideas that have a better potential to become successful innovations or design the innovation process in such a way that the innovation will become successful. Thus, the following research question was developed:

What are the drivers and barriers for innovations in extraction and application of roadside grass-fibre, and can patterns be detected?

Research field

This study focuses on the grass clippings from verges of roads, ditches and waterways. These grass clippings amount to approximately 30% of green waste from public green spaces, totalling circa 900kton/year (RVO, 2014).

At present, most of the grass is collected and composted, the remaining grass is either fermented or left to rot on site (RVO, 2014). Compost can be considered as a circular product, however compost is a low value product and verge owners do not have a revenue from the grass clippings. To the contrary the costs of recycling grass into compost are primarily charged to the organizations producing the grass residues (RVO, n.d.-b). The waste processors do earn at the front gate, taking-in the grass clippings as waste, and at the back door, selling the composted grass clippings as (organic) compost.

Theoretical framework

The Technological Innovation System approach (TIS) is an analysis tool for understanding and improving the innovation ecosystem. To assess the functioning of the technological innovation system, Hekkert et al. (2007) have identified seven system functions (table 1).

Table 1: Description of the seven functions (Hekkert et al., 2007; Hekkert et al., 2011

System function	Explanation
F1. Entrepreneurial experimentation	Entrepreneurs take advantage of new business opportunities by acting on the potential of new knowledge, networks, and markets
F2. Knowledge development	The creation and protection of knowledge for innovation
F3. Knowledge exchange	The exchange of knowledge for R&D, but also where R&D meets governments, competitors and the marker
F4. Guidance of search	Activities that can positively affect the visibility and clarity of specific wants among governments, industries and/or markets
F5. Formation of markets	The creation of protected space for new technologies to develop by e.g. the formation of temporary niche markets, favourable tax regimes, and minimal consumption quotes (e.g. the German fed-in law for renewable energy)
F6. Mobilization of resources	Physical-, human-, and financial-resources, that make innovation possible
F7. Counteracting resistance to change/creation of legitimacy	The coming together of different actors to initiate the development and use of the innovation and counteract resistance to the innovation

This research used the seven functions of the TIS as a framework to inductively identify patterns that can explain success and failure. Barriers require attention by the system actors and the innovation management in order to guarantee the success of the innovation at hand.

It should be noted that the system functions do not operate in isolation, rather they interact and influence each other. Furthermore, the necessary fulfilment of the system function varies with the development phase of the innovation (Hekkert et al., 2011).

Methodology
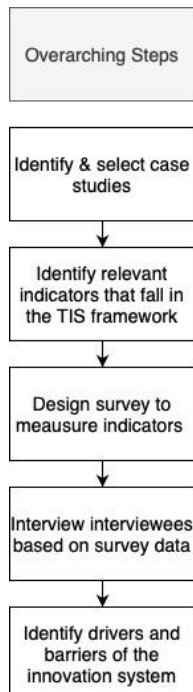
Figure 1 illustrates the general flow of the research. First, case studies were selected. Second, relevant indicators were identified. Third, a survey was developed and sent to interviewees to assess each indicator for their respective case. Fourth, interviews were held to get an in-depth understanding of the survey results. Lastly, drivers and barriers of the innovation process were identified.

Overall, 18 interviews were conducted among 13 interviewees. Whilst all interviews provided general information on grass-fibre innovations, four interviews focused on determining the case studies. A total of seven interviews were held on five different case studies, ensuring at least one interview per case. Another six interviews were held with relevant actors (e.g. The Netherlands Enterprise Agency (RVO) and the Knowledge Centre for Paper and Cardboard (KCPK), that helped get an understanding of the eco- system surrounding grass-fibre innovations.

Figure 1: Overarching research steps

A total of five case studies were analysed for this research namely: Van Berm tot Bladzijde, Paper and Cardboard, Potting soil, Bio-composite, and Grassbloxxx.

Results

In Table 2, a summary of the main conclusions per function is shown. This research found that for six out of seven TIS functions there was "Room for Improvement" (RFI). The only function that was not considered a barrier is (Technical) Knowledge Development.

Table 2: Main conclusions per function and function fulfilment assessment

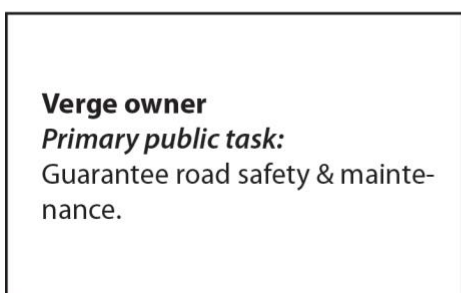| TIS function	Main conclusions	Room for improvement (RFI)/OK
F1: Entrepreneurial experimentation		
	1. It is challenging to retain partners in the innovation as there is no market outlook and end-users are not engaged early on in the innovation process.	RFI
	2. Ideally the innovation team: a) represents all actors in the value chain, including end-users b) is composed of intrisically motvated partners, and c) is led by someone with experience who can oversee the complexity of an innovation process. In the studied cases mostly a & c have been lacking.	
	3. Implementing the necessary organizational change, especially for public entities like road managers, to play a role in a market driven innovation is challenging.	
F2: Knowledge development		
	1. Technical knowledge development is not an issue anymore, it is now the market that needs to pull the innovation.	OK
F3: Knowledge exchange		
	1. Information sharing & value chain collaboration are important for success, but currently innovations have limited to no knowledge sharing with end-product consumers and producers.	RFI
F4: Guidance of search		
	1. There is a discrepancy between Government vision and procurement actions. Governement procurement prioritizes economics over sustainability.	RFI
	2. Laws and regulations are generally experienced as problematic but are not necessarily a bottleneck if properly managed.	
	3. There is a general need for innovating laws & regulations, that not only regulate the present, but also anticipate the future and help innovations.	
F5: Market Formation		
	1. The innovations are currently being pushed onto the market whilst the competitiveness of the grass fibre (products) in terms of quality, price or environmental impact is either insufficient or unclear, making market penetration difficult.	RFI
	2. It is necessary that the market starts pulling, otherwise a business case cannot be made. Including end-product users in the innovation process can help secure the market.	
F6: Mobilization of resources		
	1. The innovations teams lack someone with the experience to oversee and manage the complexity of an innovation process.	RFI
	2. The technology and infrastructure available are sufficient for innovations in a pilot phase. However, to scale up considerable investments are needed, while market outlook is unclear.	
	3. In order to mobilize resources for continued investment a clear business case and market outlook are needed.	
F7: Counteracting resistance to change		
	1. There is insufficient attention from the innovation team for reasons of resistance to change. Lobbying activities and marketing strategies are currently only limited.	RFI
	2. Engaging the market early on in the innovation process can help counteract the resistance to change.	

Conclusion

The grass-fibre innovations can be labelled as *substitute innovations* that aim to replace a product with a more sustainably competitive product. Whilst the development of these products is often not the problem, market penetration is.

This research found three prominent barriers that need to be addressed first, namely:

- **Late market engagement:**
  The innovations at hand are *substitute innovations* that operate in existing fibre markets. However, these markets are only engaged late in the innovation process which reflect negatively on, amongst others, insights in market demands and dynamics, product development, and the ability to develop a good business case.

- **Non-competitiveness of the grass-fibre:**
  The competitiveness of grass-fibre (in terms of quality, price, or environmental impact) is not significant and varies per end-product, making market penetration difficult.

- **Organizational change:**
  The tasks and responsibilities of a public entity, like roadside managers, are almost 180 degrees opposite to the tasks and responsibilities of a commercial supplier of primary resources to a demanding market (figure 2). Implementing organizational change to remain serving its public responsibilities, while also becoming a resource supplier to the demanding private market is challenging.

PRESENT ROLE

FUTURE ROLE

Verge owner
Primary public task:
Guarantee road safety & maintenance.

Verge owner
Primary public task:
Guarantee road safety & maintenance.

Primary private task:
Guarantee a constant supply of quality grass clippings at a specific length, homogeneity, purity and pollution level to grass fibre producers.

The future role entails combining two primary tasks, each with their own, sometimes contradictory, demands, in one organization and operation.

Figure 2: Organizational change for grass verge owners

This research also found two important drivers for the innovations, namely:

- **Motivation & perseverance**
  Actors that are intrinsically motivated and that have perseverance are more likely to remain invested in the innovation project in comparison to actors that engage in the innovation for greenwashing purposes.

- **Smart Management of existing laws and regulations:**
  Smart Management of existing laws and regulations, such as the waste status, creates legal space for the innovation.

Recommendations

Before elaborating on the recommendations, it must be understood that it is inherent to innovations that only some will make it to a successful scale up and failure is inevitable linked to innovation and to success.

The aim of the research was therefore not to come up with recommendations that will bring every innovation effort to a successful scale-up. Rather the recommendations should allow innovators to better understand and manage the innovation challenges and increase the chance of success or decide on an early exit, so that less time and resources are lost, while valuable knowledge is still gathered. The recommendations are elaborated below.

Recommendations for the innovation process

Innovation is not a linear process, but rather should be approached as cyclic refinery process. During the process it is important to ask the following questions in several stages of the innovation:

- What are my organization's motivations to engage and stay engaged in the innovation process?
- Are all value chain partners, including the end-product producers and consumers on board?
- What are the motivations of each of the other value chain partners to engage in the innovation process?
- Who has the experience and will lead the innovation in the different stages?
- Can the product we are developing meet the expectations and increase the motivations of all value chain partners in order to make them stay engaged and investing?
- Can we see a tipping point from market push to market pull (or should we call a stop to the innovation)?
- Can each organization in the innovation process deliver on the organizational change required to play its future role in the innovation?
- What alternative options (to reach the same or alternative goals, e.g., cost reduction) does my organisation have if it does not engage in, or disengages from the innovation?

Furthermore, this research calls for specific actions from both the research team and the Government and its institutions.

Recommendations for the innovation team:

- As this is a *substitute innovation*, it is advisable to engage the market early in the innovation process, co-create end-products and secure large market players, for instance, Bol.com as a major carboard user.
- This research recommends searching for new/other applications where the grass-fibre characteristics are not a disadvantage but can provide an added value in terms of quality, price or environmental impact. There should be clear added value for all actors in the value chain, including the end-user. If added value for all partners in the value chain cannot be found, it is advisable to stop the innovation process.
- This research advises partners engaging in the innovations to approach innovation not only as a technological development, but also to look at the organizational innovation needed to play their role in the innovation. If the organizational innovation is not compatible with other primary tasks of the organization, it is recommended to stop the engagement in the innovation.

Recommendations for Government:

- Government can kick start innovations by aligning visions, laws and regulations, and fielding public spending power through enforcing sustainable procurement for Government and its institutions.

Abbreviations

BBE	Biobased Economy
BC	Bio-composite innovation
BVOR	The Dutch Association of Biowaste Processors
GBX	Grassbloxxx innovation
KCPK	Knowledge centre paper and cardboard
P&C	Paper and Carboard innovation
PS	Potting soil innovation
RHP	European knowledge centre for growing media and certification standard
RVO	Netherlands Enterprise agency
RWS	Directorate-General for Public Works and Water Management
VBTB	Van Berm to Bladzijde innovation
VPN	Association of Potting Soil and Substrate Manufacturers in the Netherlands

1. Introduction

In response to constraints in the availability of resources and large amounts of (residual) waste, as a result of the traditional "take-make-dispose" economic model, there has been a growing demand to transition to a circular economy (Ellen MacArthur Foundation, 2013; Wageningen University, n.d.-a). The circular economy is *"an industrial system that is restorative or regenerative by intention and design"* (Ellen MacArthur Foundation, 2013, p. 7), and distinguishes between biological and technical cycles (figure 1). According to RVO (2016), the need to transition also stems from the ability to reduce dependency on another country's raw materials, avoiding potential geopolitical tensions.
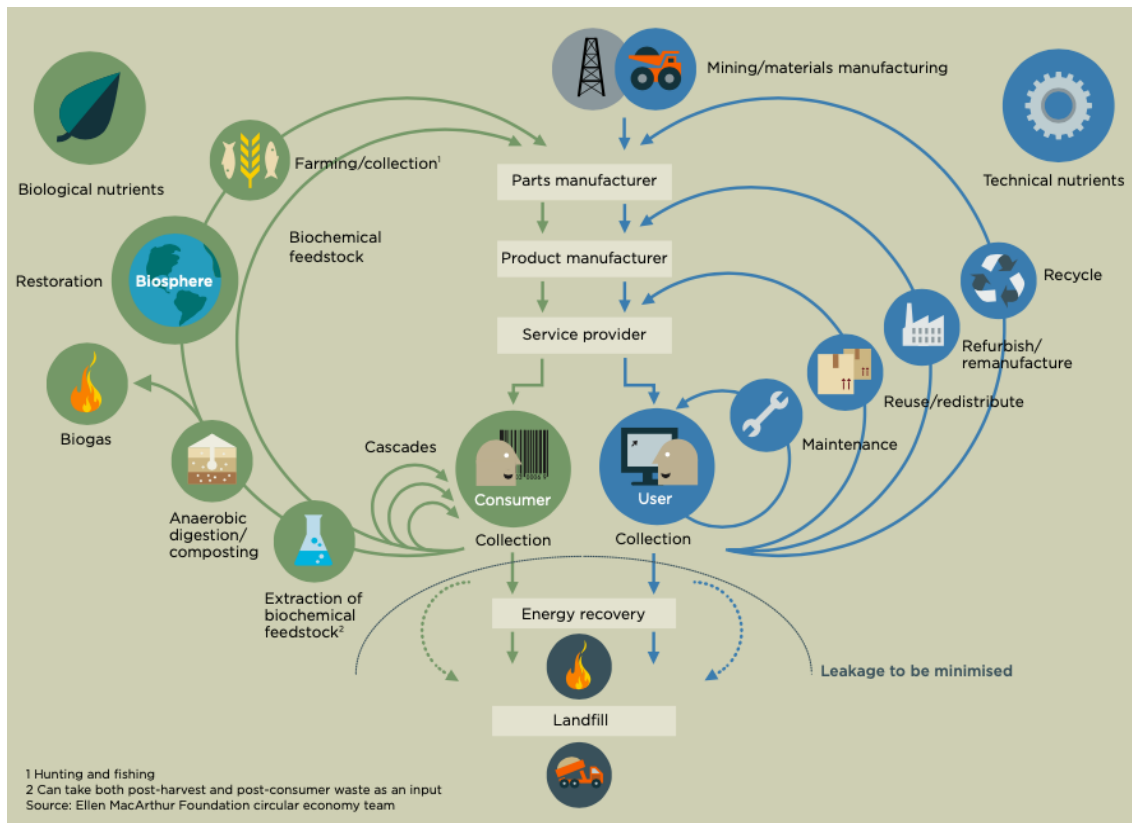
Figure 1: The circular economy (Ellen MacArthur Foundation, 2013, p.24)

The biobased economy (BBE) plays an important role in the circular economy. In the BBE, biomass is used for non-food applications such as the production of materials, chemicals, fuel and energy (RVO, n.d.-a). Biomass includes green resources from plants, trees, and food waste streams, as well as residual waste from agriculture which may contain valuable components (RVO, n.d.-a.; Wageningen University, n.d.-b).

The Dutch Association of Biowaste Processors (BVOR) and her members aim to play an important role in the transition to a biobased circular economy (BVOR, n.d.-a). It is a Dutch association of enterprises that work in the field of reuse, transformation and upgrading organic residues into high value primary materials and end-productss, like fibre and compost respectively. The BVOR is an advocacy and knowledge centre for the sector and has an important network function. The BVOR also manages four certification schemes for compost, soil products, invasive species control and tree disease control.

Figure 2: Innovation process

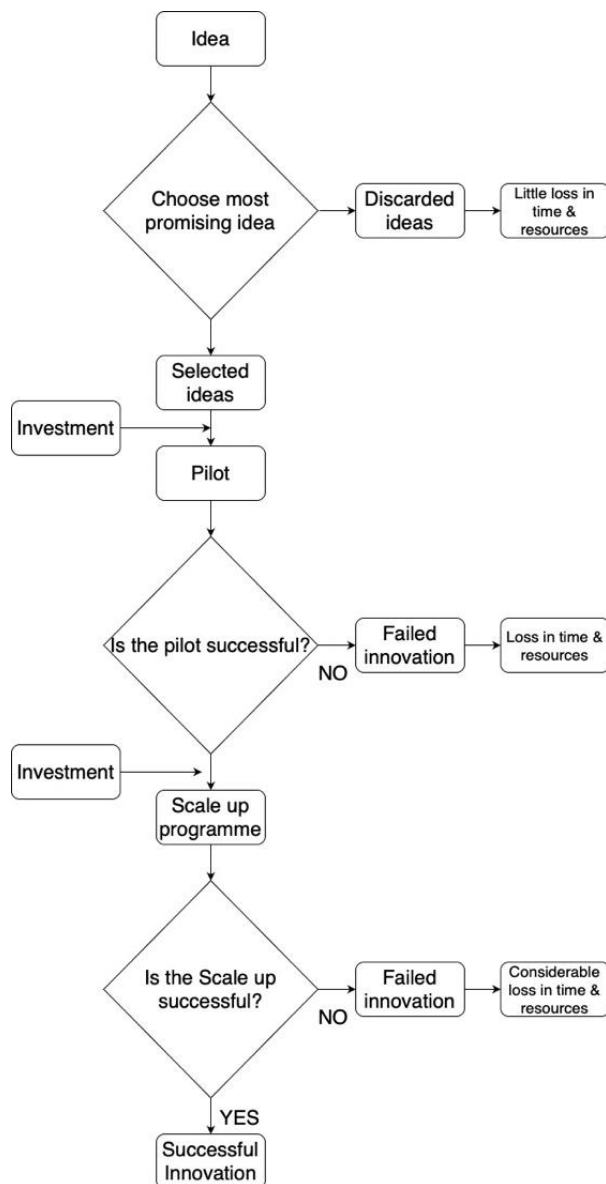This research came on the request of BVOR. It observed that since the '80's green waste has mostly been converted into low valued compost (BVOR, n.d.-d). Despite lots of research into high valued applications of green waste, few technological inventions developed beyond their pilot phase and made it into a successful scale-up and innovation (figure 2). This leads to a considerable loss in the invested finances, resources, and time. While companies can recover financial losses and resources, time can never be recovered, thus delaying the transition to a circular economy.

Green waste is defined by the National Waste Management Plan 3 as *"organic material that is released during the construction and maintenance of public green spaces, woodland and nature areas and all the waste that can be compared with this, such as bulky garden waste, roadside and ditch cuttings, waste from landscaping companies, agricultural waste and waste that is released at the construction and maintenance of sites of companies and institutions"* (BVOR, n.d.-b, para. 2).

Several studies have identified success and failure factors of innovations within the biomass sector, but they have been rather product specific, such as for the production of biogas and algae (Nevzorova & Karakaya, 2020; Paluszkiewicz & Mak, 2009). Currently there is a large field to cover. In consultation with BVOR, it was decided that this research will explore the success and failure factors of innovations regarding the extraction and application of fibres from grass clippings, where there is currently still a knowledge gap. More specifically, this research's desk study has not found any publications that have systematically researched and documented the success and failure factors of grass-fibre innovations among multiple cases.

The focus lies on grass-fibre innovations in the Netherlands that have been developed within the last decade. The timeframe of ten years was chosen to assess cases more in line with present day conditions. The geographical scope of the Netherlands has been chosen as the BVOR is interested in knowing why local innovations are unable to scale-up. Researching case studies only in the Netherlands also allowed for more accurate comparison as the conditions in which the innovations operate are similar. Furthermore, including case studies from other countries would increase the time and resources beyond what are available for this research. Nevertheless, a follow up study could be interesting, especially if there are clear indications of successfully completed scale-ups. So far, this study has not come across any indications specifically for roadside grass.

According to BVOR (A. Brinkmann, personal communication, October 15, 2020), different stakeholders including local authorities involved in public green area maintenance, grass recycling/composting companies and research institutes have researched business cases on the extraction and application of fibres from grass residues. None of the business cases has reached full scale commercialisation. One reason is that grass is a residue material of which the composition may differ depending on, among others, the location it grows and the season in which it is harvested. This makes it difficult to compete with alternative (common) feedstocks which are easily available in constant quality, e.g., recycled paper. Other reasons have never been thoroughly researched.

For BVOR, and the sector, it is useful to have insights that can guide them to either invest in ideas that have better potential to become successful innovations or design the innovation process in such a way that the innovation will become successful.

2. Research Aim and Question

Innovation is more than simply the development of technological tools or processes, it is the successful exploitation of the (technological) advancement (Roberts, 2007). Roberts codified his definition into the following equation:

Innovation = Invention + Exploitation.

Reasoning from Roberts definition, an invention is dependent on the ecosystem in which it operates in order to become a successful innovation. The Technological Innovation System approach (TIS) is an analysis tool for understanding and improving the innovation ecosystem. More specifically, it aims to identify the structure and processes of the innovation system that hamper or support the successful adoption of the innovation (Hekkert et al., 2011).

If the innovation ecosystem is functioning well, innovations are likely to be successful, but some might still fail due to a failing innovation management approach. Likewise, if the innovation ecosystem is malfunctioning, most innovations are likely to fail, unless the malfunctioning was recognized and adequately dealt with by the innovation management.

Taking the feasibility of this research into account, this study focused on using case studies to analyse the innovation ecosystem surrounding the extraction and application of roadside grass-fibres, with the aim to identify the drivers and barriers for grass-fibre innovations. This will enable BVOR and the sector to direct their investments to (technological) innovations that have the most potential for success. Based on the aim of the research, the following research question has been formulated.

What are the drivers and barriers for innovations in extraction and application of roadside grass-fibre, and can patterns be detected?

Success factors are defined as the factors that have contributed positively to reaching the stage where commercial scale-up is feasible, or already happening. Failure factors are defined as factors that contributed negatively to the process.

The following sub-questions were developed to help answer the research question.
- What is the structure of the Technical Innovation System surrounding the grass-fibre innovations?
- Are there barriers at system level that inhibit the system from functioning successfully?
- Are there drivers at system level that help the system function successfully?
- Can the identified drivers and barriers be used to determine which inventions are more likely to become successful innovations and thus worth of investing in?

In order to answer the research question and its respective sub-questions, this study mainly used interview data. Both grey and scholarly literature were used to support the findings from interview data. In contrast to grey literature, scholarly literature has been reviewed by experts prior to publication (ASU, n.d.; GreyNet International, n.d.). The methodology is further elaborated in chapter 5.

As aforementioned, this study builds on the existing body of literature on biobased innovations by identifying success and failure factors of fibre extraction from grass. This study addresses the societal need for understanding success and failure factors of innovations in order to

allocate limited resources for innovation and transition towards a circular economy more effectively and timely. This research also serves as a basis for further research on biobased innovation. For example, further research could analyse common success and failure factors amongst bio-based innovations and develop a decision-making framework for the sector.

3. Description of the grass-fibre field

Grass clippings are often categorized according to its origin (RVO, 2014), namely: grass from agriculture, public gardens, and recreation areas within built-up areas; grass from verges of roads, ditches, and waterways; and grass from nature areas. In consultation with the BVOR this study focuses on the grass clippings from verges of roads, ditches, and waterways, which all fall under the waste regulations (BVOR, n.d.-c). These grass clippings amount to approximately 30% of green waste from public green spaces, totalling circa 900kton/year (RVO, 2014).

At present, most of the grass is collected and composted, the remaining grass is either fermented or left to rot on site (RVO, 2014). Compost can be considered a circular product; however, compost is a low value product and verge owners do not have a revenue stream from the grass clippings. To the contrary the costs of recycling grass into compost are primarily charged to the organisations producing the grass residues (RVO, n.d.-b). The waste processors do earn at the front gate, taking in the grass clippings as waste, and at the back door, selling the composted grass clippings as (organic) compost.

For over a decade there has been recognition that grass contains components that could be extracted for high value recycling (Essink, 2019), thereby potentially reducing the environmental impact of existing products, while simultaneously potentially reducing overall grass residue treatment costs (RVO, n.d.-b). Grass-fibres are of particular interest as they have the potential to replace fibres in, for example, paper and cardboard applications, and insulation materials (Newfoss, n.d.-a).

Biorefinery and cascading are examples of how the fibres are extracted. In biorefinery installations grass is converted into a fibre and a juice, through for example methods of crushing and pressing (Grassa, n.d.-a). The fibres can, for example, serve as a raw material to produce insulation material, paper and cardboard, and fertilizers (NewFoss, n.d.-a). The juices can be further extracted into proteins, sugars and minerals which can be used to produce animal feed and a de-icing agent, amongst others (Grassa, n.d.-a; Grass2Grit, n.d.-a).

Cascading is a step-by-step process of the application and utilization of biomass components (Adriaanse. 2020). Cascading can be done based on three different aspects: time, value and function (figure 3). The aspect time focuses on using the component as long as possible (e.g., through recycling). The aspect value focuses on using the component with the highest value in each step. Function focuses on using biorefinery to extract the multiple components and then applies a single use or cascading in value or time for each of component. An example of cascading in value for gras is as follows: first the grass is fermented, following, a biodegradable fraction, including carbohydrates, proteins, hemicellulose, is removed and converted into biogas. After this process, the digestate, mainly consisting of fibres and lignocellulose, can serve as a soil improver and as a feedstock for lignocellulose (Gielen, 2020).
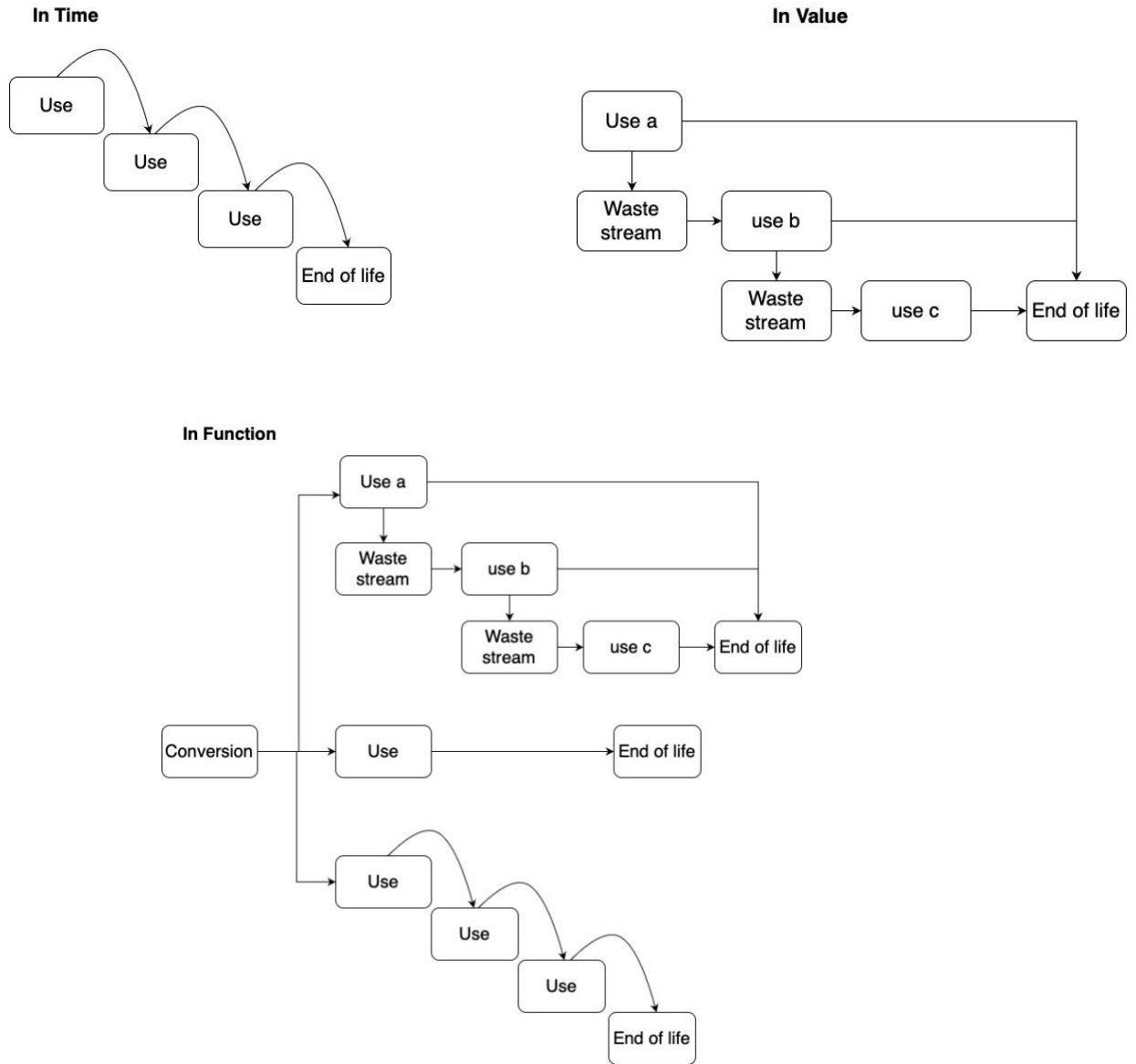
Figure 3: Cascading in: time, value, and function, Modified from (Adriaanse, 2020).

4. Theoretical framework

BVOR observed that multiple grass-fibre pilots did not make it to successful innovations, in this case the scale-up. There are no specific studies that explain this phenomenon for grass-fibre innovations specifically, suggesting that an inductive research method should be applied.

Nevertheless, there are two distinctive theories that describe the pathways that lead to successful innovations. *Innovation System Theories* consider innovations to thrive in an ecosystem in which the innovators interact with Governments, Knowledge Institutions, Networks and Markets. *Innovation Management Theories* describe how companies can manage their ideas to turn inventions into successful innovations. For the success of an innovation both are considered important: the ecosystem must function, and the technological invention must be managed within an innovation eco-system.

Taking the feasibility of this research, the focus lies on understanding the innovations systems ecosystem (through case studies), rather than assessing how innovations managed the innovation ecosystem. Using concepts of the innovation's systems approach, inductive research was used to look at patterns that arise from different cases that can explain success and failure.

To describe and understand the *innovation* and *transitions ecosystem* theoretically, two dominant approaches exist: Innovation Systems and Socio-technical Transition approach (Twomey & Gaziulusoy, 2014).

The *Innovation Systems Approach* argues that the success of innovations largely depends on the presence of a well-functioning innovation ecosystem. The systems approach aims to identify both the structure and the functioning of the innovation system, (Hekkert et al., 2011; Twomey & Gaziulusoy, 2014). The system can be studied on a national, regional, sectoral, and technological level: NIS, RIS, SIS and TIS, respectively. As this study focuses on technological grass-fibre innovations, the TIS is the most relevant variation of IS and is further discussed.

The *Socio-technical Transitions Approach* includes the Multi-Level-Perspective (MLP), Strategic Niche Management (SNM), and Transition Management (TM). Both SNM and TM are management strategies rather than frameworks of analysis. MLP is broader and more policy oriented and aims to identify and understand the *"complex interplay of different forces at the macro-, meso- and micro-level in creating disruptive change"* (Twomey & Gaziulusoy, 2014, p. 4).

Although the TIS and MLP are appropriate frameworks to describe and analyse how systems facilitate or inhibit innovations, there are important differences (table 1). While the MLP is concerned with successful societal transformation processes, like the transition to a circular economy, the TIS is concerned with the successful diffusion of a particular technology or product innovation.

	Technological Innovation Systems	Multi-Level Perspective
Focuses on:	Prospects and dynamics of a particular innovation	Prospects and dynamics of broader transition processes/variety of innovation
Concerned with:	Successful diffusion of a particular technology or product	Successful transformative societal processes

Grass-fibre-innovations are not expected to revolutionize the fibre market and lead to revolutionary new consumer end-productss that bring about large societal transformations. Grass-fibre innovations will, in the first place, lead to an alternative fibre source in existing product manufacturing. These innovations will therefore follow the path of 'substitution innovation'. In order to describe and analyse the innovation ecosystem for grass-fibre innovations, the MLP is unnecessarily complex and the TIS approach is considered the most appropriate.

4.1 TIS Framework

As aforementioned, the TIS approach is concerned with understanding the diffusion of a particular technology or product. According to Hekkert et al. (2011), a technological innovation system *"can be defined as the set of actors and rules that influence the speed and direction of technological change in a specific technological area"* (p.3). Ultimately a TIS analysis helps identify processes that hamper and support the diffusion of the technology or product.

There are three core steps in a TIS (figure 4). First, the structure of the system is analysed. Second, how the system functions is assessed. Third, barriers that inhibit the system from functioning and drivers are identified. These steps are discussed further below.
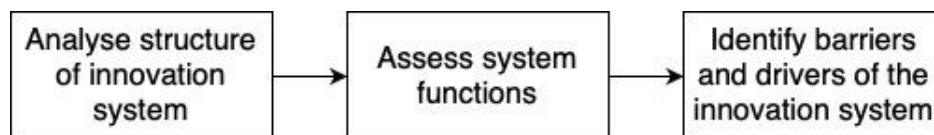
Figure 4: Overarching steps of the TIS (Hekkert et. al., 2011)

Analysing the structure of the innovation system, in detail, over the case study period of 10 years was too complex for the time and resources available for this study. Thus, this research focused on assessing the system functions on case level and inductively identified drivers and barriers of the innovation system.

4.1.1 System functions

To assess the functioning of the technological innovation system, Hekkert et al. (2007) have identified seven system functions. Table 2 provides an overview and short description of the seven system functions. According to Hekkert et al. (2011) system functions do not operate in isolation, rather they interact and influence each other (figure 5, section 4.1.2).

Table 2: Description of the seven system functions (Hekkert et al., 2007; Hekkert et al., 2011)

System function	Explanation
F1. Entrepreneurial experimentation	Entrepreneurs take advantage of new business opportunities by acting on the potential of new knowledge, networks, and markets
F2. Knowledge development	The creation and protection of knowledge for innovation
F3. Knowledge exchange	The exchange of knowledge for R&D, but also where R&D meets governments, competitors and the marker
F4. Guidance of search	Activities that can positively affect the visibility and clarity of specific wants among governments, industries and/or markets
F5. Formation of markets	The creation of protected space for new technologies to develop by e.g. the formation of temporary niche markets, favourable tax regimes, and minimal consumption quotes (e.g. the German fed-in law for renewable energy)
F6. Mobilization of resources	Physical-, human-, and financial-resources, that make innovation possible
F7. Counteracting resistance to change/creation of legitimacy	The coming together of different actors to initiate the development and use of the innovation and counteract resistance to the innovation

A desk study was performed on drivers and barriers to sustainable innovations to identify indicators other than the indicators found in TIS literature. In section 5.3 the function indicators are presented. The results on the desk study are presented in appendix I, a short explanation as to why they are categorized as drivers and barriers (identified as success and failure factors) is provided.

Noticeably, the success and failure factors can be classified under the functions of the TIS framework. The factors are also interlinked, supporting Hekkert et al.'s (2011) observation that functions do not function in isolation, rather they interact and influence each other. For example, according to Kemp, Schot and Hoogma (1998), scaling up is a risky process. Whilst there is a potential to develop a new market, the incentive to do so is not high when there is no guarantee that consumers will buy the product or when there are no external factors such as legislation that require people to buy the product.

Further it can be noted that although various factors are classified as either contributing to the success or failure of an innovation, most factors can contribute to both depending on the presence or absence of the factor. For example, the perceived risk of entering an innovation can be either high or low. A high risk might stop an entrepreneur from proceeding the innovation while a low risk will motivate multiple entrepreneurs to engage in the innovation

4.1.2 Barriers & drivers to system functioning

When the performance of the system functions is assessed, barriers and drivers within the innovation system can be identified. The barriers require attention by the system actors and the innovation management to guarantee the success of the innovation at hand.

The necessary fulfilment of the system function differs per phase of development the innovation is in (Hekkert et al., 2011). Figure 5 shows possible functional patterns. In each phase there are critical functions, important supportive functions, and less critical functions.
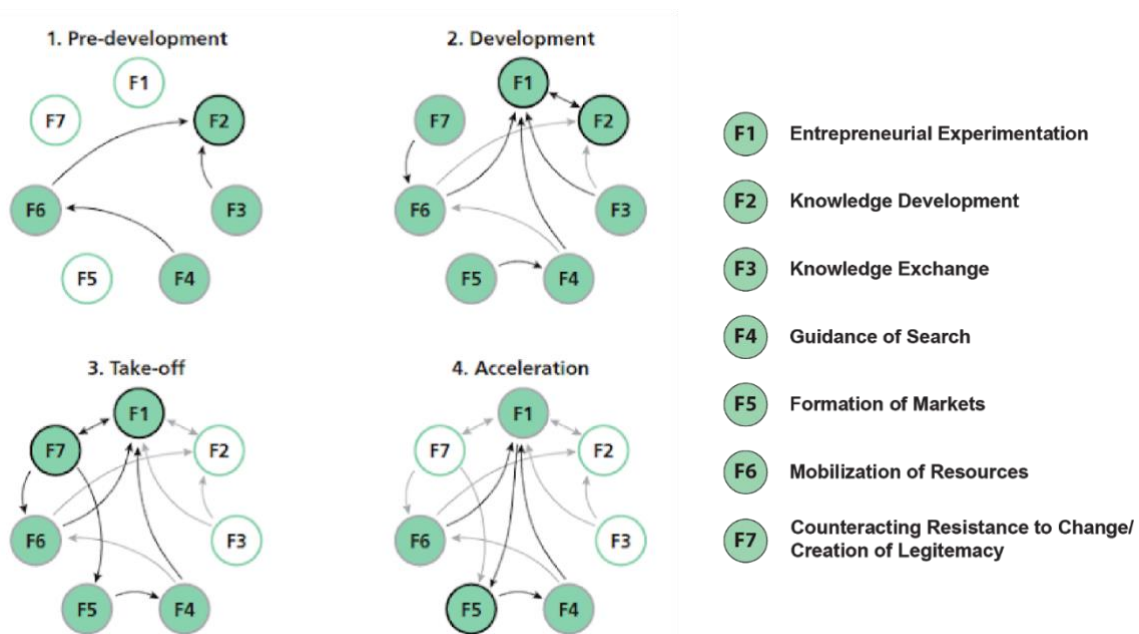
Figure 5: Potential functional patterns per phase (Hekkert et al., 2011)

Per phase "The black arrows are the relations that occur in the current phase, whereas the grey arrows represent the relations that occurred in previous phases and are still occurring in order to further improve the development of the technology into 2nd or 3rd generations." (Hekkert et al., 2011, p.11). The green circles outlined in black are critical in the current phase, the green circles outlined in grey are important supportive functions, and the white circles are considered less critical in this phase.

Per phase, the same functions of the innovation system can be filled in differently. When scaling up from pilot to commercial scale, the innovation is in the take-off phase. In this phase, *Entrepreneurial experimentation* and *counteracting resistance to change* are critical. *Guidance of search*, *market formation* and *resource mobilization* are important supporting functions. *Knowledge development* and *Knowledge exchange* are less critical. For a technological idea to make it into a successful innovation, the critical and supportive functions should be fulfilled to go through all four phases (Hekkert et al., 2011).

4.2 Building theory

In sum, this research analysed the innovation ecosystem by evaluating the functions of the TIS on case level. Thematic analysis in combination with a priori coding (section 5.5) helped provide insights and identify patterns to determine the drivers and barriers of grass-fibre innovation projects.

Furthermore, the TIS functions were used as an 'inspiration' to identify indicators more applicable to study innovations on a case level (section 5.3). By applying the TIS in this manner, it allowed this research to discover the flaws and potential new additions to the TIS. The outcomes are further discussed in the discussion (chapter 8).

5. Methodology

This section elaborates on the research design. Figure 6 provides an illustration to help visualize the research as is described in chapter 4 and 5.
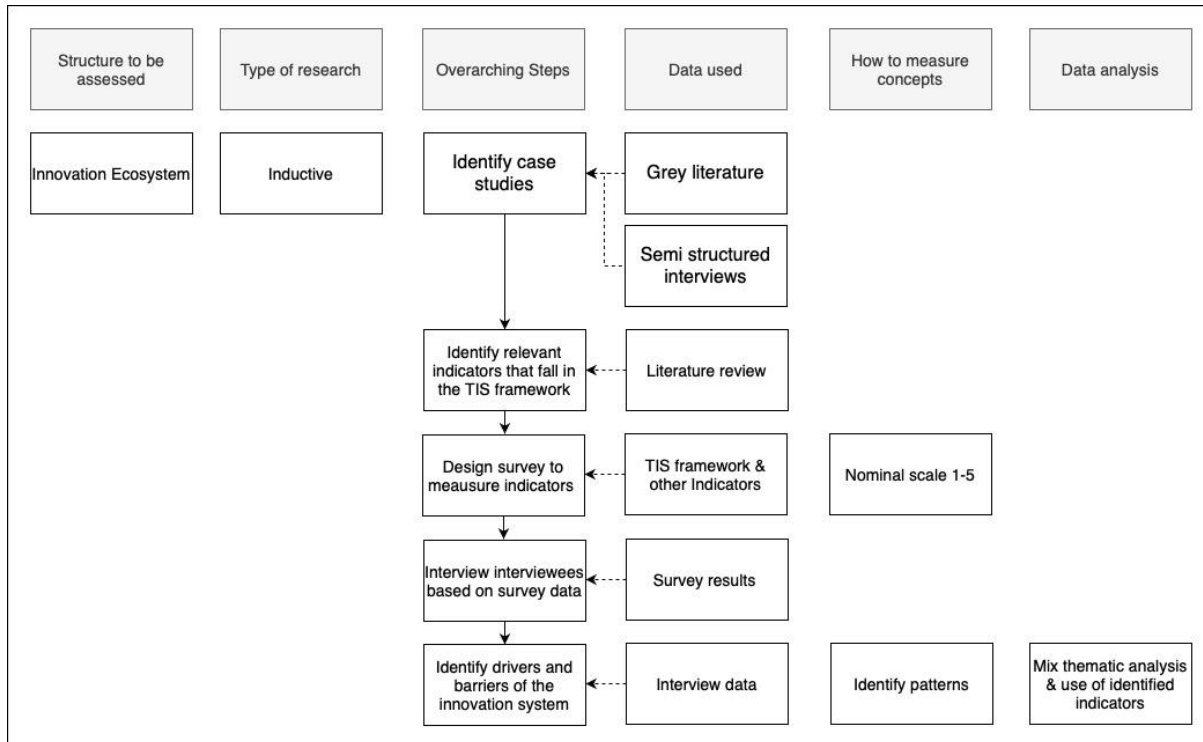
Figure 6: Illustration of the research method

5.1 Research strategy & design

This study used a qualitative research strategy. Qualitative research strategies are used to understand concepts, thoughts, or experiences, by getting insights on topics that are not well understood (Streefkerk, 2019). According to Patton (2005), qualitative research strategies analyse data from direct fieldwork observations, in-depth, open-ended interviews, and written documents.

This study applied a multiple case-study research design. Case study research allows for a detailed exploration of a specific case, e.g. a community, organization or a person, and is often qualitative in nature (Bryman, 2012; Verschuren Doorewaard & Mellion, 2010). The unit of analysis in this research is a grass-fibre innovation project (the individual cases). A multi-case study approach improves theory building because *"the researcher is in a better position to establish the circumstances in which a theory will or will not hold"* (Bryman, 2012, p. 67). Moreover, concepts related to the emerging theory may be more easily identified.

5.2 Sampling strategy & data collection

This research carried out an in-depth analysis of five case studies. To select the case-studies, criterion sampling was used. According to Patton (1990), cases are selected based on predetermined criterion of importance. The following selection criteria were defined:
- The outcome of the innovation process;
- The phase of innovation development reached;
- The recentness of the innovation;
- Access to the case companies.

Ideally the outcome of the innovation process included both failed and successful innovations. However, since to-date no successful innovations exist, only "failed" and "not yet successful" innovations were assessed. Regarding the phase of development, at least three cases should have successfully completed the development phase. In this research three case successfully completed the development phase. Furthermore, the innovations were developed in the past 10 years and the researcher had access to at least one company per case for data collection.

Case selection followed a dual process by conducting both desk research and interviews. This approach was chosen as desk research alone provided limited information on all criteria. Chapter 6 provides an overview of the selected case studies. The case studies chosen include actors that have been working at the front line of grass-fibre innovations and are therefore considered representative for the field of study.

The research used scholarly and grey literature, survey data, and semi-structured interviews for data collection. Scholarly literature was used to understand success and failure factors of sustainable (grass) innovations in order to help determine the most important indicators, in line with the TIS functions, to be assessed.

A survey was developed and sent to interviewees to assess each indicator for the respective case. This helped interviewees familiarize themselves with the multiple topics to be assessed in the interview. Furthermore, there were too many indicators to be assessed in a single interview. Thus, the survey results helped select the most important indicators per case and develop semi-structured interviews for more in-depth analysis. Semi-structured interviews helped give the researcher space to keep an open mind on what he or she needs to know, so that theories could emerge from the data (Bryman, 2012).

The conducted interviews mainly consisted of open-ended questions but included closed questions as well. Closed questions helped improve the consistency in responses and allowed for easier data comparison and analysis (DeFranzo, 2018). Open-ended questions allowed the interviewee to speak more freely, and thereby include more information the interviewer might not have thought of initially (Cleave, 2017). Appendix II provides the interview guide for the case selection. Appendix IV provides the interview guides for the case studies, and general interviews on grass innovations (listed per company).

The interviews were mainly held online due to the Covid-19 pandemic. With the online interviews, video calls were preferred, allowing the interviewee and interviewer to feel more at ease by seeing who they are talking to. Additionally, it allowed the interviewer to interpret the information better as body language and expressions could be observed. All interviews were held in Dutch, allowing interviewees to feel more comfortable and be more expressive. Table 3 below shows the list of companies interviewed.

Overall, 18 interviews were conducted among 13 interviewees. Whilst all interviews provided general information on grass-fibre innovations, four interviews focused on determining the case studies. A total of seven interviews were held on five different case studies, ensuring at least one interview per case. Another six interviews were held with relevant actors (e.g., RVO, knowledge centre for paper and cardboard, potting soil certifier, the BVOR), that helped get an understanding on the system surrounding grass-fibre innovations. Additionally, introductory conversations were held with two members of the BVOR to familiarize the researcher with the topic.

Table 3: List of interviewees. PS- Potting soil; P&C – Paper & Cardboard; VBTB – Van Berm tot bladzijde; BC – Bio-composite; GBX – Grassbloxxx

Company	Introductory conversations	Case selection interviews	General grass interviews	Case study interviews
Non-disclosed			X	
Non-disclosed		X	X	
Non-disclosed		X	X	
Non-disclosed		X	X	PS
Non-disclosed		X	X	BC
Non-disclosed			X	P&C
Non-disclosed			X	VBTB
Non-disclosed			X	VBTB & GBX
RWS			X	VBTB
Knowledge Centre Paper & Cardboard			X	
RHP			X	
RVO			X	
VPN			X	
BVOR	X			
BVOR	X			

All interview data was treated confidentially. It was stored on the researcher's private online storage and is not shared publicly. All interviewees were asked to fill out the informed consent form. Prior to the start of the interview, the interviewer asked for consent to record the interview. The data provided by the interviewees were not altered to fit ideal results. Further, the researcher did not anticipate, nor has it experienced any risks for interviewees participating in interviews.

5.3 Data measurement

To assess the system functions, indicators were selected and slightly modified from Hekkert et al. (2007), Hekkert et al. (2011), Negro, Hekkert and Smits (2007), and the literature review on success and failure factors in sustainable innovations (discussed in chapter 4), (table 4).

The indicators assessed in the survey were on a general level and scored on a nominal scale from 1 to 5 (appendix III). The questions and statements were posed in such a way that a score of 1 always shows a negative relation of the indicator on the success of the innovation, and a score of five a positive relation.

How well the different functions are fulfilled was scored based on the whether there is room for improvement or not.

Table 4: Function indicators Hekkert et al. (2007), Hekkert et al. (2011), Negro, Hekkert and Smits (2007), and a literature review (chapter 4).

System function	Survey Indicator	Function Indicator
F1. Entrepreneurial experimentation		
	Partnerships (for business opporutinty)	Partnerships (for business opporutinty)
	Real and perceived risks	Real and perceived risks
F2. Knowledge development		
	Human resources	Investments in R&D (financial resources)
	Financial resources	Patents
	Patents	Human resources
F3. Knowledge exchange		
	Learning from others (mistakes)	Learning from others (mistakes)
	Value chain collaboration	Value chain collaboration
	Partnerships & networks	Partnerships & networks
F4. Guidance of search		
	Targets set by governments	Targets set by governments
	Legislation and regulation	Legislation and regulation
	Media attention	Media attention
F5. Formation of markets		
	(Expected) market	Expected market
	Cost of the innovation/competitive marketable product	Consumer demands
	Quantity and quality	Quailty assurance of processes and products
		Cultural and psychological factors
		Cost of fibre
		Costs of end-product
F6. Mobilization of resources		
	Human resources	Availability of relevant skills
	Financial resources	Capability of the technology/infrastructure
		Subsidies and investments
	Physical resources	Quality of the input resources (grass)
		Quantity of the input resources (fibre)
F7. Counteracting resistance to change		
	Lobbying	Lobbying activities positively affect the innovation
	Marketing	Env benefits persuade consumers

5.4 Quality of the data

The reliability and validity of the data is important to address, in particular in qualitative research where the researcher's subjectivity can affect the outcomes of the study. Further, it can increase the credibility and trustworthiness of the researcher's findings (Brink, 1993).

"Reliability refers to the consistency of a measure of a concept" (Bryman, 2012, p. 157). Its main concern is whether the results of a study are replicable. When measuring reliability, it is important to take into account stability, internal reliability and inter-rater reliability. Stability refers to the consistency in results of a measure over time, i.e. the results relating to a measure should not fluctuate. Internal reliability refers to the consistency in indicator scores that

measure the same aspect. Inter-rater reliability is *"the degree to which two or more individuals agree about the coding of an item"* (Bryman, 2012, p. 712).

"Validity is concerned with the integrity of the conclusions generated from a piece of research" (Bryman, 2012, p. 41). There are five important factors of validity namely: measurement validity, internal validity, external validity, ecological validity, and inferential validity. Measurement validity is mainly used in quantitative research and aims to assess whether a measure is really able to measure the concept it intends to measure. Internal validity is concerned with conclusions based on causal relationships and whether they hold water. External validity is concerned with the degree to which the results are generalizable beyond a specific context. Ecological validity questions whether social findings are applicable to the natural, social setting of people in daily life. Inferential validity concerns the warranty of the research and findings to support inferences and conclusions drawn from the research.

In this research not all dimensions of reliability and validity are of concern. Inter-rater stability is not an issue as the research is an individual assignment. Ecological validity will not be addressed as the natural social setting of people in daily life is not of interest for this research.

Concerning reliability, stability and internal reliability are shortly discussed. Stability is ensured as the data from the research are facts from the past. Internal reliability is assured by first evaluating indicator scores by means of the survey and asking for more in-depth questions during the interview.

To address validity, measurement validity is ensured by also using existing indicators of the TIS from credible researchers in the field of innovation sciences (Hekkert et al., 2007). The external validity for this research is ensured by analysing cases representative for the studied field. The internal validity and inferential validity of this research was assured by actively questioning the causal relationship and seeking alternative explanations.

5.5 Data Analysis

Data analysis was done in various steps. First grey literature and interviews were analysed and used to develop a bird's eye view of potential case studies. Case criteria (section 5.2) helped select the cases.

Second, the survey results were analysed in order to determine the most important indicators to be assessed in each interview. Rather than working in a linear process, conducting all surveys and then identifying the most important indicators, this research alternated between conducting a survey and then an interview. This iterative process allowed the researcher to identify trends, to determine indicators that did not need any further questioning, or to determine indicators that required further in-depth questioning. This was particularly done for indicators that scored positively. For example, when multiple interviewees already indicated that government goals helped the development of the innovation due to the circular economy goals, this theme was not further explored, giving more time to explore other indicators.

As a rule of thumb, indicators that scored a "1" or a "2" in the survey were questioned in the post-survey interview. This as they pose a barrier to the success of the innovation. Indicators that scored a "3" were also often questioned as they could represent a barrier that could have been managed. Indicators that scored a "4" or "5" were treated as explained above.

For the inductive part of this research, assessing drivers and barriers, interviews were conducted and coded. Coding was done based on a mix of a-priori codes i.e. to reflect categories already of interest (Harding, 2015), and thematic analysis, i.e. transcripts were coded into identifiable themes and patterns (Aronson, 1995). A-priori coding helped evaluate the indicators (section 5.3). Thematic analysis is useful when analysing perspectives of different research participants, highlighting similarities and differences, and generating unanticipated insights (Aronson, 1995). According to Braun and Clarke (2006), a theme is able to capture relevant information in relation to the research question, and *"represents some level of patterned response or meaning within the data set"* (p. 82). An advantage of thematic analysis is that it allows the research to analyse meaning across the entire data set or a particular aspect of a phenomenon in depth. This left room to investigate the different functions of the TIS in depth.

Six core steps were conducted which combined thematic analysis with a-priori coding:

1. **Familiarization with data.**
   The researcher became familiar with the data. This entails actively, analytically, and critically analysing the interview data to understand what is meant.

2. **Semantic, latent, and a-priori coding**
   Initially semantic codes were developed, staying close to the content of the interview data. Secondly, based on the function indicators found in the literature review, a list of a-priori codes was developed, under which the semantic codes could fall. If there was no appropriate a-priori code more latent, i.e. more interpretive codes were developed and placed under an appropriate function.

3. **Identification of themes from codes**
   First similarity and overlap between codes was identified. Similar codes were grouped under themes. A miscellaneous theme, codes that do not clearly fit anywhere, was created, and ultimately used to generate new themes or be discarded. Moreover, table 5 was used as a guideline to retrieve themes and themes will also be based on preconceived ideas from the TIS function indicators.

4. **Revision of themes**
   Potential themes were revised in relation to the coded data and entire data set.

5. **Final theme naming and definition**
   Final themes were defined and renamed as required.

6. **Report writing**
   A structured report was written.

Table 5: Guidelines for retrieving themes (Sonnenschein et al., 2020, p.27)

What to look for	Definition	Value
Repetitions	Topics that occur and recur	Important themes appear
Indigenous typologies or categories	Local expressions that are unfamiliar or used in an unfamiliar way	Important for identification of subthemes
Metaphors and analogies	Particular representation of thoughts	Can give more meaning to statements
Transitions	How topics shift	May be markers for themes
Similarities and differences	Discussing similar topics in different ways	Keeps researcher focused on data instead of theory
Linguistic connectors	Examining use of words such as *since* or *because*	Can generate themes Signifies relations (e.g. dependency or causal)
Missing data	Reflecting what is not in the data	Can signal important themes for further exploration
Theory-related material	Using scientific concepts as springboards for themes	How data illuminates questions
		Contribution to science

6. Case studies

This section contains a brief description of the case studies in this research.

Van Berm tot Bladzijde (VBTB)

In May 2016, the same year the Paris Agreement went into effect, a letter of intent for the 'Van Berm tot Bladzijde' project, (VBTB), was signed (Biomassa-alliantie, 2016). It was among the first projects to engage in high value application of roadside grass-fibres, due to an increasing interest in sustainability (De Ommer Marke, n.d.; Royal Haskoning DHV., n.d.). The project aimed to use roadside grass-fibres to produce paper and carboard.

Whilst the innovation was technologically possible, the project stopped in 2017 for various reasons, amongst others: insufficient funds, a lack of trust in the fibre extraction technology, and the paper producing company was taken over (De Ommer Marke, n.d). Nevertheless, site managers and contractors still come together every half a year to inform each other of any developments regarding grass-fibre innovations (Interviewee A, personal communication, June 8, 2020; De Ommer Marke, n.d).

There were multiple parties engaged in the VBTB project, from site managers to the end-product producers. The three main value chain actors were the verge owner and roadside grass supplier (Rijkswaterstaat), the technology owner and grass-fibre supplier (NewFoss), and the grass-fibre user (Parenco).

The reasons for project development were both, economic and environmental in nature. Economic reasons include cost reduction for the verge owner by turning grass clippings from a waste product into a primary resource, as well as an increase in national independence by replacing imported wood fibres by local grass-fibres. Environmental reasons include reduced tree cutting for the production of paper and carboard as well as a substitute for recycled paper. The environmental gain, however, has not clearly been shown (Interviewee B, personal communication, July 27, 2020).

Grassbloxxx (GBX)

The Grassbloxx project, located in Amsterdam, was initiated in 2018 and is more of an innovative approach rather than a product innovation. The concept behind Grassbloxxx requires sourcing, processing, and the use of the grass-fibres in end-products all to occur on one site (Interviewee C, personal communication, June 29, 2020).

On site production in Amsterdam includes insulation material, chipboard, substrate for potting soil, organic fertilizer, and a de-icing agent (Circkelstad, 2020; Interviewee C, personal communication, June 29, 2020). In this light the main actors for the innovations include the verge owner and grass suppliers (such as Rijkswaterstaat), the grass defibering technology owner (NewFoss) and the grass-fibre users (not-disclosed), (Interviewee C, personal communication, June 29, 2020).

The main reasons for project development were economic and environmental. There is potential for roadside grass-fibres as valuable resource for multiple end-productss. Environmentally, the use of grass clippings is said to reduce the CO_2 footprint in comparison

to composting, the use of rock wool and peat (BUN-K, n.d.; Circkelstad, 2020). Whilst articles claim that the grass products developed in the Grassbloxxx concept are environmentally friendly compared to current alternatives, an environmental impact assessment confirming this has not been found. This research found the environmental impact being debated. An interviewee mentioned rockwool insulation material to be recycled and grass clipping insulation to be burnt as a reason to disengage from the innovation. Regarding potting soil, an interviewee from The Association of Potting Soil and Substrate Manufacturers in the Netherlands (VPN) stated that for the extraction of peat no new areas are being drained, and peat areas oxidize daily resulting in CO_2 emission, even without peat extraction. Without a clear environmental impact assessment, it is difficult to convince investors and the market of its benefits.

Paper and Cardboard (P&C)

For the waste processing company (non-disclosed), the development of paper and carboard from grass clippings started in 2015 and ended in 2019 (Anonymous, 2019; Interviewee D, personal communication, June 29, 2020). Two different production lines were tested within this timeframe. The first production line ended due to pollution in grass and the strength of the fibres. The second production line was stopped due to the (un)competitiveness of the grass-fibre price in comparison to recycled paper fibres.

The partners for the value chains included the grass collector/transporter, the waste processor (non-disclosed), and the end-product producers (Non-disclosed), (Anonymous, 2019; Interviewee D, personal communication, June 29, 2020).

The main reasons for product development were economic and environmental. Economic reasons initiated from the waste processor aiming to extract extra value from grass clippings (Anonymous, 2017). Environmental reasons included the aim to reduce the CO_2 footprint in comparison to the production of compost (Anonymous, 2019).

Potting soil (PS)

The innovation project, started in 2019 and stopped in 2020, aimed at developing potting soil from grass clipping as a by-product of the production of biogas. The innovation was in the pilot phase and required high investments for demonstration infrastructure. Consequently, the management decided to stop the innovation as a means to cut back on costs (Interviewee E, personal communication, June 11, 2020).

The innovation was led by the waste processor and did not have any partners. However, the company did test samples with potting soil companies and technology suppliers. Rather than looking for partners, the company was inclined to sign contracts with external parties to secure agreements.

The main reason to engage in the innovation was economic: responding to the increasing market demand for sustainable peat alternatives (Anonymous, 2020). Similar to the Grassbloxxx case, an environmental impact assessment for potting soil from roadside grass has not yet been established.

Bio-composite (BC)

The production of bio-composite from grass clippings is still ongoing; the innovation project is currently in the pilot phase. The use of grass in bio-composites has been used to develop and test several end-products such as kitchen units, serving trays, road signs, tables, and chairs (Interviewee F, personal communication, May 5, 2020).

There are several actors engaged in the innovation project. The main actors include the verge owner and grass supplier (non-disclosed), the bio-composite maker (non-disclosed) and multiple end-product producers (non-disclosed) as well as market parties, in the case of road signs, road managers are the client.

Reasons for investment are economic and environmental. The former helps reduce verge maintenance costs, and the latter reduces the environmental footprint. For example, end-productss can replace the use of products such as chipboard which do not have the best environmental impact assessment (Interviewee F, personal communication, May 5, 2020), due to the emissions from transportation as well as a leach of urea formaldehyde resin into the atmosphere (Hussain, Malik, & Taylor, 2018).

7. Results

In this chapter interview data relevant to the research questions are presented. The chapter is structured as follows: Sections 7.1-7.7 present the seven functions of the TIS which was used as the guiding framework of this research. Within each function there are sub-sections where the indicator results are presented. There are also sub-sub-sections which try give more in-depth insights to the indicator. At the end of each section there is a short conclusion on the respective function.

7.1 F1: Entrepreneurial experimentation

For function 1, Entrepreneurial experimentation, initially two indicators were to be assessed (table 6): *Partnerships* and *Real & Perceived risks*. Emerging from interview data, the indicator *Motivation for Project Investment* was added. Each indicator is discussed below.

Table 6: Indicators F1

Indicators F1 Entrepreneurial experimentation
Motivation for project investment
Partnerships
Real & perceived risks

7.1.1 Motivation for project investment

Table 7 shows motivations for project investment that were provided. Overall, the motivations can be classified into *Economic* and *Environmental,* however, the two categories do not exist in isolation. Whilst interconnected, *Environmental* motivations are leading above economical. However, it is questionable if the innovations at hand would be developed (and pursued) if the intention would not be cost-cutting.

Concerns about *Environmental impact* are an important motivator for project investment. For some products, this is amplified by environmentally motivated social pressure, for example, opposition to the use of peat in potting soil. Peat extraction is associated with high CO_2 emissions.

Important Economic motivators include the need to *reduce costs*, to replace *(scarce) non-renewable resources* and the need to *secure a market position*. The need to *secure a market position* is economic in nature but responds to environmentally motivated social pressures.

Only one interviewee mentioned an increasing *market pull* for biobased resources as a reason for investment. Interestingly, five interviewees mentioned the need to innovate in response to market pull (table 27, section 7.5.1), whilst they had engaged in innovations without a clear market pull, suggesting that the lack of market pull could be a failure factor.

Table 7: F1 indicator - Motivation for project investment

Subcategory Level 1	# of interv.
Environmental	
Environmental impact	7
Social pressures	4
Replacing conventional resources	3
To increase market interest	1
Economic	
Reducing costs	4
Securing market position	4
Replacing conventional resources	3
Green image	2
Market pull	1

7.1.2 Partnerships

Table 8: F1 indicator - Partnerships

Category	# of interv.	# of interv.	Category
Expressed need to innovate together	3	1	Not actively searching for partnerships
Easy to engage partners	8	8	Difficult to engage partners
Easy to maintain partners	2	8	Difficult to maintain partners
Desired partner characteristics	1	3	Disadvantageous partner characteristics
Need desired partner characteristics	6		

The data in table 8 show the partnership categories that emerged from interview data. While the data show a divided image in the *difficulty to engage partnerships*, they show clearly that it is difficult to maintain partnerships in the innovation.

Six interviewees stressed that a successful innovation asks for special partner characteristics, such as intrinsic motivation, perseverance and a partner who takes the lead (table 11, section 7.1.2.3). This is especially of importance for retaining partners in the innovation. While the need for special partner characteristics was of general consent, only one interviewee mentioned favourable partner characteristics as evident in the case. Three interviewees mentioned a lack of favourable characteristics or even the presence of non-favourable partner characteristics.

7.1.2.1 Reasons for ease and difficulty of engaging partners

Table 9: Difficulty to engage in partnerships

Category	Subcategory Level 1	# of interv.
Difficult to engage partners		8
	Finanacial & strategic	5
	No innovation culture	4
	No specific reason	2
	Loyalty to business partners not engaged in the innovation	1
	Negative environmental impact	1
	Failed past innovations	1
	Potential partners unknown	1
Easy to engage partners		8
	No specific reason	4
	Existing relationships	2
	Existing market pull	2
	Under specific conditions	2

Prominent reasons for *difficult partner engagement* are financial and strategic, as well as a lack of innovation culture within the (grass waste) sector (table 9). Financial and strategic reasons include, among others, focusing only on short term profits and fear of investing in failing projects.

> *"…Trying to keep shareholders happy in the short-term. And then forget that it is necessary to invest in the long-term if you want to continue to exist…"*

> *"… a few times I have now literally heard: super good idea, we really do believe in it, but we have failed so much in recent years. That you just get the disadvantage of the doubt."*

Most interviewees that consider it *easy to engage in partnerships* do not mention a specific reason for it (table 9). Factors that enable partner engagement include existing business relationships and market pull, but while the latter is felt to be needed it is not present in the cases.

Existing business relationships facilitate the process of exchanging and idealizing innovative ideas. A clear market pull increases the willingness of actors to collaborate and invest in partnerships.

> *"…Last week they [a potting soil company] came to visit and they said seriously: ah we do want to produce more [with alternative resources]. A manager was there, and when external parties say it, it makes more of an impression."*

Table 10: Difficulty in maintaining partnerships

Category	Subcategory Level 1	# of interv.
Difficult to maintain partners		8
	Financial and strategic	5
	Negative results & experiences	2
	Stopped partners	2
	Higher negative environmental impact	2
	Government cannot interfere with market	1
	Greenwashing parties	1
	Lack of sustainability goal	1
Easy to maintain partners		2
	Engage with motivated partners	1
	Project exposure	1

Table 10 shows that Financial and strategic reasons also lie central to the *difficulty of retaining partners* engaged in the innovation. In particular, a (perceived) lack of a (future) market disengages partners from pursuing the innovations.

> *"Yes, they [the acquiring company], did not see a future in the innovation project. They saw the end-customer as a barrier. ... They suspected that it would be difficult to sell the end-product to the customer."*

This is in line with the findings in table 9 (section 7.1.2.1). Thus, market pull is important to engage as well as to maintain partners in the innovation.

Table 11: Innovation team composition and characteristics

Category	Subcategory Level 1	# of interv.
Need desired partner characteristics		6
	Intrisically motivated & active parties	5
	Value chain forward puller	3
	Partners reflect whole value chain	2
	Perseverance	2
Desired value chain actors		4
	All value chain actors needed	3
	Need to secure end customers	2
Disadvantageous partner characteristics		3
	Lacking someone to pull (lead) the innovation forward	3
	Lack of perseverance	1
	Competition	1
	Negative partner relationships	1
	Contract external party to facilitate the innovation	1
	Too many partners	1
Transition - approach to value chain (push to pull)		3
Desired partner characteristics		1
	Motivated partners	1
	Entrepreneur with perseverance	1
	Value chain builder	1

The data in table 11 show that, interviewees stress that for a successful innovation, there is a need for intrinsically motivated actors with perseverance.

> *"A partner that is intrinsically motivated. That is what is necessary. It is very nice if you have a market party that is into it [the innovation] and says: I want this and how are we going to do this?"*

Interviewees also express the need for an organization or someone leading the innovation, taking the responsibility for the innovation process, and pulling the innovation forward.

> *"... Someone who really pulls the value chain out of the interest: I want this product and I will do anything for it to be successful. And then you get a completely different flow in the process..."*

Two interviewees stressed the need for the innovation team to reflect partners from the entire value chain, including the user of the grass-fibres as well as end-product users. If large end-product users are committed to investing in the innovation process, investment and market risks are reduced.

> *"... So the success factors are that ... that in any case all value chain partners are represented from all steps in the chain"*

> *"… We ensure, for example, that bol.com is at the table [with us] because they want, they need packaging [material] and they can steer the market."*

Including, in particular, end-product users as essential actors in the innovation team, is a transition that interviewees claim is taking place.

7.1.3 Real & perceived risks

Table 12: F1 indicator – Real & perceived risks

Category	Subcategory Level 1	# of interv.
Innovation risks		6
	Market risk	3
	Investment risk	2
	Adapting to new roles	2
	No research on success and failure factors	1
	Vulnerability of start-ups	1
Risk aversity		4
	Financial & strategic	4
	Personal image	1
Risk reducing strategies		1
	Shared long-term investments	2

The data in table 12 show the risks interviewees associated with the innovations. They also mention the innovation to be impacted by risk aversity among the partners. Two interviewees mentioned a risk reducing strategy by striving to make long-term agreements among the partners.

Financial & strategic risks lie central to both the innovation risks and risk aversity. Prominent *innovation risks* include investment and market risks, and the ability to innovate the organization (table 12). Investment risks are connected to market risks, but not limited to market risks. It includes risks like failing of technologies, and the rise of competitive technologies or alternatives.

Innovation often requires adapting to new roles that require organizational changes. The transition from a waste producer to a resource supplier is a 180 degrees turnaround. It requires a public entity, like municipality or road owner, to become a supplier in a demanding market, meeting quality standards and guaranteeing a timely supply. This is a much more challenging process for which its complexity is often underestimated.

> *"And uhm and that requires different work from a lot of people who are always programmed to do something on A. But if you want something different at the end, that asks something of them too. So, every step is a potential risk."*

7.1.4 Main conclusions F1

Cost reduction is a strong motivation for the current waste producer, but not for the other value chain actors. Companies and organizations are willing to engage in the innovations on the argument of reducing their environmental footprint. However, eventually markets will have to sustain the innovation for partners to maintain engaged in the innovation. Therefore, it is of utmost importance that the innovation team includes end-product users in the early stages of product development and not only in the scale-up.

Innovation teams that are composed of intrinsically motivated partners, representing the whole value chain with both, "push & pull" actors, are considered more likely to succeed. It is also important that the innovation team has an actor that takes up the challenge and responsibility to lead the innovation process.

A major success or fail factor is the ability of public organizations, like road managers and municipalities to realize organizational change and play a role in a market driven innovation.

7.2 F2: Knowledge development

The function knowledge development was thought to be assessed by three indicators *human resources, financial resources,* and *patents.*

The pre-interview survey did not point to human or financial resources as a potential constraint (Appendix V) and was also not raised in the interviews. As a result, interview data only show information on the indicator IP protection. Emerging from the data*, Investment in knowledge development*, was included as an indicator (table 13). Below the two indicators are discussed.

Table 13: F2 indicators

Indicators F2 Knowledge development
IP protection
Investment in knowledge development

7.2.1 IP protection

Table 14: F2 indicator – IP protection

Category	Subcategory Level 1	# of interv.
IP protection important		4
	IP protection agreements	4
	IP protection important	1
IP protection difficult to secure		1

The data in table 14 shows that of the five interviewees that mention IP protection, four stated that IP protection agreements were in place, either as patents or as non-disclosure agreements. IP protection is mainly important for the IP owner of the technology or the process of the innovation.

> *"Well, there is an NDA under that. But she shares the knowledge about its production process and the specs et cetera uhm, without reservation. Only that does not help us [road site managers] very much… because we are concerned with what is the characteristic of plant fibers and what do plant fibers do."*

The importance of intellectual property protection is reflected in the number of IP agreements.

7.2.2 Investment in knowledge development

Table 15: F2 indicator – Investment in knowledge development

Category	Subcategory Level 1	# of interv.
Improved understanding of the technology		2
	Transition - better understanding of the technology	2

Two interviewees indicated that knowledge is not a limiting factor anymore (table 15). There is sufficient understanding of the technology that has resulted in a reduction of the R&D investment over the past years. The challenge lies now in getting the market to pull.

> *"... I think the R&D efforts in the grass field about five years ago were much more intensive and extensive than they are now. And that is not surprising, because the problem of getting that grass into products in large quantities is not of technological nature. We know that now. So, there is not much to hoard in the sphere of research, it is now the market that must allow, and the market is not doing that."*

7.2.3 Main conclusion F2: Knowledge development

From the interviews it emerges that IP protection is in place, knowledge development is no longer an issue, and there are currently several technologies on the market to extract and use grass-fibres. Therefore, the innovation should be considered "technologically ready for scale up", and it is now the market that needs to pull the innovation foreword.

7.3 F3: Knowledge exchange

The function knowledge exchange was thought to be assessed by means of the following indicators: *Information sharing*, *Value chain collaboration*, and *Partnerships & networks*. In practice it turned out to be impossible to distinguish between *Information sharing* and *Partnerships & Networks*, as *Information Sharing* takes place among partners and within networks. Therefore, these indicators have been combined into one indicator: *Information Sharing* (table 16).

Table 16: F3 indicators

Indicators F3 Knowledge exchange
Information sharing
Value chain collaboration

8.3.1 Information sharing

Table 17: F3 indicator - information sharing

Indicator	Category	Subcategory Level 1	# of interv.
Information shared			8
		Knowledge sharing on product innovations	5
		Knowledge examples learnt from innovations	5
		Feedback from partner	3
		Transition - actors willing to share knowledge	2
		Quality criteria and knowledge sharing	1
Limited information shared			2
		Financial & strategic	3
		Failures not shared externally	1
		No specific reason	1
No information shared			4
		Actors unwilling to share information	3
		No feedback from partner	1
Small network of experts			1

Information sharing is considered a success factor from the initial desk research (appendix I). According to the data in table 17, the interviews give a divided picture on the reality of knowledge sharing. Whilst eight interviewees state that information is being shared, six interviewees are of the opinion that information is not or only limitedly shared.

Detailed insights into the quotes of the interviewees show that financial reasons lie central as to why actors are unwilling or only limitedly sharing information. For example, one interviewee stated to fear losing out on the business model.

> *"...We had an open discussion with a number of parties about it [limitedly sharing information]. And [it was] the fear of the business model, that they are going to lose on their business model."*

Two interviewees express experiencing a transition in the willingness of potential partners to share information. For example, facilitating this transition is the clear environmental goal in the potting soil sector with the aim to use 60% renewable resources by 2025. The necessity for potting soil companies to innovate and share information increases to realize this transition.

> *"Yes, they simply want those raw materials. So they share more information and want to work together better. It used to be [that they asked] what do you have? [And after responding] Ok, it is too expensive. And they wouldn't take it. They had enough supply from all kinds of other processors... But nowadays, they see that they just have to engage to achieve that ambition [60% renewable resources by 2025]."*

Actors that generally share information amongst each other specified partner relations to be of importance, as well as financial & strategic reasoning (table 18).

> *"So we also have to look at our partners, partners in the biomass alliance. ... We meet once every six months, to say well, inform each other about the developments and especially if we are going to become a supplier, what does that mean for us?"*

Table 18: Knowledge sharing

Indicator	Category	# of interv.
Knowledge sharing on product innovations		5
	Existing partner relations	3
	Financial & strategic	2
	No specific reasons	2

Overall, financial & strategic motives can ensure and inhibit actors from sharing knowledge. On the other hand, environmental targets encourage innovation and knowledge sharing.

7.3.2 Value chain collaboration

Table 19: F2 indicator – Value chain collaboration

Indicator	Category	Subcategory Level 1	# of interv.
Value chain collaboration			6
	Need to collaborate		4
		Co-creation	3
		Think beyond own interests	1
	Actors collaborate		3

Four interviewees spontaneously mentioned the need for value chain collaboration as a factor that facilitates the success of the innovation (table 19). Three interviewees mentioned that value chain actors in their case collaborated, while two found there had been failures in value chain collaboration.

> *"The whole tender process was a big bottleneck actually. Of how the agreements are between the value chains, or in the value chain actually: Does someone provide something that someone else can use? That was the problem. Parties just talked alongside each other."*

Value chain collaboration is important to be able to develop and deliver the desired (end-) product to a demanding market.

> *"And precisely that is evident from chain collaboration: that the person who mows it [the grass] knows exactly what the problems can be if he mows it this way or that that way, for the person who has to do something with that grass. If you know that about each other and you take that into account, it all goes a lot smoother of course."*

7.3.3 Main conclusion F3: Knowledge exchange

For both, *Information Sharing* and *Value Chain Collaboration*, there is consensus about the need but there is no consensus on whether they were successfully executed. Therefore, it is concluded that there is room for improvement on both issues.

It is important to note that in Function 1 Entrepreneurial Experimentation was suffering from the lack of presence of, in particular, fibre product producers and consumers, in the pre-development and development phases. Partly failure in knowledge sharing points to the same cause: the lack of involvement of fibre product producers and consumers.

7.4 F4 Guidance of search

Guidance of search was initially to be assessed by the indicators *Targets set by Governments, Legislation and regulation*, and *Media Attention*. Emerging from the interviews, *Targets set by Governments* was expanded and divided into *Vision & Policy, and Implementation (Specific targets & actions)*. Resulting in 4 indicators for Guidance of search (table 20).

Table 20: F4 indicators

Indicators F4 Guidance of search
Vision & policy
Legislation & regulations
Implementation (specific targets & action)
Media attention

7.4.1 Vision & policy

Table 21: F4 indicator – Vision & policy

Category	Subcategory Level 1	# of interv.
Supportive		8
	General sustainability vision & targets	8
	Grass stimulated in tenders & policy	1
Lack of support		1
	Lack of direction from government	1
Need support		1
	Shared ambition	1
	Feel urgency and importance of project	1

The data in table 21 show that a fair number of interviewees (8) indicate the existence of sustainability vision and targets set by the Government & Institutions, as supportive to the development of the innovations. Particularly, the aim for a circular economy by 2050, an ambition set in line with the Paris agreement established in 2015. However, this is a general target and not specific for biomass waste streams, such as innovations aiming at the use of roadside clippings. Specific targets regarding the use of bio streams or even more specific, the use of grass clippings have not been identified.

7.4.2 Legislation & regulations

Table 22: F4 indicator Legislation & regulations

Category	# of interv.
Laws & regulations are problematic	7
Need supportive laws, regulations & legislations	6
Laws & regulations potentially problematic	4
Laws & Legislations are not problematic	3
Laws & regulations not promoting innovation	3
Laws & regulations promoting innovation	2
General information subsidy regulations	1

There is a clear indication that laws & regulations are considered problematic for grass-fibre innovations (table 22). The "waste status" of roadside clipping is considered most problematic (table 23). Two interviewees counteracted that statement as present regulations also allow to manage the innovation in such a way that grass clippings are classified differently.

> *"Something is considered waste for one reason only: that you want to get rid of it. As soon as you can demonstrate that you do not want to dispose of the clippings, prior to mowing, then it does not fall under the waste regulations."*

Two interviewees indicate that in general *Laws and Regulations* are most often targeting present practices and not favouring innovation.

> *"Laws and regulations are always set to the present. When you develop something new, the innovation usually does not fit into current legislation and regulations."*

Table 23: Insights into category 'Laws and regulations are problematic"

Subcategory Level 1	Subcategory Level 2	# of interv.
Problematic laws & regulations		7
	Waste status	7
	General	4
	Environmental impact not taxed	1
	Fertilizer laws	1
Laws & regulations outdated		2
Limitations to waste status exemptions		2
Waste status not managed appropriately		1

7.4.3 Implementation (specific targets & actions)

Table 24: F4 indicator - Implementation (specific targets & actions)

Category	Subcategory Level 1	# of interv.
Lack of supportive implementation actions		3
	Government procurement prioritizes economics over sustainability	3
Need for supportive implementation actions		3
	Government needed as launching customer	2
	Need for governmental leadership	1
Supportive implementation actions		2
	Actors set sustainable example	2

Despite a supporting vision and policy, table 24 shows that interviewees claim the innovations to experience limited supportive actions. For example, procurement from Governments & institutions ultimately still prioritizes lower prices over sustainability score (table 24). Interviewees also mention a need for supportive governmental action such as taking on the role as launching customer, as they can have a leading sustainable impact.

> *"...With launching customers it is meant that the government acts as an early adopter. That they take innovations forward through sustainable procurement...*
>
> *The government, which buys in for billions a year, can move a showcase further into a business case. And also set an example. But in practice that really doesn't happen, because you see that in tenders, in too many cases the price is the deciding factor."*

The same problem, a lack of supporting Government procurement practises, was found in a recent, much larger research by PWC (Anthoni et al., 2018).

7.4.4 Media attention

Table 25: F4 indicator – Media attention

Category	# of interv.
Media disadvantageous for innovations	2

In the pre-interview survey interviewees did not mention media attention as a barrier or important factor for the specific innovations at hand, (appendix V). In the interviews however, two interviewees mentioned media to be disadvantageous for the innovation (table 25). Interestingly, one interviewee mentioned that the failed innovations discourage potential partners from engaging in similar grass-fibre innovations.

> *"So in that sense I think that the media can really destroy things. And what I said. I once heard, Jansen*, great idea, uhm clearly explained, we know what the costs are, we know you can do it. Really, not a problem, but you get the disadvantage of the doubt. And the disadvantage you get from those [van Berm tot Bladzijde] kind of projects."*
>
> *Jansen is used a pseudonym for privacy purposes

However, in general the research did not find an indication that media attention has played a decisive positive or negative role in the success or failure of the case studies.

7.4.5   Main conclusion F4: Guidance of search

Whilst there are general sustainability targets for the circular economy, there are no specific targets regarding the use of grass-fibres in high value applications. This research also found a discrepancy between the sustainable vision of the Government and key actors and their actions. Overall governmental procurement actions prioritize economics over sustainability or environmental impact.

Laws and regulations are generally experienced as problematic but are not necessarily a bottleneck if properly managed. There is, however, a general need for innovating laws & regulations. Laws and regulations should not only aim at the present, but anticipate the future, and stimulate sustainable innovation.

Ultimately there is a need to align vision, laws & regulations, and actions, in support of sustainable (grass-fibre) innovations.

7.5 F5: Market formation

Market formation was initially assessed by the following indicators: *Expected market, Quality assurance of products & production process, Cultural & psychological factors* and *Cost of fibre & end-productss.* Emerging from interview data, the indicator *Business case* was included (table 26).

Table 26: F5 indicators

Indicators F5 Market formation
Expected market
Quality assurance of products & production process
Cultural & psychological factors
Cost of fibre & end products
Business case

7.5.1 Expected market

Table 27: F5 indicator – Expected market

Category	# of interv.	# of interv.	Category
Market push	8	6	Market pull
Need to operate in response to market insights	6	3	Operate in response to market insights
Lack willingness to purchase sustainably	5	3	Willingness to purchase sustainably
No market questioned prior to engagement	1	3	Expected market foreseen
Lack of market	8		
Market pull needed	5		
Market research needed	5		
		1	Transition - better understanding of the market

The data in table 27 show that six interviewees mentioned the innovations to have been developed following a market demand (market pull). Particularly for the potting soil sector which has the ambition to use more sustainable resources, as it is considered a CO_2 emitting sector in the eye of the public.

Nevertheless, eight interviewees considered there to be a lack of a market. This makes sense as different cases target different end-products and consumers. Roughly the same eight interviewees also considered the innovations to be developed by a market push, particularly from a cost reduction perspective of the waste producers. Buyers and users of end-products are not always engaged in the innovation development.

> *"See, the point is, all those parties that have biomass, they tend to make something and go sell it on the market. It's a kind of force-feeding, force-feeding of geese in France. They ask you to open your mouth, and then they push all kinds of grass-fibre in there, and then they push your jaw together, they assume that it is very tasty and then they say how much do you want, huh?"*

Interviewees mention the need for a concrete market pull and to operate in response to market insights, rather than pushing the innovations onto the market.

> *"The market can solve many things. But viewed from a demand perspective and not from a supply perspective… That is why I do not believe that governments should push us and ask what kind of sustainable processing everyone has. And so on"*

The data also show that there is a divided opinion if the market is willing to pay for a sustainable option. More importantly, the sustainability gain from the innovative products is not always clear (table 28) and varies per product: potting soil, paper, and isolation materials.

Table 28: Sustainability

Category	# of interviewees
Roadside grass product has higher Environmental impact	1
Roadside grass product has lower Environmental impact	2
No difference in LCA	1
No fair LCA on alternative fibres	1
Short lifecycle grass product	1
Unclear if roadside grass has lower environmental impact	4

This also allows the research to conclude that the motivation for the market push is primarily cost-cutting. If the market push would be environmental, there could be more arguments to convince the market, even at a higher cost.

7.5.2. Quality assurance of products

Table 29: Indicator - Quality assurance of products

Category	Subcategory Level 1	Subcategory Level 2	# of interv.
Quality requirements			11
	Product quality requirements		9
	Mowing requirements		3
		Length	1
		Humidity	1
		Method	1
		Season	1
	Quality requirements problematic		5
		Difficult to achieve correct specifications	3
		Unfamiliarity with ideal specs	2
		Customer requirements too high	1
		Need flexibility in resource demands	1
	Quality requirements not problematic		4
		Grass specs achievable	4
	Need for quality requirements		2
		Through contracts	1
		Verge vegetation	1
Certifications			3
	Certification potentially problematic		1
	Certification requirements		1
	Certification upon request		1
	Increased interest in certified products		1

Industrial use of grass-fibre requires different quality grass clippings than composting. Industrial use requires a constant quality in terms of length, strength, humidity, and composition, which translate into, amongst others, seeding and mowing requirements. As such, organizational change is needed, and is not simply achievable.

Currently, there is a divided image on the quality of the grass (products); whilst some say it is possible to achieve the correct grass specifications, others disagree (table 29). This shows that in terms of quality, improvements are still necessary.

Furthermore, product and process certification is not an essential part of the development phase and depends on the end-product. For example, in the potting soil sector phytosanitary certification is a must and not meeting standards can pose a threat to the scale-up. Interestingly, certification standards become important when consumer demands are taken into consideration. Again, this points to early engagement with end-product producers and consumers in the development stage.

7.5.3 Cultural & psychological factors

Table 30: F5 Indicator – Cultural and psychological factors

Category	# of interv.
Product adaptation is challenging	2

For most end-products in this study, (bio-composite, potting soil, insulation panels) the research did not find cultural or psychological factors that hampered market penetration. Two respondents mentioned that the paper market did not like to see grass in the end-product, posing a threat to the scale up (table 30).

> *"...You have large organizations that say yes, well, all those [grass] specks are so disturbing because people are used to virgin white. Yes, then it actually stops there."*

7.5.4   Cost of fibre & end-products

Table 31: F5 indicator – Cost of fibre & end-products

Category	Subcategory Level 1	# of interv.
Unclear cost competitiveness		11
Price not competitive		10
Competitive markets or topics		4
	Composting	4
	Biodiversity	1
Price competitive		3
Need change perspective grass cost		2
Need to be price competitive		1

The data in table 31 show a clear image that the price competitiveness of the grass-fibre and end-productss is either not present or unclear. In combination with an unclear environmental/circularity advantage, as added value for the end-user, market penetration becomes problematic.

The data also show that there are competitive interest for the use of verges and its grass clippings. Firstly, using grass clippings in composting is part of the present business model for waste processors. Secondly, there is a public interest in the use of verges for creating biodiversity. Biodiversity asks for non-homogeneous seeding, while grass-fibre markets ask for a homogeneous fibre (product).

The creation of biodiversity is a public task and fits public parties, like road managers & municipalities, better than the task of grass supplier to the private sector. Perhaps it is possible to focus on creating biodiversity through subsidies and save costs.

Table 32: F5 indicator – Business case

Category	Subcategory Level 1	# of interv.
No profitable business case		7
	No feasible business case	5
	No revenue model	2
Business case strategies		5
	Combination old & new	1
	Hubs	1
	Transition in revenue model	3
Need to profit from innovation		3
Unclear business case		2

According to seven interviewees the business case of the innovations is not profitable (table 32), meaning the innovation is unable to sustain itself in the long-term. Amongst others, high processing costs and relying on subsidies without a perspective market are detrimental for the business case.

> *"An entire chain has to be developed in advance to offer the right quality, quantity and [continuity] to grass-fibre customers. And that will cost a lot of money. ... I can sit down and set up the whole innovation chain, but I can't make a living from it yet. So, I'm just going to throw it [the grass] to composting because it is not worth it. And we're stuck on that."*

Four interviewees mention strategies that could help with the business case. Amongst others, the importance of creating hubs to ensure minimal transport costs, and a transition in the current revenue model. Rather than considering grass as a waste product and paying waste processors to get rid of the grass clippings, interviewees express the need for considering grass clippings an input for compost and other products and have waste processors to pay for the grass clippings and increase the revenue from compost, biogas, fibres, and other grass products.

> *"So, the time of pre-payment, ..., for delivering [grass] to such a company [waste processor], ... is over for me. In fact, waste processors should pay for it [grass]. Basically, a BVOR member should say 'Rijkswaterstaat, what do you want for that grass? Come here with it and I pay so much for it."*

> *"... It's not waste processing, it's becoming a raw material producer, that's actually the idea. But, as long as most of the money is earned up front as waste [coming in], then that transition [to raw material producer] is, of course, harder to make."*

7.5.6 Main conclusion F5: Market formation

Although there is a growing demand for biobased products, grass-fibre innovations start from a cost cutting perspective. The question 'What's in it for the market?' comes in too late in the process.

The markets want a constant supply of a constant quality and competitive product. Competitiveness can be either in quality, in price or in environmental impact. Currently all three are either insufficiently competitive or unclear.

Somewhere in the innovation process the competitiveness needs to become clear and the market has to start pulling, otherwise a business case can't be made. Without a business case mobilization of resources is compromised.

While market formation is a function in the scale-up, paying attention to market demands is important in the development process. The sooner end-product consumers participate in the innovation process the better.

7.6 F6: Mobilization of resources

Mobilization of resources was assessed by means of the following indicators: *Availability of relevant skills, Capability of the technology/infrastructure, Financial resources (Subsidies & investments), Quality of the input resources (grass & fibre)*, and *Quantity of the input resources (grass)*. Emerging from interview data, quality of the end-product was included as an indicator (table 33).

Table 33: F6 indicators

Indicators F6 Mobilization of resources
Relevant skills & Educational needs
Capability of the technology/infrastructure
Financial resources
Quality of input resources
Quality of end product
Availability of resource

7.6.1 Availability of relevant skills

Table 34: F6 indicator – Availability of relevant skills

Category	# of interv.
Limited knowledge	4
Qualified personnel problematic	1
Transition in knowledge	1

Interview data shows that interviewees expressed limited knowledge present in the waste sector (table 34). In general, there has been a transition in the knowledge availability. Initially there was limited knowledge of innovation processes in the sector and little knowledge about grass-fibre (extraction) and market. Over time knowledge on the technology and processes has been built.

> *"We are now in 2020/2021 and when we started in 2013, ... over 7 years ago. It was a completely different time-period. At the time there was a completely different picture of the situation of the market. If you would do it again, then I think the market is much better prepared. There is much more known now. ... That wasn't the case then."*

Partner characteristics, (intrinsic motivation, perseverance), team composition (including market partners early) and innovation process management are important learning points but can come in too late in the innovation process or not at all. Some partners may have already disengaged from the process.

> *"... the person who led the process, who should also have done a bit of acquisition. There were some competencies missing there, so to speak, or it is a difference in opinion. ... But there were quite a few gaps there."*

7.6.2 Capability of the existing technology/infrastructure

Table 35: F6 indicator – Capability of the existing technology/infrastructure

Category	Subcategory Level 1	# of interv.
Challenges with tecnhology		8
	Unfit for alternatives	8
	Ability to withstand scale up unclear	1
Infrastructure needed		6
	To scale up	5
	Letter of intent (LOI)	1
Infrastructure lacking		5
	Cannot withstand scale up	4
	For pilot	1
	Market needed to scale up	1
Technology is not the problem		3
Sufficient infrastructure		2
	Can withstand scale up	2
Scale up in stages		1
Description of existing infrastructure for innovation		7

According to the data in table 35, there is existing technology/infrastructure for pilot phase, however for the scale up it has its flaws, and investments in the technology and infrastructure is needed. For example, the innovation may involve manual labour, or the refinery is not sufficient and disturbs the production process of bio composites.

> *"... a failure factor is that the entire process cannot be mechanized yet. .... It is mixed manually. It's real manual labour. That really has to be mechanized, otherwise you'll never have a competitive product. Then it becomes way too expensive."*

In pilot scale these problems occur and can be solved, but for a scale-up considerable investment in new technology or infrastructure are required.

7.6.3 Financial resources (subsidies & investments)

*Table 36: F6 indicator - subsidies * investments/financial resources*

Indicator	Category	Subcategory Level 1	# of interv.
Sufficient financial resources			8
	If will is there		7
	For research		3
	For scale up		1
	Byproducts important for success		1
Financial resources lacking			8
	Unwilling to invest		6
	Insufficient finances		5
	Unforseen financial costs		2
Need for investments			3
Investor lacking			2
Lacking sibsidy for scale up			2
Critique on finance distribution			1
Origin of finances			4
	Private investments		3
	Public subsidies		2
Finances challenging to secure			4
	Actor responsible for investments unclear		2
	Investor challenging to secure		2
	Subsidy grant challenging		1
Sufficient finances questionable			1

Interviewees agree on the fact that there are sufficient financial resources among the innovation partners (table 36). The problem is committing the resources to the innovation. The latter is only done when there is a clear incentive, such as a market pull or sustainability advantage.

> *"We have entire business cases laying on a shelf, we have factory drawings, you name it. But we have never really seen a sufficient market to pursue this. If a sufficient market develops, we will take it off the shelf, invest in it, and it will run within a year."*

Interviewees point to a difference between the development phase where investments are relatively low and subsidies are available and the scale-up phase where investments are higher, subsidies are less available and desired, and financing is dependent on clear business case, including a market

> *We always try to do it without subsidies, because it also has to be a sustainable economic model, an economically sustainable model. Otherwise, it will be of no use to us in the long term"*

Interestingly, RVO subsidises mostly the (pre)-development stage, and while sometimes asking for proof of market interest, RVO does not require market engagement.

R=Researcher
I= Interviewee

R: "But it is not the case that customers or a sales market should be part of a subsidy application?"

I: *"Well, preferably, well, yes. [...]"*

R: "*[...] But it's not a requirement?"*

I: *"I think sometimes, yes, yes. But I don't know about all the arrangements. [...]"*

7.6.4 Quality of the input resources (grass & fibre)

Table 37:F6 Indicator - Quality of the input resources (grass & fibre)

Category	# of interv.
Quality is problematic	12
Quality cannot compete	9
Quality grass (fibres) affected by verge characteristic	9
Quality competitiveness questionable	7
Quality is sufficient	4
Quality not problematic	4
Quality can compete	3
Questionable quality	2
Need quality grass	2

From the data in table 37 it is clear that the quality of grass(fibres) is problematic and cannot compete with (conventional) alternatives. In particular, pollution, grass composition, and fibre strength are problematic.

The quality of the grass(fibres) are variable and depend amongst others, on the location, the season, and mowing technique. Interestingly, one interviewee suggested that instead of trying to strive for a flow of constant quality, the quality of the clippings in a lot should be assessed to determine its use in bio-composite, paper or composting. This would be helped by a concentration of different users in the same locations. The Grassbloxxx concept, whereby different product producers are in a hub, allows for this approach.

"At this moment we are, ... we can always process the overflow. Suppose a truck is not good enough to make fibres, well then it just goes into the process, and you can make a nice homogeneous product from it in the form of compost or something else."

7.6.5 Quality of the end-products

Table 38: F6 indicator – Quality of the end-products

Category	Subcategory Level 1	# of interv.
Quality competitiveness questionable		4
	General quality	3
	Lifespan	2
Sufficient quality		3
	Attractive	2
	Sufficient quality	1

The data in table 38 show a divided image on the quality competitiveness of the grass-fibre end-products. None of the interviewees mentioned the quality of the end-product to be (noticeably) better than the product it aims to substitute.

7.6.6 Quantity of the input resources (grass)

Table 39: F6 indicator - Quantity of the input resources (grass)

Category	Subcategory Level 1	# of interv.
Availability of resources is questionable		10
Distance between resources		8
Need to secure (continuous supply of recources)		7
Availability of resources not problematic		7
Insufficient resources		5
Availability of resources problematic		5
Grass preservation		1
Not neessary to use own [waste streams for biobased products]		1

The data show a scattered image on the availability of sufficient grass as a resource. Whilst ten interviewees claimed the availability to be questionable, seven mentioned it not to be problematic, and five considered it problematic (table 39).

Interestingly, interviewees that claimed sufficient availability of grass-fibres for their innovation, also recognized that there might be insufficient supply for the scale up of multiple grass-fibre innovations.

> *There was sufficient material [grass-fibres] available... But we are the largest machine factory in the Netherlands. So I had the idea that we already secured all roadside grass before the others got a bit of fibre, so I don't know whether that [sufficient quantities of grass-fibres] applies to the whole of the Netherlands.*

Of importance is not only the quantity but also the continuous supply of grass as a resource. Roadside grass is a seasonal resource and requires grass storage for continuous supply year-

round. The data in table 40 show that there is a divided image on whether it is problematic or not.

Regarding grass storage, interviewees made clear that when grass is stored wet, biological activities take place, reducing the quality of the grass over time. Mowing regimes however are planned with unpredictable weather conditions, thus dry grass is not guaranteed.

The distance between the verge, the fibre extraction plant and the end-product manufacturer is also critical. Minimal transport is desired, otherwise the cost-effectiveness is jeopardized.

Table 40: Insight into the indicator "Quantity of the input resources (grass)" categories

Category	Subcategory Level 1	# of interv.
Availability of resources is questionable		10
	Grass storage is challenging	8
	Sufficient volumes resources questionable	6
	Continuous supply bermgras is questionable	3
Distance between resources		8
	Need minimal travel distance of resources	7
	Problematic distance between resource & infrastructure	4
	Specified limit for grass transport	2
	Non problematic distance between grass & infrastructure	1
Need to secure (continuous supply of recources)		7
Availability of resources not problematic		7
	Sufficient volumes of resources	6
	Grass silage not problematic	5
	Grass is stored (silage)	3
	Continuous supply bermgras resources	1
Insufficient resources		5
Availability of resources problematic		5
	Grass is seasonal resource	4
	Continuous volumes bermgras is problematic	1
Grass preservation		1
Not neessary to use own [waste streams for biobased products]		1

7.6.7 Main conclusion F6: Mobilization of resources

Regarding relevant skills, the innovations lack someone with the experience to oversee and manage the whole innovation process. This is also reflected in the need for someone who can lead the innovation process, discussed in section 8.1 (Function 1: Entrepreneurial experimentation).

For pilot quantities a functional technology has been found, however, there are some steps where technology is not yet sufficiently developed to scale-up to larger quantities successfully. There is insufficient suitable storage and production infrastructure available for the scale-up in almost all the cases at hand. There is a need for considerable investments of either adaptation of the present technology, or investment in new technology and infrastructure to make it suitable for scale-up.

Financial Resources are available, but the business case is not very clear and therefore resources are hard to mobilize:
- Are grass-fibres competitive in price?
- Are grass-fibre qualities competitive?
- Is grass-fibre a more sustainable alternative?
- Is there a market for the end-product?

For all four aspects the answer is not a very loud and clear "yes", but the answer is rather problematic or unclear. From this it can be concluded that the market demands probably much more than the grass (fibre) can deliver.

7.7 F7: Counteracting resistance to change

Counteracting Resistance to Change is initially assessed by the indicators *Lobbying* and *Marketing. Resistance to change* emerged from the data and was added as an indicator (table 41). All three indicators are discussed below.

Table 41: F7 indicators

Indicators F7
Counteracting resistance to change
Lobbying
Marketing
Resistance to change

7.7.1 Lobbying
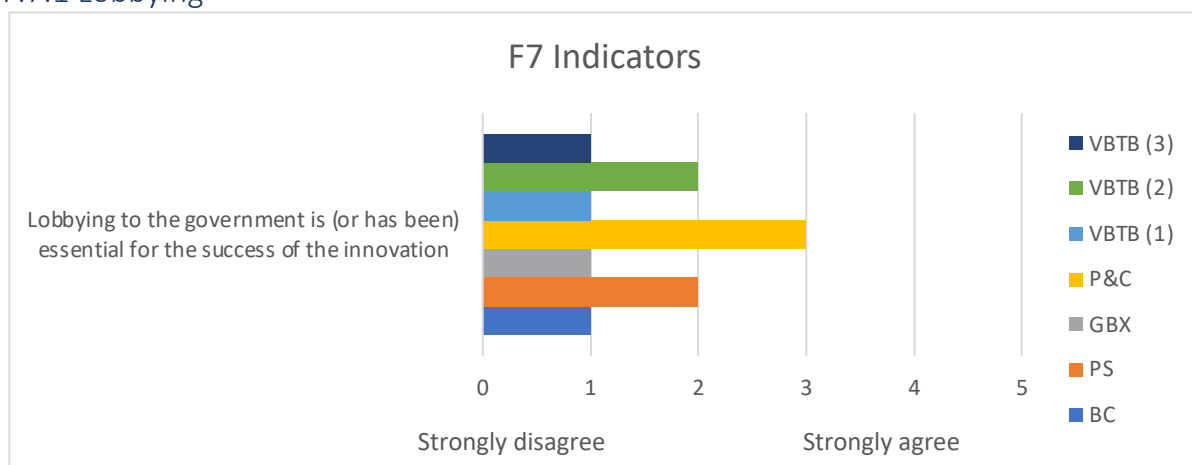
Figure 7: Survey results G7 Lobbying

From the pre-interview survey, lobbying (the Government) was not considered essential for the success of the innovation (figure 7).

The observation that Government procurement practises are still reigned by "old economics", and the divided image on Laws and Regulations, point to the need for a larger effort in lobbying.

7.7.2 Marketing

Table 42:F7 indicator - Marketing

Category	# of interv.
Marketing actively needed	4
Insufficient marketing	1
Incorrect marketing	1
Marketing done	1

From the interviews and pre-interview survey it became clear that marketing is considered essential by the innovating partners (table 42 and Appendix V). However, it remained unclear

whether the innovating partners feel they invested sufficiently in marketing. One interviewee claimed that the innovation was insufficiently supported through marketing (table 42).

> *"Oh, yes, I don't think that that [marketing] happens enough .... It is really necessary to tempt end partners so that they start engaging. And not from the idea 'you have to have this', but that they themselves are intrinsically motivated themselves."*

> *"Because putting it [roadside grass clippings] in a product, not telling the customer, and putting the price advantage in our own pocket. Yes, it is a conceivable direction, but it is simply not possible with grass."*

The quote above illustrates that simply expecting consumers to pay for the (more expensive) alternative product is unlikely to succeed. Consumers need to be made aware of what the added value is of the grass-fibre products in order to persuade them into purchasing. Actively marketing has the potential to do so.

7.7.3 Resistance to change

Table 43: F7 indicator – resistance to change

Category	Subcategory Level 1	# of interv.
Resistance to change		6
	Actors support conventional resource extraction	1
	Actors not willing [eager] to change to alternative	5
Negative impact lobby on innovation		2
	Lobby against grass resource and benefits	1

From the research it emerged that sustainable (grass-fibre) innovations experience resistance to change from a variety of actors and for a variety of reasons (table 43), examples include:
1. Ownership of peat mining areas by potting soil companies, makes them reluctant to engage in grass-fibre potting soil;
2. The existing business model of the composting industry, who receive a fee at the front gate as waste managers and receive a second time when selling compost, makes them reluctant to engage in the grass-fibre innovation;
3. The lesser costs of (oil based) alternative resources;
4. Unfamiliarity of the products;
5. And the slight difference in the 'look & feel' of the products.

> *"They [oil companies] don't want to keep it in the ground. It is the same with peat farms. Of course they didn't buy those peatlands because it's so beautiful. They obviously want to excavate and exploit it, so yes. They would still continue to use peat."*

> *"...It touches their [waste processors] business model. That's one. Straight away. They will immediately notice it at the gate."*

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> *"Somehow people don't want to get rid of that virgin oil-based plastic. It is also cheaper than recycled. But, apart from that, it's so standard that somehow, uh, individual companies can't and can't partially make that transition. … In fact, you also have that with grass-fibre."*

> *"… often the unknown makes it unloved. The look and feel is sometimes slightly different and you always have to have a little better than what it was before people want to switch."*

7.7.4 Main conclusion F7: Counteracting resistance to change

In general, the picture emerges that there is insufficient attention from the innovation teams for the reasons of resistance to change from various actors. This is reflected in low or absent lobbying activities and an unclear marketing strategy. In the development phase there is little threat to other actors, but in a scale up phase it becomes more evident. Engaging the market early on in the innovation process can help limit the resistance to change.

8   Discussion

This section aims to discuss the findings in section 8, and answer the Research questions sub questions:
- What is the structure of the Technical Innovation System surrounding the grass-fibre innovations?
- Are there barriers at system level that inhibit the system from functioning successfully?
- Are there drivers at system level that help the system function successfully?
- Can the identified drivers and barriers be used to identify which inventions are more likely to become successful innovations and thus worth of investing in?

8.1 The Technical Innovation System and its barriers & drivers

The findings from the case study interviews presented in the results chapter, allow for a general understanding of the TIS for grass-fibre innovations. Table 44 shows a summary of the main conclusions per function, and whether there is still room for improvement in the respective function. Functions that have room for improvements are indicated with an "RFI". Functions that do not necessarily need improvements are indicated with a "OK". Overall, all the functions but one are in need of improvement.

Table 44: Main conclusions per function and function fulfilment assessment

TIS function	Main conclusions	Room for improvement (RFI)/OK
F1: Entrepreneurial experimentation		
	1. It is challenging to retain partners in the innovation as there is no market outlook and end-users are not engaged early on in the innovation process.	RFI
	2. Ideally the innovation team: a) represents all actors in the value chain, including end-users b) is composed of intrisically motvated partners, and c) is led by someone with experience who can oversee the complexity of an innovation process. In the studied cases mostly a & c have been lacking.	
	3. Implementing the necessary organizational change, especially for public entities like road managers, to play a role in a market driven innovation is challenging.	
F2: Knowledge development		
	1. Technical knowledge development is not an issue anymore, it is now the market that needs to pull the innovation.	OK
F3: Knowledge exchange		
	1. Information sharing & value chain collaboration are important for success, but currently innovations have limited to no knowledge sharing with end-product consumers and producers.	RFI
F4: Guidance of search		
	1. There is a discrepancy between Government vision and procurement actions. Governement procurement prioritizes economics over sustainability.	RFI
	2. Laws and regulations are generally experienced as problematic but are not necessarily a bottleneck if properly managed.	
	3. There is a general need for innovating laws & regulations, that not only regulate the present, but also anticipate the future and help innovations.	
F5: Market Formation		
	1. The innovations are currently being pushed onto the market whilst the competitiveness of the grass fibre (products) in terms of quality, price or environmental impact is either insufficient or unclear, making market penetration difficult.	RFI
	2. It is necessary that the market starts pulling, otherwise a business case cannot be made. Including end-product users in the innovation process can help secure the market.	
F6: Mobilization of resources		
	1. The innovations teams lack someone with the experience to oversee and manage the complexity of an innovation process.	RFI
	2. The technology and infrastructure available are sufficient for innovations in a pilot phase. However, to scale up considerable investments are needed, while market outlook is unclear.	
	3. In order to mobilize resources for continued investment a clear business case and market outlook are needed.	
F7: Counteracting resistance to change		
	1. There is insufficient attention from the innovation team for reasons of resistance to change. Lobbying activities and marketing strategies are currently only limited.	RFI
	2. Engaging the market early on in the innovation process can help counteract the resistance to change.	

System drivers & barriers

The findings summarized in table 44 contain several reasons as to why the innovations currently do not manage to scale up. The most important barriers are:

1. The innovations originate from the perspective of cost reduction for one partner without clear benefits for the other value chain partners remain to be discovered in the innovation process.
2. There is a late engagement of consumers/end users in the innovation process.
3. Grass-fibres are, depending on the end-product they are used in, not convincingly competitive in terms of quality, price, and sustainability.

4. Considerable investments needed in technology & infrastructure while there is an unclear competitive advantage on the fibre market.
5. Government vision not aligned with laws & regulations, as well as Government actions and procurement.
6. A lack of innovation leadership and management experience amongst the value chain partners.
7. Difficulty implementing organizational change.

The most important drivers are:
1. Smart Management of existing laws and regulations, such as the waste status, creates legal space for the innovation.
2. Motivation & perseverance.

It is important to note that although they are singled out as individual barriers, they are also interlinked in the innovation process. An elaboration on the different drivers and barriers is provided below.

Barriers

Market push

In practice innovations can start at different points in the value chain, shown in white (figure 8). In red, are the starting points of the different cases. Orange indicates which other actor types were involved in the innovation process of each case.
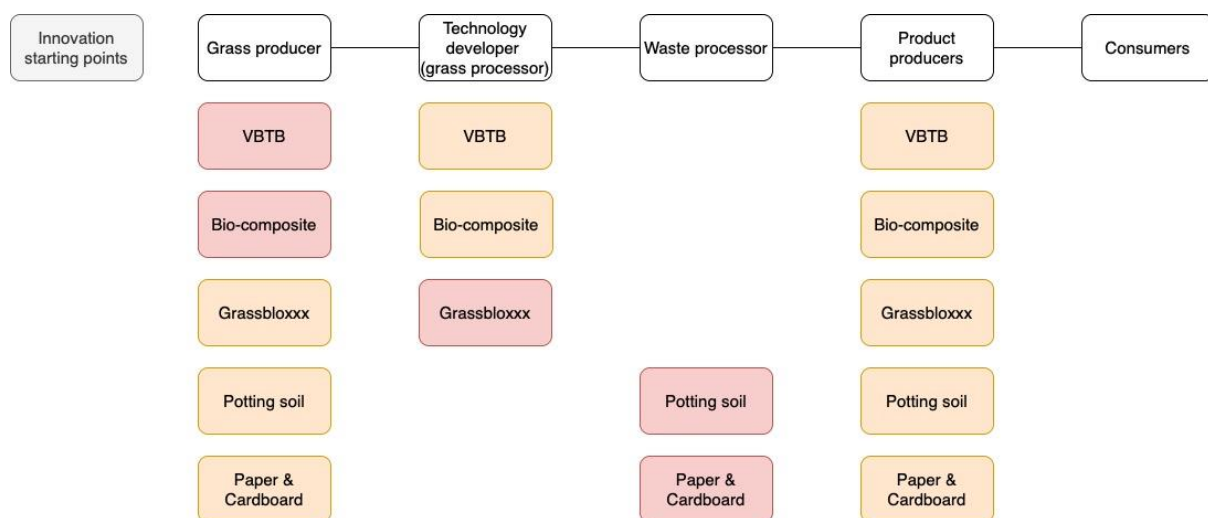

Figure 8: Starting points and actors involved in the different cases.

For the cases in this research the innovations started either at the grass producer or at the grass processor/technology owner who then attempted to penetrate the (fibre) market with their products, rather than responding to a market demand for grass-fibre products. According to Gerpott (2005, as cited in Brem & Voigt, 2009), if the technology is pushed onto the market there is no certainty that it will be able penetrate the market (table 45). The outcome of the "market push" in grass-fibre innovations has not been successful. Consequently, organizations now aim to develop their innovations in response to a market demand, also known as a "market pull" (BUN-K, 2019).

According to Pierson, Mante-Meijer and Loos (2011), a market push alone is not sufficient for consumers to adopt the product. A change in customer behaviour is needed (table 45). Furthermore, without a specific market demand for grass-fibre products, there is a higher necessity for the innovations to prove sufficient quality, alongside reasonable pricing, and/or environmental or social benefits in order to mobilize resources for scale-up and penetrate the market. As grass-fibres innovations have been unable to prove its competitiveness, market push has been problematic.

Table 45: Differentiation technology push and market pull Gerpott (2005, as cited in Brem & Voigt, 2009 p.256)

Description/attribute	Technology push	Market pull
Technological uncertainty	High	Low
R&D expenses	High	Low
R&D duration	Long	Short
Sales market-related uncertainty	High	Low
Time-to-market	Uncertain/ unknown	Certain/known
R&D customer integration	Difficult	Easy
Kinds of market research	Qualitative-discovering	Quantitative-verifying
Need for change of customer behavior	Extensive	Minimal

Figure 9 shows the present market dynamics and the difference in dynamics between a market push and market pull. In a market push scenario, the verge owner and fibre producer/technology developer are more invested in the innovation and can see a direct financial benefit besides any other motivations. The product manufacturer and end-user are looking for any competitive fibre resource, not limited to grass-fibres. In a market pull scenario the dynamics change. Product manufacturers respond to a demand for a more competitively priced, sustainable and/or circular product that meets a certain quality standard. Fibre producers will seek to respond to that demand and might or might not find a solution in grass.

When an innovation starts from a market push scenario somewhere along the road the innovation needs to transition from a market push to a market pull scenario. This will only happen if grass-fibre is the better option for the end-user and product manufacturer. In a push scenario the quest for the innovation team is to find out in which end-product grass-fibres will have their largest competitive advantage. In a single-use innovation like van Berm tot Bladzijde this quest is neglected which makes it vulnerable for failure.

PRESENT MARKET DYNAMICS

Verge owner
Tasked with road maintenance, produces grass clippings as waste, and pays waste handling fees.

Waste processor/ compost producer
Paid to take in the verge waste, processes it into compost and sells the compost on the market.

Compost end-user
Buys compost at a reduced price, as the compost production is de facto subsidized by waste handling fees.

Note: Compost is a circular and sustainable product, (although contributing to methane production), making the competive advantage of alternative use of grass clippings in terms of circularity and sustainability hard to prove.

MARKET PUSH

Verge owner
Looking for cost reduction and a circular and/or sustainable high value use of its produced waste.

Fibre producer/ Technology owner/developer
Looking to apply its technology at a profit and contribute to a sustainaible circular economy.

Fibre processor/ product manufacturer
Looking for a suitable competitively priced circular and sustainable constant quality fibre for its products, not necessarily grass.

End product user
Looking for competitively priced circular and/or sustainable quality products, not necessarily made with grass.

MARKET PULL

End product user
Looking for competitively priced circular and sustainable quality products, not necessarily made from grass.

Fibre processor/ product manufacturer
Looking for competitively priced circular and sustainable constant quality fibre alternatives for its products.

Fibre producer/ Technoly owner/developer
Looking for competitively priced circular and sustainable quality fibre sources for its clients, willing to consider grass.

Verge owner
Offered an oportunity to make a profit or realize a cost reduction and a sustainable use of its waste.

Figure 9: Present market dynamics, and the difference between a market push and market pull scenario

The innovations discussed only engaged the market late in the innovation process affecting almost all functions of the TIS. For example, partners stopped due to insufficient trust in the business case and resources were immobilized, and insufficient knowledge exchange.

This research points to the importance of the role of Market Formation within the technological development and pre-development phase (phase 1 and 2), figure 10b. The TIS describes four phases, pre-development, development, take-off and acceleration, (figure 10a). In each phase different functions are important and interact with other functions. In the TIS diagrams from Hekkert, markets formation seems to have the "external" role to absorb the outcome of the technological development (Phase 1 and 2). Dewald and Truffer (2011) also criticized the TIS for paying little attention to structures and processes to end-user markets in early development phases whilst they play an important role in the long-term success of the innovations.

In this research it was clear that early engagement impacts several functions of the TIS. For example, early inclusion of market players will lead to:
1. Better knowledge of the market, its players and alternatives;
2. A better insight in market dynamics and demands;
3. A better product for the market;
4. A better business case, and consequently motivating partners to pursue and continue investing in the innovation;
5. And less resistant to change from important market players.

Furthermore, early market engagement can either contribute to the success of the innovation, or an abandoning at an early stage. Both are favourable outcomes compared to a prolonged investment in an eventual failure.
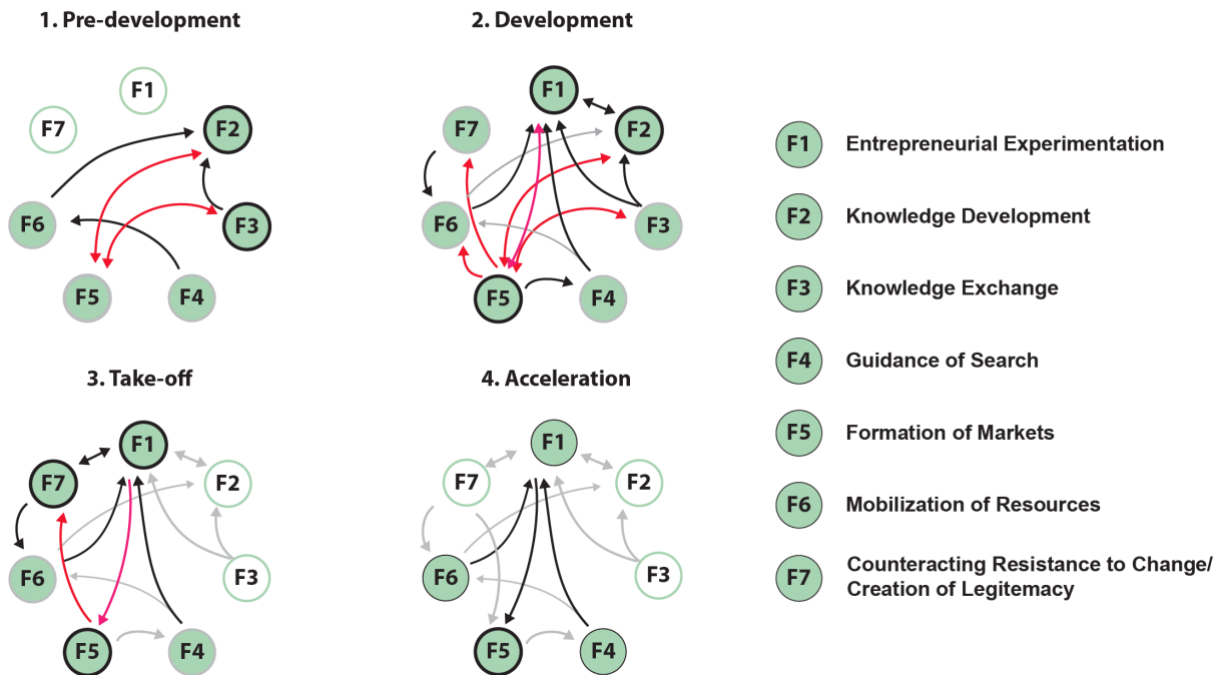
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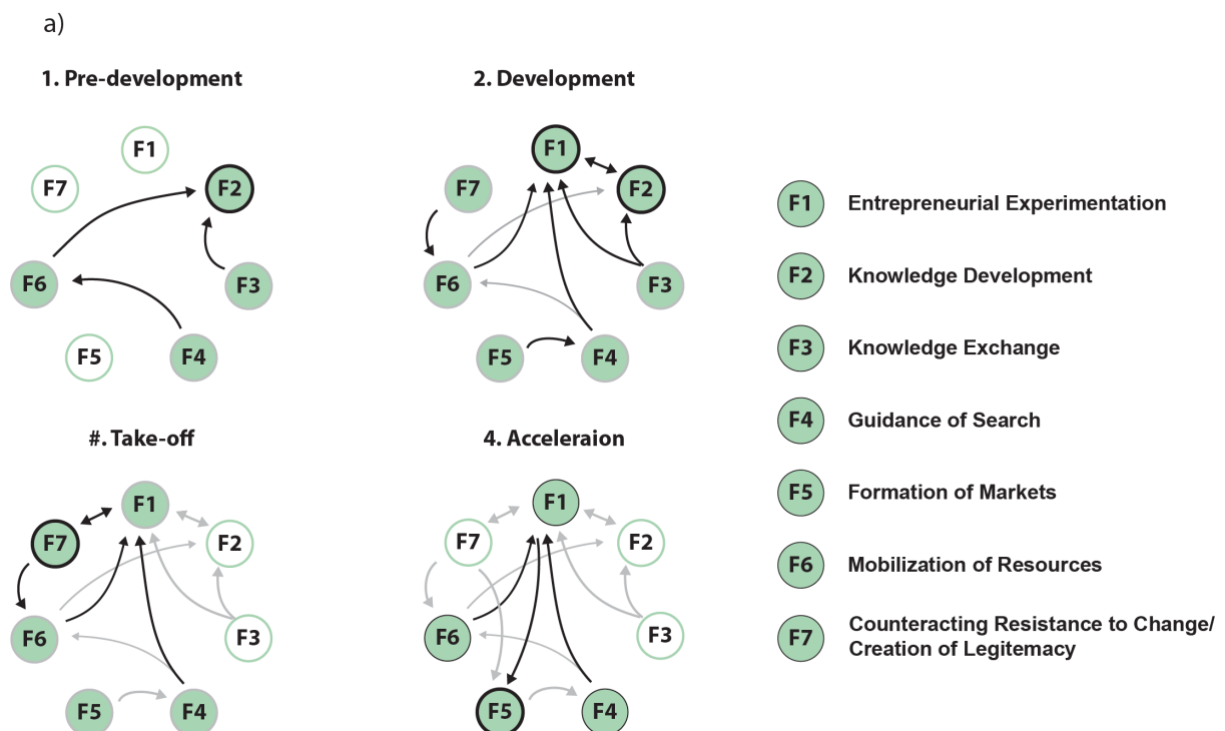
b)

Figure 10a & 10b: Stages of innovation and respective important functions (Hekkert et al., 2011)

Per phase "The black arrows are the relations that occur in the current phase, whereas the grey arrows represent the relations that occurred in previous phases and are still occurring in order to further improve the development of the technology into 2nd or 3rd generations." (Hekkert et al., 2011, p.11). Red arrows are new insights regarding the importance of market formation and its relations. The green circles outlined in black are critical in the current phase, the green circles outlined in grey are important supportive functions, and the white circles are considered less critical in this phase.

Non-competitive grass-fibre

Roadside grass is a major waste stream and the innovations at hand have been developed from the perspective to reduce maintenance costs. An unclear and non-competitive price-quality-environmental ratio has proved market penetration to be difficult and consequently resulted in a difficulty to maintain partners engaged in the innovations and mobilize the resources for scale-up.

Regarding quality, roadside grass is the least wanted among the grasses, as it has higher pollution levels and a lower strength compared to other grasses and alternatives such as hemp, heather grass, and grass from nature areas (also already recognized by Gielen (2020)). Only a limited percentage of grass-fibres can be used as substitute if quality of the end-product is to be maintained. Whilst companies are sometimes ok with sacrificing quality, this should correspond with either a more competitive price or environmental impact of the product.

The price of the grass-fibre however has not proven to be competitive (also mentioned recognized by Gielen, (2020) and Den Ouden Group B.V. (2019)). Reaching acceptable quality of the roadside grass-fibres corresponds to high processing costs (also already recognized by Gielen (2020)). In addition, roadside grass sometimes comes from afar, increasing transport costs (also mentioned by Circulair terreinbeheer (n.d.-a)), and ultimately decreases the price competitiveness of the fibre. Furthermore, the price competitiveness is impacted by market dynamics (also recognized by Joppen (2017)). For example, in 2016 China stopped importing

used paper from Europe, resulting in used paper flooding the European market at low prices, which compromised the price competitiveness of grass-fibre.

An approach, as proposed by Grassbloxxx, where grass clippings are separated in different components, like proteins and fibres, that are fed into a variety of products by different industries operating on the same location, reduces transport and storage costs, while increasing the beneficial use of grass clippings. This approach is potentially more successful and less vulnerable than single streams like grass clippings into grass-fibre for making paper and cardboard. However, it is also more complex to manage (Interviewee G, personal communication, June 29, 2020). Single streams favour a constant feed of a certain grass-fibre, while multiple streams allow selection and direction of the different incoming streams to certain applications (e.g., fibres for potting soil, insulation, bio-composite).

Lastly the environmental benefit for the use of roadside grass-fibres is not always clear nor competitive. The present use of roadside grass in producing organic compost is already a circular process and supports amongst others, food production. In terms of circularity, the added value of an alternative use of roadside grass depends on the end-product. Grass-fibre as a substitute for wood and used paper fibre, in paper and cardboard, has a lower impact on the environment and circularity than substituting cement fibre in concrete. When the environmental benefit of using roadside grass in end-products is clear, Government and market players are more likely to align their actions with their sustainability targets and facilitate market penetration.

According to Porters (1980) generic strategies, in order for a product to have a competitive advantage it either needs to be cost competitive or be able to differentiate itself from other products. It bears the question if the innovations are not asking for too much from the grass-fibres. It is therefore important to first establish *if* there is an added value of roadside grass for the market. Then it is important to make it known, incentivizing the market to purchase the products.

Investments needed for technology & Infrastructure

In line with with Kemp, Schot & Hoogma, (1998), Nevzorova & Karakaya, (2020) and van den Bergh et al. (2007), who identified infrastructure and the compatibility and or flexibility of the technology as a success factor, this research considers it as a barrier for innovation.

Currently the innovations are often technically possible but focus on the pilot (technology) development. Consequently, the developed technology is sometimes not fit for market quantities (scale-up), (also recognized by Den Ouden Group B.V. (2019) and Joppen (2017)). For example: interfering substances such as grass proteins only really become problematic when paper needs to be produced in large quantities. To produce bio-composites from grass cuttings one part of the process is still done by hand. Whilst this can be done for small scale product testing and production, it is not feasible for the scale up. Thus, meeting market demands in terms of quality, quantity, availability, and costs need a considerable investment in adaptation of the present technology or investments in new technology and infrastructure. Innovating parties, however, are only willing to invest in the infrastructure if there is a clear business case (also recognized by AEC (n.d.-a)). Thus, it is important to engage the market early in the innovation process.

Vision, laws & regulations, and actions

Governmental (sustainability) visions, laws and regulations, and Governmental actions are currently not aligned. The development of grass-fibre innovations are indirectly encouraged through general (Governmental) sustainability visions and targets. However, Governmental actions, such as procurement, are not supportive towards sustainability and the innovations at hand. Laws and regulations, in particular the waste status of roadside grass, tend to complicate the development of the innovations (also mentioned by Gielen (2020)).

Although some interviewees are of the opinion that laws & regulations can be managed, innovating laws & regulations would facilitate the scale up of the innovations. Rather than focusing on the present, laws & regulations should anticipate the future and stimulate sustainable innovation. In this light, laws and regulations are neither a driver or barrier as van den Bergh et al. (2007) and Kemp, Schot & Hoogma (1998) suggest.

It is desirable for the Government to become a major client of sustainable (grass) products and to make her procurement procedures sustainability inclusive (also recognized by Rijkswaterstaat (2020)). As such, setting a sustainable example for potential markets. This will only help if sustainability gains are clear.

Lack of innovation leadership experience

Leadership experience in innovation management is often lacking in the innovation team. An experienced person or team that can oversee, manage, take responsibility, and pull the innovation forward is needed. According to the results in chapter 7, the leader or leading team is intrinsically motivated and has perseverance, and thereby 'fights' for the success of the innovation.

Organizational change

The grass-fibre innovations require business model innovation and organizational change from value chain partners. The tasks and responsibilities of a public entity and waste producer are almost 180 degrees opposite to the tasks and responsibilities of a commercial supplier of primary resources to a demanding market (figure 11).
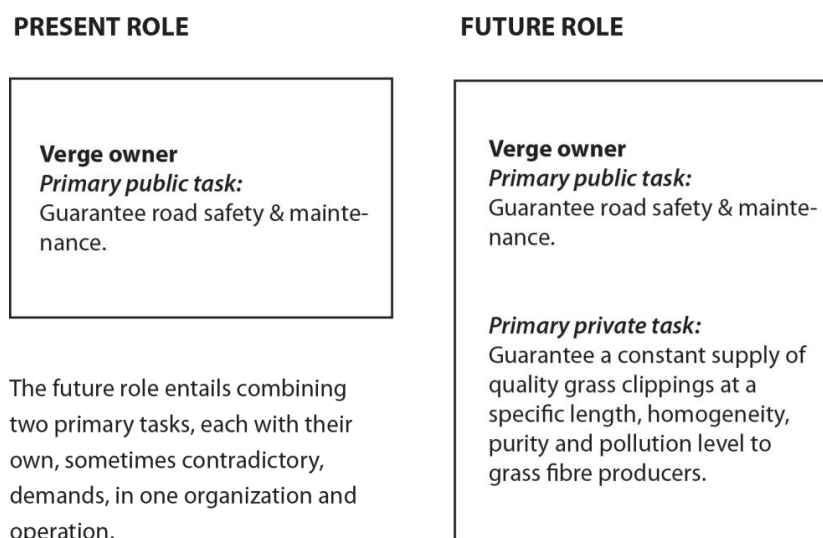
PRESENT ROLE

Verge owner
Primary public task:
Guarantee road safety & maintenance.

The future role entails combining two primary tasks, each with their own, sometimes contradictory, demands, in one organization and operation.

FUTURE ROLE

Verge owner
Primary public task:
Guarantee road safety & maintenance.

Primary private task:
Guarantee a constant supply of quality grass clippings at a specific length, homogeneity, purity and pollution level to grass fibre producers.

Figure 11: Organizational change for grass verge owners

The requirements for grass clippings as a waste material for compost are comparatively low. Grass as a primary resource for high value application comes with a series of requirements for, amongst others, the type, homogeneity, pollution level, mowing techniques, length, storage, and availability. It is therefore to no surprise that the innovations have trouble in achieving the required standards and change in organizational processes.

Whilst barriers to organizational change are often identified (Bojesson & Fundin, 2020; Rosenburg & Mosca, 2011; Zogjani & Raçi, 2015), organizational change itself is not often identified as a barrier. Furthermore, organizational change processes required for business model innovation are often not mapped in supportive tools (e.g., business model canvas) (Chesbrough, 2010), nor is it included in the TIS as an important factor of the innovation's ecosystem.

The innovation process is not only technological, but also organizational. The question, "Can my organization innovate in order to be able to play its future role in the innovation value chain?", should be asked and answered early in the innovation process. This research therefore calls for the integration of organizational change into the TIS framework and other supportive tools.

Drivers

Motivation & Perseverance
The innovations at hand have proven difficult to scale-up. Entrepreneurs that are intrinsically motivated and have perseverance. Intrinsically motivated actors with perseverance are more likely to remain invested in the innovation project in comparison to actors that only engage in the innovation for greenwashing purposes. Particularly when difficulties arise.

Management of laws and regulations
As aforementioned, laws and regulations, such as the waste status, do not facilitate the development of grass-fibre innovations but can be managed such that they were no longer problematic. Smart innovation management is therefore important.

Root problems
Over the past years several technologies to extract fibre from grass have been developed, and a variety of innovative end-products where grass-fibre substitutes traditional fibres have been designed. Whilst the development of innovative products is often not the problem, market penetration and transitioning from a market push to pull is. Grass-fibre innovations have the following challenges:
1. Grass-fibre is not a unique fibre that permits for revolutionary new end-products, rather it aims to substitute fibres in existing end-products, like paper, cardboard, and road signs. The physical properties of grass-fibre, (length, strength, purity), limit its use and competitiveness in the existing markets.
2. The added value or competitiveness of grass-fibre (in terms of quality, price and environmental) on the market is not a constant and highly dependent on the fibre being substituted, and the end-product (paper, potting soil, bio-composite, etc).
3. The supply of grass cuttings for the fibre market requires organizational and operational changes that come at an increased cost, as compared to the supply of grass cuttings for composting.

4. The price competitiveness is also influenced by the approach taken by the innovation. Approaches that combine multiple end-uses around a centrally located fibre extraction plant seem to be more resilient.

The grass-fibre innovations could be labelled as a *substitute innovation* rather than a *radical innovation* Where radical innovation is defined as a newly developed technology in a new (to be created) market (Kennedy, 2020), a substitute innovation aims to replace a product with a more sustainbly competitive product.

The innovation process can/must now focus on where in the fibre market the grass-fibre can have its highest added value, and if the added value is sufficient to build a business case that allow continued investment. Additionally, the actors in the innovation process should re-evaluate if their organizational structures can meet the demands of the business model. Ultimately, addressing the three most prominent barriers:
1. Late Market engagement
2. (Non-)competitiveness of grass-fibre (in terms of quality, price, or environmental impact)
3. The organizational change.

Alternatives for "grass owners"
All public space and infrastructure (roads, ditches and waterways) are owned and managed by public entities, and while cost reduction is important, establishing a positive impact on other public causes, like biodiversity, well-being, aesthetics, or pollination can be equally important and an alternative option to cost reduction (O'Sullivan, 2017). Increasing the biodiversity, the composting value and the aesthetics of verges, while bringing down mowing costs, might require less organizational change from public entities. Looking into these options is beyond the scope of this research.

8.2 Limitations

This research does not come without limitations. Below the top four limitations are discussed.

First and foremost, this research was conducted individually. Whilst inter-rater reliability was therefore not an issue, it also did not allow for other interpretation of the qualitative data.

Secondly, whilst the research question is concerned with understanding the success and failure factors of the scale-up phase, this research also includes innovations that were still in the development stage of the innovation. Consequently, drivers and barriers more prominent to the (pre-) development stages have also been put in the spotlight.

Thirdly, whilst multiple interviews were conducted, only few interviewees represented the cases themselves and end-product users were not interviewed. On the other hand, more general interviews on the innovative products from actors working in the sector allowed for a more holistic view of the ecosystem in which the innovations operate.

Fourthly, by basing the interview questions on the iterative process of conducting surveys and interviews, not all interviewees were asked the same questions. This means that some indicators were put more in the spotlight than others.

Lastly, interviewees mentioned that actors do not like to admit to failures. As such, they often give a more positive spin to the information provided, resulting in a slight positivity bias.

9   Conclusion & Recommendations

Over the past decade both time and resources have been invested in roadside grass-fibre innovations, however none of the business cases have reached full-scale commercialization. This research gathers and analyses the experiences from different partners in past innovations in order to come up with recommendations based on these experiences that will enhance the success of future innovations.

Before elaborating on the conclusions and recommendations it must be understood that it is inherent to innovations that only some will make it to a successful scale up and failure is inevitable linked to innovation and to success.

The aim of the research was therefore not to come up with recommendations that will bring every innovation effort to a successful scale-up. Rather the recommendation should allow innovators to better understand and manage the innovation process challenges and enhance the chance of success or decide on an early exit, so that less time and resources are lost, while knowledge is still gathered.

It follows that this research aimed to answer the following research question: What are the drivers and barriers for innovations in extraction and application of roadside grass-fibre, and can patterns be detected? To do this it used the functions of the TIS as guiding principle to generate theory.

This research found three prominent barriers that need to be addressed first, namely:

- **Late market engagement:**
  The innovations at hand are *substitute innovations* that operate in existing fibre markets. However, these markets are only engaged late in the innovation process which reflect negatively on, amongst others, insights in market demands and dynamics, product development, and the ability to develop a good business case.

- **Non-competitiveness of the grass-fibre**
  The competitiveness of grass-fibre (in terms of quality, price, or environmental impact) is not significant and varies per end-product. Consequently, there is little incentive for the market to purchase grass-fibre products, making market penetration difficult.

- **Organizational change:**
  The tasks and responsibility of a public entity, like roadside managers, are almost 180 degrees opposite to the tasks and responsibilities of a commercial supplier of primary resources to a demanding market. Implementing organizational change to remain serving its public responsibilities, while also becoming a resource supplier to the demanding private market is challenging.

Other important barriers are:
- The innovations originate from the perspective of cost reduction for one partner, whilst clear benefits for the other value chain partners remain to be discovered in the innovation process (market push).
- Considerable investments needed in technology & infrastructure while there is an unclear competitive advantage on the fibre market.
- Government vision not aligned with laws & regulations, as well as Government actions and procurement.
- A lack of innovation leadership and management experience amongst the value chain partners.

The most important drivers are:
- Motivation & perseverance. Actors that are intrinsically motivated and that have perseverance are more likely to remain invested in the innovation project in comparison to actors that engage in the innovation for greenwashing purposes.
- Smart Management of existing laws and regulations, such as the waste status, creates legal space for the innovation.

This research calls for refining the TIS theory on two aspects. Firstly, the TIS theory should add the *organizational capacity to change* as an 8th function to the innovation system. Secondly, the TIS should distinguish between *radical innovation* and *substitute innovation* when it comes to the importance of function in different development stages of the innovation. Traditionally, the TIS describes the importance of the different functions as per figure 10a. While this might me applicable to radical innovation where new markets have to be formed, this research found that substitute innovation calls for market engagement and co-creation process early on in the innovation process, as per figure10b.

Recommendations for the innovation process

Innovation is not a linear process, but rather should be approached as cyclic refinery process. During the process it is important to ask the following questions in several stages of the innovation:

- What are my organization's motivations to engage and stay engaged in the innovation process?
- Are all value chain partners, including the end-product producers and consumers on board?
- What are the motivations of each of the other value chain partners to engage in the innovation process?
- Who has the experience and will lead the innovation in the different stages?
- Can the product we are developing meet the expectations and increase the motivations of all value chain partners in order to make them stay engaged and investing?
- Can we see a tipping point from market push to market pull (or should we call a stop to the innovation)?
- Can each organization in the innovation process deliver on the organizational change required to play its future role in the innovation?
- What alternative options (to reach the same or alternative goals, e.g. cost reduction) does my organisation have if it does not engage in, or disengages from the innovation?

Furthermore, this research calls for specific actions from both the research team and the Government and its institutions.

Recommendations for the innovation team:
- As this is a *substitute innovation*, it is advisable to engage the market early in the innovation process, co-create end-products and secure large market players, for instance, Bol.com as a major carboard user.
- This research recommends searching for new/other applications where the grass-fibre characteristics are not a disadvantage but can provide an added value in terms of quality, price or environmental impact. There should be clear added value for all actors in the value chain, including the end-user. If added value for all partners in the value chain cannot be found, it is advisable to stop the innovation process.
- This research advises partners engaging in the innovations to approach innovation not only as a technological development, but also to look at the organizational innovation needed to play their role in the innovation. If the organizational innovation is not compatible with other primary tasks of the organization, it is recommended to stop the engagement in the innovation.

Recommendations for Government:
- Government can kick start innovations by aligning visions, laws and regulations, and fielding public spending power through enforcing sustainable procurement for Government and its institutions.

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References

Adriaanse, M. (2020). GEA Biomassastudie; Volledige verwaarding Gelderse biomassa; -lokale aanbieders en afnemers verenigd-.

Amsterdam Economic board (AEC). (n.d.-a). Bermgras waardevol isolatiemateriaal: afnemers gezocht!. Retrieved from: https://amsterdameconomicboard.com/nieuws/bermgras-als-isolatiemateriaal-waardevol-voor-de-regio-we-zijn-op-zoek-naar-afnemers.

Angelo State University (ASU). (n.d.). How to recognize peer-reviewed (refereed) journals. Retrieved from: https://www.angelo.edu/services/library/handouts/peerrev.php.

Anonymous. (2017). Title withheld for anonymity.

Anonymous. (2019). Title withheld for anonymity.

Anonymous. (2020). Title withheld for anonymity.

Aronson, J. (1995). A pragmatic view of thematic analysis. *The qualitative report*, 2(1), 1-3.

Anthoni, P., Cheppih, M., Tap, M., Kluft, R-S., Mombers, L., & van den Dool, L. (2018). Prille kansen: de samenwerking tussen sociale ondernemingen en gemeenten in Nederland. Retrieved from: https://www.pwc.nl/nl/assets/documents/samenwerking-tussen-sociale-ondernemingen-en-gemeenten.pdf.

van den Bergh, J. C. J. M., van Leeuwen, E.S., Oosterhuis, F.H., Rietveld, P., & Verhoef, E.T. (2007). Social learning by doing in sustainable transport innovations: Ex-post analysis of common factors behind successes and failures. *Research Policy,* 36, 247-249.

Biomassa-alliantie. (2016). Q&A Van Berm tot Bladzijde. Retrieved from: https://biomassaalliantie.files.wordpress.com/2016/05/qa-van-berm-tot-bladzijde-2016.pdf

Bojesson, C., & Fundin, A. (2020). Exploring microfoundations of dynamic capabilities – challenges, barriers and enablers of organizational change. *Journal of Organizational Change Management*, 34, 1.

Branche Vereniging Organische Reststromen (BVOR). (n.d.-a). Profiel BVOR. Retrieved from: https://bvor.nl/organisatie/profiel-bvor/.

Branche Vereniging Organische Restromen (BVOR). (n.d.-b). Organische restromen. Retrieved from: https://bvor.nl/organische-reststromen/.

Branche Vereniging Organische Restromen (BVOR). (n.d.-c). Bermgras en slootmaaisel – afvalstof, meststof of grondstof?.

Branche Vereniging Organische Restromen (BVOR). (n.d.-d). Hoogwaardiger benutting van organische reststromen: succes- en faalfactoren Stageplaats bij de BVOR.

Branche Vereniging Organische Restromen (BVOR). (2017). Innovatief aanbesteden van groenafval en gras Een handreiking voor aanbestedende diensten: Module 300 Wat kan met groenafval en gras? Technische mogelijkheden.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology,* 3, 77–101.

Brem, A., & Voigt, KI. (2009). Integration of market pull and technology push in the corporate front end and innovation management—Insights from the German software industry. *Technovation*, 29, 351–367.

Brink, H. I. L. (1993). Validity and reliability in qualitative research. *Curationis*, 16(2), 35-8.

Bryman, A. (2012), *Social Research Methods.* Oxford: Oxford University Press.

BUN-K. (n.d.). Grassbloxxx LOI. Retrieved from: https://bun-k.nl/nieuws/grassbloxxx_nieuws/

BUN-K. (2019). Kijken met andere ogen naar… ketensamenwerking. Retrieved from: https://bun-k.nl/wp-content/uploads/2019/09/BUN-K-Ketenintegratie.pdf.

Chesbrough, H. (2010). Business Model Innovation: Opportunities and Barriers. *Long range planning*, 40, p. 354-363.

Cleave, P. (2017). The Pros And Cons Of Using Open Ended Questions. Retrieved from: https://blog.smartsurvey.co.uk/the-pros-and-cons-of-using-open-ended-questions#:~:text=Open%20ended%20questions%20allow%20respondents,attitudes%20about%20the%20survey%20subject.

Circkelstad. (2020). GrassBloxxx: van bermgras naar duurzame bouwmaterialen. Retrieved from: https://www.cirkelstad.nl/grassbloxxx-van-bermgras-naar-duurzame-bouwmaterialen/.

Circulair terreinbeheer. (n.d.-a). Van berm tot bladzijde. Retreved from: https://circulairterreinbeheer.nl/wp-content/uploads/2017/10/van-berm-tot-bladzijde.pdf.

DeFranzo, S. E. (2018). Advantages and Disadvantages of Closed Questions in Course Evaluations. Retrieved from: https://www.snapsurveys.com/blog/advantages-disadvantages-closed-questions-course-eval/.

Den Ouden Group B.V. (2019). Voortgangsrapportage- Ketenanalyse Bermgras.

De Ommer Marke. (n.d.). Impressie van de landelijke dag Circulair Terreinbeheer**.** Retrieved from: http://ommermarke.nl/cms/wp-content/uploads/2021/09/21-09-14-Impressie-Circulair-Terreinbeheer-dag-6-7-2021.pdf.

Dewald, U., & Truffer, B. (2011). Market Formation in Technological Innovation Systems—Diffusion of Photovoltaic Applications in Germany. *Industry and Innovation*, 18 (3), 285–300.

Ekwadraat. (n.d.). Bermgrasvergisting. Retrieved from: https://ekwadraat.com/projecten/bermgrasvergisting/.

Ellen MacArthur Foundation. (2013). Towards the circular economy. Retrieved from: https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Ellen-MacArthur-Foundation-Towards-the-Circular-Economy-vol.1.pdf.

Essink, S. (2019) Grasraffinage na 15 jaar nog in proeffase. Retrieved from: https://www.boerderij.nl/Rundveehouderij/Achtergrond/2019/10/Grasraffinage-na-15-jaar-nog-in-proeffase-481212E/.

Foxon, T. J., Gross, R., Chase, A., Howes, J., Arnall, A., & Anderson, D. (2005). UK innovation systems for new and renewable energy technologies: drivers, barriers and systems failures. *Energy Policy,* 33, 2123 – 2137.

Gielen, P. (2020). Nieuwe markten voor de verwaarding van bermgras. Retrieved from: https://www.agro-chemie.nl/artikelen/nieuwe-markten-voor-de-verwaarding-van-bermgras/.

Grassa. (n.d.-a). Bioraffinage, Retrieved from: https://grassa.nl/bioraffinage/.

Grass2Grit. (n.d.-a). Grassap, het groene alternatief voor strooizout. Retrieved from: https://www.grass2grit.nl.

GreyNet International. (n.d.). Research, publication, open access, education, and public awareness to grey literature. Retrieved from: http://greynet.org/.

Harding, J. (2015). Identifying themes and coding interview data: Reflective practice in higher education. SAGE publications.

Hekkert, M. P., Suurs, R. A. A., Negro, S. O., Kuhlmann, S., & Smits, R. E. M. H. (2007). Functions of innovation systems: a new approach for analysing technological change. *Technological Forecasting and Social Change,* 74, 413 - 432.

Hekkert, M., Negro, S., Heimeriks, G., & Harmsen, R. (2011). Technological innovation system analysis: A manual for analysts. *Universiteit Utrecht*, 1-16.

Hussain, M., Malik, R. N., & Taylor, A. (2018). Environmental profile analysis of particleboard production: a study in a Pakistani technological condition. *The International Journal of Life Cycle Assessment*, 23, 1542-1561.

Joppen, L. (2017). Parenco test met bermgeas. Retrieved from: https://www.agro-chemie.nl/wp-content/uploads/2017/09/AgroChemie-2017-2-spread.pdf.

Kemp, R., Schot, J., & Hoogma, R. (1998). Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. *Technology Analysis and Strategic Management*, 10 (2), 175-195.

Kennedy, R. (2020). Types of innovation. *Strategic Management*. Retrieved from: https://pressbooks.lib.vt.edu/strategicmanagement/chapter/7-4-types-of-innovation/.

Negro, S. O., Hekkert, M. P., & Smits, R. E. (2007). Explaining the failure of the Dutch innovation system for biomass digestion—A functional analysis. *Energy policy*, 35, 925-938.

Nevzorova, T., & Karakaya, E. (2020). Explaining the drivers of technological innovation systems: The case of biogas technologies in mature markets. *Cleaner production*, 259, 1-11.

NewFoss. (n.d.-a). Producten. Retrieved from: https://newfoss.com/producten/.

O'Sullivan, O. S., Holt, A. R., Warren, P. H. & Evans, K. L. (2017). Optimising UK urban road verge contributions to biodiversity and ecosystem services with cost-effective management. *Journal of Environmental Management*, 191, 162 – 171.

Paluszkiewicz, E., & Mak, W. (2009). Common factors behind success or failure of innovations: Algae farming in the port of Rotterdam.

Patton, M. (1990). Qualitative evaluation and research methods. SAGE publications.

Patton, M.Q. (2005). Qualitative Research. In B.S. Everitt and D.C. Howell (Eds.), *Encyclopedia of Statistics in Behavioral Science*.

Pierson, J. E., Mante-Meijer, A., & Loos E. F. (Eds.). (2011). *New Media Technologies and User Empowerment,* 27-43.

Porter, Michael E. 1980 Competitive strategy New York: Free Press.

Raats. S. (2017). Biomassa als productgrondstof concurreert nog lastig met traditionele grondstoffen. Retrieved from:
https://www.stad-en-groen.nl/upload/artikelen/sg8bakkerden_ouden.pdf.

Royal Haskoning DHV. (n.d.). Van berm tot bladzijde. Retrieved from:
https://global.royalhaskoningdhv.com/nederland/projecten/van-berm-tot-bladzijde.

Rijksdienst voor Ondernemend Nederland (RVO). (n.d.-a). Biobased Economy Retrieved from:
https://www.rvo.nl/onderwerpen/duurzaam-ondernemen/circulaire-economie/biobased-economy.

Rijksdienst voor Ondernemend Nederland (RVO). (n.d.-b). Winning van hoogwaardige vezels uit bermgras voor productie van biocomposieten. Retrieved from:
https://www.rvo.nl/subsidies-regelingen/projecten/winning-van-hoogwaardige-vezels-uit-bermgras-voor-productie-van-biocomposieten.

Rijksdienst voor Ondernemend Nederland (RVO). (2014). Een studie naar kansen voor grasvergisting.

Rijksdienst voor Ondernemend Nederland (RVO). (2016). A circular economy in the Netherlands by 2050.

Rijkswaterstaat. (2020). Rijkswaterstaat aan de slag met het regeerakkoord: Voortgang negen innovaties.

Roberts, E. B. (2007). Managing invention and innovation. *Research Technology Management*, 50 (1), 33-54.

Rosenburg, A., & Mosca, J. (2011). Breaking Down The Barriers To Organizational Change. *International journal of management & Information systems*, 15 (3), 139-146.

Sonnenschein, J., Pruijsen, J., Onrust, M., van Rhenen, R., & Pisa, R. (2020). Enriching the SDG Compass: The case of Priva.

Streefkerk, R. (2019). Qualitative vs. quantitative research. Retrieved from: https://www.scribbr.com/methodology/qualitative-quantitative-research/.

van Thuijl, E., & Deurwaarder, E. P. (2006). European biofuel policies in retrospect. *Energy Research Center of the Netherlands,* 1-50.

Twomey, P., & Gaziulusoy, d. (2014). Review of System Innovation and Transitions Theories Concepts and frameworks for understanding and enabling transitions to a low carbon built environment.

Verschuren, P., Doorewaard, H., & Mellion, M. J. (2010). *Designing a research project* (2nd ed.). The Hague: Eleven International Publishing House.

Wageningen University. (n.d.-a). Een circulaire economie. Retrieved from: https://www.wur.nl/nl/Onderzoek-Resultaten/Themas/Een-circulaire-economie.htm.

Wageningen University. (n.d.-b). Renewable raw materials. Retrieved from: https://www.wur.nl/en/Research-Results/Themes/theme-biobased-economy/Renewable-raw-materials.htm.

Zogjani, J., & Raçi, S. (2015). Organizational Change in Business Environment and the Main Barriers during Organizational Changes. *Academic Journal of Interdisciplinary Studies*, 4 (3), p. 83-87.

Appendix I

Success and failure factors of sustainable innovations

Function	Factor	Success or Failure	Explanation	Source
F1. Entrepreneurial experimentation				
	Partnerships	S	Partnerships help promote innovation and provide a competitive advanatage through e.g. providing financial resources	(Foxon et al., 2005; Kemp, Schot & Hoogma, 1998)
	Real and perceived risks	F	Risks are high while perceived rewards are low preventing large-scale deployment	(Foxon et al., 2005; Kemp, Schot & Hoogma, 1998)
F2. Knowledge development				
	IP protection	S	IP protection helps secure finances and allows for collaboration with universities	(Foxon et al., 2005)
F3. Knowledge exchange				
	Learning from others (mistakes)	S	Learning from others (unsuccessful events) helps spur innovation	(Foxon et al., 2005; Nezorova & Karakaya, 2020)
	Partnerships & networks	S	Key for knowledge development and diffusion	(Nezorova & Karakaya, 2020)
	(Value) chain collaboration	S	Companies look beyond their traditional practices. There is room to learn from each other within the value chain to advance innovations	(BVOR, 2017)
F4. Guidance of search				
	Expectations of key actors	S	The expectation of key actors in the innovation system influences the direction of success	(Foxon et al., 2005; Nezorova & Karakaya, 2020; van den Bergh et al., 2007)
	Policy	S + F	Policies can lack a clear message or support why specific new technologies are necessary for sustainble development	(Kemp, Schot & Hoogma, 1998; van Thuijl & Deurwaarder, 2006)
	legislation and regulations	S + F	(A lack of) legislations and regulations can facilitate innovations or be a barrier.	(van den Bergh et al., 2007; Kemp, Schot & Hoogma, 1998)
	Passion and enthusiasm	S	Passion and enthusiasm can encourage development of the innovation	(van den Bergh et al., 2007)
	Media attention	S + F	Positive media attention mobilizes socio-political support for innovations. Negative does the opposite	(van den Bergh et al., 2007)

Function	Factor	Success or Failure	Explanation	Source
F5. Formation of markets				
	Expected market	S	The creation and/or existence of an expected and emerging market is essential throughout all stages of a technological development	(BVOR, 2017; Foxon et al., 2005; van Thuijl & Deurwaarder, 2006)
	Costs of innovation	F	Expensive innovations whilst consumers are unsure what to expect from the innovation, acts as a barrier for success	(Kemp, Schot & Hoogma, 1998)
	Consumer demands	F	When an innovation does not meet consumer demands, consumers will either have to adapt to the innovation or not buy it	(Kemp, Schot & Hoogma, 1998)
	Cultural and psychological	F	Cultural and psychological factors inhibit consumers from buying the innovation	(Kemp, Schot & Hoogma, 1998)
	Price	F	Costs of new innovations are often high due to small scale production.	(Kemp, Schot & Hoogma, 1998)
	Rebound effect	F	Rebound effect the image and performance of the technology	(Kemp, Schot & Hoogma, 1998)
F6. Mobilization of resources				
	Relevant skills and educational needs	S + F	Relevant skills and educational needs are essential for success from R&D to applied engineering and maintenance	(Foxon et al., 2005; Kemp, Schot & Hoogma, 1998)
	Capability of the technology	S	and/or the features of the technology are flexible, then successful innovations are more likely	Nezorova & Karakaya, 2020; van den Bergh et al., 2007)
	Financial resources	S + F	Sufficient financial resources (through e.g. tax exemptions) make innovation projects feasible. Insufficient funds make the innovation unfeasible.	2005; Kemp, Schot & Hoogma, 1998; van Thuijl & Deurwaarder, 2006)
	Quality of the input resources	S	Consistent quality and up to standards	(BVOR, 2017)
	Quailty assurance of processes and products	S + F	(A lack of) quality assurance through e.g. certifications are important for success	(BVOR, 2017; van Thuijl & Deurwaarder, 2006)
	Complementary technologies	F	Complementary technologies are not available (in short supply) or expensive	(Kemp, Schot & Hoogma, 1998)
F7. Counteracting resistance to change				
	Technology and environmental challenge	S	makes clear why a certain technology is needed. Thereby, modifying beliefs and values in favour of the specific technology	(Nezorova & Karakaya, 2020)
	Lobbying	S	Lobbying works in favour of innovations	(van Thuijl & Deurwaarder, 2006)

My name is Jannah Sonnenschein, I am a Master student at Utrecht University studying Sustainable Business & Innovation. For the coming six months I have to work on my thesis and I have decided to focus on identifying success and failure factors of grass-fibre innovations. This means that I hope to analyse both failed and successful innovations.

I am relatively new to the world of grass-fibre innovations, and I have done some research into different innovations from different companies, however I find that it is rather difficult to get an overview of the different innovations. This is partly because the innovations are similarly described, there seem to be plenty of partnerships in the sector and there is little information on the innovations that were not successful. Therefore, with this interview I aim to get an understanding of which innovations your company was involved in, the stage of innovation development the innovation was able to achieve, and whether there are any other grass-fibre innovations that I should be aware of.

This interview will be used for research purposes and will not be publicly disclosed. It will only be available to academics from Utrecht University. Do you give consent for this? May I record the interview? I do not anticipate that there are any risks associated with your participation, however you have the right to stop the interview or withdraw from the research at any time.

Introduction

1. Can you tell me a bit about yourself?
    1. How long have you been at Company X?
    2. What positions have you had at company X?

General

1. I would like to know about the several grass-fibre innovations X has been involved in. Can you tell me about the different innovations Company X has been involved in over the past 15 years?

Per innovation:

1. What phase of innovation development did the innovation reach?
    a. Pre-development
    b. Development
    c. Take-off
    d. Acceleration
2. What was the outcome of the innovation process?
3. Do you have a rough idea why the innovation (only) reached this stage?
4. How many partners were involved with the innovation?
5. Are you available for another interview later on in my research, so that I can gather more information on these innovations and how your company managed the innovations?

6. Would you be able to put me in contact with colleagues and/or partners that can provide me with information on the specific innovations and how they were managed?
    a. If so, for which innovations would this be possible?
7. Are there any grass-fibre innovations that are not specific to your company but that I should be aware of?

Closing

1. Is there anything else that I should know about the world of grass-fibre innovations?
2. Do you have any further questions?

Survey

My name is Jannah Sonnenschein, I am a master student at Utrecht University, and I study Sustainable Business & Innovation. In the coming months I will be working on my master's thesis: identifying success and failure factors of grass-fibre innovations. My focus is on valorising roadside grass.

Success factors are defined as the factors that have contributed positively to reaching the stage where commercial scale-up is feasible or already happening. Failure factors are defined as factors that contributed negatively to the process.

I have selected a number of innovation projects that serve as case studies. The case studies will provide insight on the success and failure factors by means of an interview with various interested parties in the innovation chain.

The purpose of this survey is to quickly gain insight into a number of general topics that are possible explanations for the success and/or failure of the innovation. The results of this survey will help me determine the focus of the interview, in which the possible factors will be further explored.

In the enclosed consent form, you can indicate the degree of confidentiality of the data that must be observed. By completing and (electronically) signing the consent form, you give me permission to use your data for my thesis research.

This survey consists of 6 short introductory questions followed by 23 short multiple-choice questions.

1. Do you agree to participate in this research?
    a. Yes
2. Company name
3. Your name
4. Name of the project you are answering questions about:
    a. Grassbloxxx
    b. Van Berm tot Bladzijde
    c. Bio-composite
    d. Paper & Cardboard
    e. Potting soil
    f. Reflector poles
    g. Road signs
    h. Other:
5. In which part of the chain was your company involved in this project?
    a. Grass selection, sowing and planting
    b. Grass maintenance and mowing
    c. Grass supplier
    d. Grass-fibre extraction
    e. Producers of end-productss (for example: from grass-fibres to paper/cardboard)
    f. Technology development
    g. Other:

6. Which other companies were involved as key players in this innovation and what was their role?
7. Where does the roadside grass for this innovation project come from?
   a. Along highways
   b. Along bike paths
8. If you have any comments, please place them in the box below.

1. Entrepreneurial activities

This section is intended to give you an idea of how easy or difficult it was for your company to start and/or continue the project.

1. Was it difficult or easy to find and keep partners who were willing to invest in the innovation process?
   a. To find
      i. 1 = very easy
      ii. 5 = very difficult
      iii. N/A
   b. To keep
      i. 1 = very easy
      ii. 5 = very difficult
      iii. N/A
2. To what extent have risks of the project prompted your organization to make decisions to stop or continue the innovation?
   a. 1 = The risks made us stope the innovation;
   b. 5 = The risks drove us to continue the innovation;
   c. N/A
3. What were your organization's main motivation(s) to participate in and, if applicable, exit the innovation?

	To participate	To stop	I am unsure	Not applicable
Financial	☐	☐	☐	☐
Environmental	☐	☐	☐	☐
Social	☐	☐	☐	☐
Other (please comment below)	☐	☐	☐	☐

4. If you have any comments, please place them in the box below.

2. Knowledge development

This section is intended to give you an idea of the possibilities of your company to create and (possibly) protect knowledge for the innovation.

1. Sufficient financial resources are (or have been) available for knowledge development
   a. 1= strongly disagree
   b. 5= strongly agree
   c. N/A

2. Sufficient financial resources are (or have been) available for knowledge development
    a. 1= strongly disagree
    b. 5= strongly agree
    c. N/A
3. Sufficient qualified personnel are (or have been) available for knowledge development.
    a. 1= strongly disagree
    b. 5= strongly agree
    c. N/A
4. Intellectual property protection, for example through patents or trade secrets, plays (or played) an essential role in the success of this innovation.
    a. 1= strongly disagree
    b. 5= strongly agree
    c. N/A
5. If you have any comments, please place them in the box below.

3. Knowledge exchange

This section is intended to get an idea of how easy or difficult it is or has been to learn with others with regard to this innovation project.

1. How easy was it to find partners and networks willing to share important knowledge for the innovation?
    a. Partners
        i. 1 = very easy
        ii. 5 = very difficult
        iii. N/A
    b. Networks
        i. 1 = very easy
        ii. 5 = very difficult
        iii. N/A
2. Learning from other (un)successful grass-fibre innovation projects (internal or external to your organisation) is (or has been) very important for the success of the innovation.
    a. Internal
        i. 1= strongly disagree
        ii. 5= strongly agree
        iii. N/A
    b. External
        i. 1= strongly disagree
        ii. 5= strongly agree
        iii. N/A
3. Actors in the value chain actively shared their knowledge, feedback and quality requirements to further develop the innovation.
        i. 1= strongly disagree
        ii. 5= strongly agree
        iii. N/A
4. If you have any comments, please place them in the box below.

4. Governmental and social stimulation

Government and social stimulation entails rules and regulations from the government (no subsidy schemes), and social or media attention that stimulate innovation.

1. Government goals have played an important role in the development of the innovation.
    a. 1= strongly disagree
    b. 5= strongly agree
    c. N/A
2. It would help if the government included sustainability more in its purchasing policy.
    a. 1= strongly disagree
    b. 5= strongly agree
    c. N/A
3. Legislation and regulations have never been a problem for the development of the innovation.
    a. 1= strongly disagree
    b. 5= strongly agree
    c. N/A
4. Did the media contribute positively or negatively to the success of the innovation?
    a. 1= very negative
    b. 5= very positive
    c. N/A
5. If you have any comments, please place them in the box below.

5. Market formation

This section is intended to help you understand your company's ability to predict and create the market for the innovation.

3. Your company had a good idea of the (potential) market before you started the innovation process.
    a. 1= strongly disagree
    b. 5= strongly agree
    c. N/A
4. The innovation has not experienced and cultural or psychological resistance.
    d. 1= strongly disagree
    e. 5= strongly agree
    f. N/A
5. The quantity, continuity and/or quality of the available grass (fibre) is sufficient and meets the requirements for the innovation (products) to be successful.
    g. Quantity
        i. 1= strongly disagree
        ii. 5= strongly agree
        iii. N/A
    h. Continuity
        i. 1= strongly disagree
        ii. 5= strongly agree
        iii. N/A

        i. Quality
             i. 1= strongly disagree
            ii. 5= strongly agree
          iii. N/A

6. The innovation (end-productss) respond to current or future markets as follows:
   j. Cheaper
   k. Equally expensive
   l. More expensive
   m. Better quality
   n. Similar quality
   o. Worse quality
   p. Local
   q. Recyclable
   r. Circular
   s. Other

7. If you have any comments, please place them in the box below.

6. Available Resources

This section is intended to provide an overview of the available resources during the innovation process.

1. Qualified personnel have never been a problem for the success of the innovation
   a. 1= strongly disagree
   b. 5= strongly agree
   c. N/A
2. Financial resources have never been a problem for the success of the innovation
   a. 1= strongly disagree
   b. 5= strongly agree
   c. N/A
3. Physical resources (e.g., infrastructure and equipment for mowing, storage, fibre extraction and end-products processing) had to be developed and/or created for the innovation to be successful
   a. Developing and creating new physical assets was an important part of the innovation process
   b. The innovation process mainly uses of existing physical resources
   c. Other:
6. Physical resources have never been a problem for the success of the innovation
7. If you have any comments, please place them in the box below.

7. Countering resistance to innovation

This section is intended to get an idea of whether it is (or has been) necessary to pay active attention within the project to eliminating possible resistance to the innovation, or to promote adoption of the innovation (products).

1. Lobbying the government is (or has been) essential for the success of the innovation
   a. 1= strongly disagree
   b. 5= strongly agree
   c. N/A
2. There is (was) lobbying against the use of grass as a raw material.
   a. 1= strongly disagree
   b. 5= strongly agree
   c. N/A
3. To what extent is active marketing of the innovation products necessary (or has been) to persuade the potential user to adopt.
   a. Active marketing is not (or has been) necessary
   b. Active marketing is (or has been) very important
4. If you have any comments, please place them in the box below.
5. If you think there are important issues that are not covered in this survey, describe them (briefly) below so we can discuss them during the interview.

Thank you for completing this survey!

Your answers have been registered.

Kind regards,

Jannah

Appendix IV
Interview guide case studies

The interview guide below are the base questions for case study interview guides. The questions were however modified along the course of the interviews and posed in such a way that they reflected (contrasts found in) the survey results. It is important to note that not all questions were posed.

Entrepreneurial experimentation

1. Was it difficult or easy to find and keep partners who were willing to invest in the innovation process?
    a. How do you choose your partners? What is important in a partner? E.g.: sustainability, greenwashing, long/short term

    b. If easy to find:
        i. What made the innovation attractive to partners?

    c. If difficult to find:
        i. What made it so difficult to find partners?

    d. To keep
        i. What makes it easy/difficult to keep the partners?
            1. To keep in the back of the mind:
            2. The number of partners?
            3. The relationship between partners
            4. Changes in ownership

2. To what extent have risks of the project prompted your organization to make decisions to stop or continue the innovation?
    a. Stop the innovation
        i. What kind of risks have these mainly been?
    b. Pursue the innovation
        i. What were the risks?
        ii. Why did you still pursue the innovation if there were risks?

3. What were your organization's main motivation(s) to participate in and, if applicable, exit the innovation?
    a. To take part:
        i. Financial
            1. Was this to save on costs or make a profit?
        ii. Environmental
            1. To what extent are the Environmental Benefits lower for the alternative compared to the conventional product?
        iii. Social
            1. Could you please elaborate?
        iv. Other:
            1. Could you please elaborate?

    b. To stop:
        i. Financial
            1. What was the problem financially?
                a. Were the costs too high?
                    i. If so, what kind of costs were these?
                b. Were alternatives cheaper?
                c. Was there no revenue model?
        ii. Environmental
            1. Did the environmental benefits turn out to disappoint, for example due to an LCA?
            2. Were there any features that made it environmentally worse than conventional products?
        iii. Social
            1. Please elaborate
        iv. Other
            1. Please elaborate

Knowledge development

1. Sufficient financial resources are (or have been) available for knowledge development
    a. Agree
        i. . Where does the money mainly come from?
        ii. Is the money easy to get or does it have to be 'fought' a lot?
    b. Disagree
        i. Was it not available or did you not look enough?
2. Sufficient financial resources are (or have been) available for knowledge development
3. Sufficient qualified personnel are (or have been) available for knowledge development.
        i. If not:
            1. Where did you miss qualified personnel?
4. Intellectual property protection, for example through patents or trade secrets, plays (or played) an essential role in the success of this innovation.
    a. You indicate that Intellectual property protection did/did not play an essential role for the success of the innovation. Can you explain this?

Knowledge exchange

1. How easy was it to find partners and networks willing to share important knowledge for the innovation?
    a. Very easy (Partners/networks)
        i. What makes partners willing to share their knowledge?
    b. Very difficult (Partners/difficult)
        i. Why did others not want to share their knowledge?
        ii. Do you think that this caused your innovation to lack certain knowledge that could have helped the project move forward?
2. Learning from other (un)successful grass-fibre innovation projects (internal or external to your organisation) is (or has been) very important for the success of the innovation.
    a. What did you learn/take away from other innovations that helped/helps this project in particular?
    b. What have you learned from other projects that is important for all grass-fibre applications?

3. Disagree
    a. Can you elaborate?
    b. Do you think your innovation could have benefitted from learning from other innovations?
4. Actors in the value chain actively shared their knowledge, feedback and quality requirements to further develop the innovation.
        i. Disagree
            1. Why did they not do this?
            2. If they did this (more), do you think the project would/have made a leap forward?
                a. If so, what would you like to know more about to help it move forward?
        ii. Agree:
            1. Was there any feedback that you missed? What was the most important?
            2. Was there any feedback that was problematic, difficult, or impossible to implement/achieve?
                a. If so, what?
                    i. Fibre length? Beauty?

Governmental and social stimulation

1. Government goals have played an important role in the development of the innovation.
    a. Which goals played a particular role?
        i. Are the goals specific/general?
        ii. Do you think specific goals are needed for Gras?
        iii. Do you think setting (more) goals could have contributed to success?
2. It would help if the government included sustainability more in its purchasing policy.
    a. Agree
        i. What weighs the most now?
            1. Economics?
        ii. How could this improve?
            1. What could the role of tenders be?
    b. Disagree:
        i. Could you elaborate?
3. Legislation and regulations have never been a problem for the development of the innovation.
    a. Agree
        i. Did you know the laws and regulations in advance?
        ii. Did you know how to manage/get around the laws and regulations?
            1. If so, which laws/regulations have you managed to circumvent?
            2. If so, are there any limitations to it? For example, that it must be processed within X kilometres.
    b. Disagree:
        i. Which laws and regulations are particularly problematic?

4. Did the media contribute positively or negatively to the success of the innovation?
    a. Negative/Positive:
        i. Could you please elaborate

Market formation

1. Your company had a good idea of the (potential) market before you started the innovation process.
    a. Agree
        i. What kind of a market was this?
        ii. Did your expectation differ from reality?
    b. Disagree
        i. Why did you not anticipate the market?
2. The innovation did not experience any cultural and/or psychological resistance.
    a. If agree/disagree:
        i. Could you elaborate?
3. The quantity, continuity and/or quality of the available grass (fibre) is sufficient and meets the requirements for the innovation (products) to be successful
    a. Quantity/continuity
        i. Agree:
        ii. Can you deliver continuously?
        iii. How do you manage that well?
        iv. Can the quantity and continuous availability compete with conventional alternatives?
        v. Do you not create other problems by using roadside grass-fibre for other products? E.g.: less compost, more old paper waste?
    b. Disagree:
        i. Why can't you (yet) deliver the required quantity continuously?
4. Quality
    a. Agree
        i. How can you deliver the right quality?
        ii. Can the quality compete with conventional alternatives?
    b. Disagree
        i. a. What requirements can you not (yet) meet in order to have optimal quality?

5. The innovation (end-productss) respond to current or future markets as follows:
    a. Cheaper
    b. Equally expensive
    c. More expensive
        i. Is the market willing to pay for your product? Or is it not competitive?
    d. Better quality
    e. Similar quality
    f. Worse quality
    g. Local
    h. Recyclable
        i. If not: Do you think this will have an impact on the success of the innovation
    i. Circular
    j. Other

Available Resources

4. Qualified personnel has never been a problem for the success of the innovation
    a. Disagree:
        i. What qualities did you miss?
5. Financial resources have never been a problem for the success of the innovation
    a. Agree:
        i. How did you ensure you have enough money?
    b. Disagree:
        i. For which phase in the innovation process is there too little money?
        ii. Do you have to compete with other 'branches' for the money?
        iii. Are there certain costs that are too high?
            1. If so, what exactly?
6. Physical resources (e.g. infrastructure and equipment for mowing, storage, fibre extraction and end-products processing) had to be developed and/or created for the innovation to be successful
    a. Developing and creating new physical assets was an important part of the innovation process
        i. Are there any problems with this?
            1. Cost?
            2. Documents?
            3. Construction time?
    b. The innovation process mainly used existing physical resources
        i. Was the scale and/or quality of the existing infrastructure sufficient?
        ii. Is the distance between the mowing area, the processing of the grass and the end-products a problem?
            1. If so, what exactly is the problem?
            2. If not, why not? Is it a clay distance?
5. Physical resources have never been a problem for the success of the innovation
    a. Disagree:
        i. What is/are the main problems?
        ii. Can the innovation process overcome these problems?

Countering resistance to innovation

1. Lobbying the government is (or has been) essential for the success of the innovation
    a. Agree
        i. What did you have to lobby for in particular? And was this successful?
2. There is (was) lobbying against the use of grass as a raw material.
        i. Why do they do this? Can you elaborate?
3. To what extent is active marketing of the innovation products necessary (or has been) to persuade the potential user to adopt.
    a. Very necessary
        i. Who are you actively marketing towards?
        ii. What do you mainly try to convince the market with?
        iii. Is this a long process or have you convinced the market quickly?
    b. Not necessary
        i. Why not? Can you elaborate?

Interview guide on general information listed per company

RHP

- Jannah introduces herself and the research.
  - 2nd-year master student studying sustainable business & innovation
  - I would like to get a picture of specific roadside grass-fibre innovations and what the success and failure factors have been. But I would also like to speak to people and actors who have been involved in one way or another in these innovations and who may also have some more general knowledge.
- That's something about me and my studies. Could you tell me something about yourself?
- Can you tell me something about RHP and their role with regard to the biobased circular economy transition and in particular roadside grass-fibre innovation?
- Is RHP often a partner or service provider with regard to grass-fibre innovations?
- Which specific roadside grass-fibre projects have you been involved in?
  - How is (or has) the RHP (been) involved in these roadside grass-fibre innovations?
    - Potting soil vs compost
- Is there a roadside grass certification program (for potting soil) and are you researching this together with companies?
  - If so, can you elaborate?
- What have you been involved in yourself?
- Do you have some more general knowledge about these innovations or also specific case innovations?
- Are there any problems with certification?
- Are there opportunities for certification?

RVO Interview 1:

- Jannah introduces herself and the research.
  - 2nd-year master student studying sustainable business & innovation
  - I would like to get a picture of specific roadside grass-fibre innovations and what the success and failure factors have been. But I would also like to speak to people and actors who have been involved in one way or another in these innovations and who may also have some more general knowledge.
- That's something about me and my studies. Could you tell me something about yourself?
- What is the role of RVO regarding the biobased circular economy transition and in particular roadside grass-fibre innovation?
- In which specific roadside grass-fibre projects has RVO been involved in?
  - Extraction of high-quality fibres from roadside grass for the production of bio-composite - United gas? Bio-composites
- How is (or has) the RVO (been) involved in these roadside grass-fibre innovations? (so no meadow and natural grass).
- What is your role when it comes to roadside grass-fibre innovations?
- Were you involved yourself or others within the RVO?
- Do you have more general knowledge about these innovations, or do you also have specific knowledge in the field of innovations, for example business cases, regulations, subsidies?

RVO Interview 2:

- How do you, as RVO, decide that you will cooperate/approve subsidies for a project?
  - Do you look at the success factors and the risks? Is there a guideline in this and is it based on experience?
    - For example, do you check whether a market study has been carried out?
- Do you look back at projects that you have approved, e.g., over the past 10 years, and have you identified overall success and failure factors?
  - If so, what are they?
- To what extent are you involved in the scaling up phase of projects?
- In the roadside innovation project that XX was involved in:
  - What did the value chain look like?
  - What were the success and failure factors there?
- Grassification project:
  - What were the success and failure factors?
- Can you tell me what you (as RVO) can and cannot subsidize in such innovation projects?
  - Where are the boundaries roughly?
  - Do you support marketing of the innovations?

Non-disclosed

- Jannah introduces herself and the research.
    - 2nd-year master student studying sustainable business & innovation
    - I would like to get a picture of specific roadside grass-fibre innovations and what the success and failure factors have been. But I would also like to speak to people and actors who have been involved in one way or another in these innovations and who may also have some more general knowledge.
- That's something about me and my studies. Could you tell me something about yourself?
- What is the role of [COMPANY NAME] with regard to the biobased circular economy transition and in particular roadside grass-fibre innovation?
- Which specific roadside grass-fibre projects has [COMPANY NAME] been involved in?
    - Facade based on roadside grass
    - What type of grass is this? Hay?
- How is the [COMPANY NAME] (or has been) involved in these roadside grass-fibre innovations? (so, no meadow and natural grass).
- What is your role when it comes to roadside grass-fibre innovations?
- Were you involved yourself?
- Do you have more general knowledge about these innovations, or do you also have specific knowledge in the field of innovations, for example business cases, regulations, subsidies?
    - Are the products circular?
    - Who do you work with?
- This interview ended up going more in depth into bio-composite innovations and their success and failure factors.

- Jannah introduces herself and the research.
    - 2nd-year master student studying sustainable business & innovation
    - I would like to get a picture of specific roadside grass-fibre innovations and what the success and failure factors have been. But I would also like to speak to people and actors who have been involved in one way or another in these innovations and who may also have some more general knowledge.
- That's something about me and my studies. Could you tell me something about yourself?
- • Can you tell me about VPN and your role in the biobased circular economy transition?
    - What kind of (sustainability) policy/objectives do you currently have?
    - What about roadside grass specifically?
        - Were you involved yourself?
- What are the influences of public opinion on the use of peat in potting soil?
- I understood that the availability of peat in Europe is decreasing, for example due to lack of permits for peat in Ireland and Germany.
    - Why is that?
    - How do current or future Dutch legislation and regulations influence the use of peat in potting soil?
    - To what extent does this drive up the price of peat and does it give alternatives to peat, such as coir, wood fibre and tree bark, a chance to compete?
- To what extent can the quality of alternatives compete with that of peat for potting soil?
    - Are you also working on roadside grass projects as an alternative?
        - If not,
            - Why not?
        - If yes,
            - Are there any results?
            - What are the difficulties?
            - Can the quality of roadside grass compete with peat and other alternatives?
            - Can the cost of roadside grass compete with that of peat and other alternatives? Will this change in the future?
        - Do you have any knowledge of other aspects of using roadside grass as an alternative that were not discussed?

Knowledge centre paper & cardboard

This interview guide was initially designed to analyse the complete TIS but then the interview design changed.

My name is Jannah Sonnenschein, I am a Master student at Utrecht University studying Sustainable Business & Innovation. For the coming six months I have to work on my thesis and I have decided to focus on identifying success and failure factors of grass-fibre innovations.

According to literature, for an invention to be successful it is dependent on the ecosystem in which it operates. With this interview I hope to get some insights on the Technical Innovation system that have surrounded the grass-fibre innovations over the past 10 years.
This interview will only be used for research purposes and will not be publicly disclosed. It will only be available to academics from Utrecht University. Do you give consent for this? Is it okay if we record the interview? I do not anticipate that there are any risks associated with your participation, however you have the right to stop the interview or withdraw from the research at any time.

Introduction (10min)
1. Can you tell me a bit about your background?
    a. How long have you been at [COMPANY NAME]?
    b. What positions have you had at [COMPANY NAME]?
    c. How long have you been involved in innovation and grass-fibre innovation in particular?
    d. What is the role and interest of [COMPANY NAME] when it comes to grass-fibre innovations?

TIS function indicators (20min)
1. Entrepreneurial experimentation
# of new entrants, # of diversification activities by incumbents, # of experiments with new technologies

       a. Which fibre application projects/research has your company been involved in?
i. Can you tell me something about these projects/studies shortly?
ii. When did they take place?
iii. What were the most interesting outcomes of these projects/studies?

       b. How has the number of companies working on grass-fibre innovations changed over time (for the past 10 years)?
         i. How many of these have been new entrants in the field of grass-fibre innovations?
         ii. How many are existing companies diversifying into grass-fibre innovations?

2. Knowledge development (10min)
R&D Projects, $ Investments in R&D, # of patents

       c. Which knowledge institutions (universities/research institutions) contribute to research on grass-fibre innovations?

    d. Have the number of R&D projects increased/decreased over time in the sector? (Is there a list? Start/Stop?)
        i. If so, when did you recognize this increase or decrease?
        ii. How would you explain this trend?
    e. Has the volume of investments ($) in R&D changed over time in the sector?
    f. Do you know of any patents related to grass-fibre innovations that have been registered?
        iii. Which are they?
        iv. What are reasons for patenting/not patenting?

3. Knowledge exchange (10min)

# of workshops and conferences; network size and intensity over time

    a. How would you describe the importance of networking among grass-fibre innovations when it comes to knowledge exchange?
    b. How has the number of network groups increased/decreased over the past 10 years?
    c. Are there many networking activities such as workshops and conferences being held regarding grass-fibre innovations?
        i. Has this been happening for years or is this a more recent activity?
        ii. Who organizes this?
        iii. Do companies communicate with actors further up and down the value chain on what should/could be changed?
        iv. When did grass-fibre innovations start looking beyond their own gate?

4. Guidance of search (10min)

Targets by Government or Industries, # of articles in professional journals

    a. Do you feel that the government is encouraging, either directly or indirectly, the development of grass-fibre innovations?
        i. What type of encouragement is this?
        ii. When did this encouragement start/stop?
        iii. Has the government set any specific targets regarding the production of grass-fibre/ processing of organic waste?
    b. Do you know of any professional journals focusing on biomass processing?
        a. Which are they?

5. Formation of markets (15min)

# of new niche markets, specific tax regimes, new favourable environmental standards

    a. What are the new niche markets for grass-fibre?
        i. What inhibits these (new) niche markets from developing? (Cost, quality, etc.?)
        ii. Are there any quality standards from buyers that make the process more challenging/expensive?
        iii. What does [COMPANY X] do to improve the quality?
    b. Have you come across or do you know of any favourable or unfavourable legislations or regulations, like tax regimes or procurement regulations, regarding grass-fibre innovations that inhibit or stimulate the formation of markets?

        i. Which are they and when were these implemented/ceased?
       ii. Why did they cease?
   c. Are there environmental standards that help or prevent the formation/development of (new) markets, technology? E.g., car pollution
        i. When were these environmental standards introduced?

6. Mobilization of resources (10min)
Physical resources, Human resources, Financial Resources

   a. Are there sufficient people with relevant skills available in the field? This includes further up and down the value chain
       ii. Is/was this a barrier for innovation?
      iii. How has this changed over the past 10 years?

   b. Are there sufficient financial resources throughout the innovation process? (R&D, scale-up?)
        i. Where does the money usually come from? Subsidies/private investment?
       ii. Do you see an increase or decrease in available funding over time?

   c. Are there physical resource constraints that hamper technology diffusion?
        i. Is the physical infrastructure well enough developed to support the diffusion of the innovation?
       ii. Do companies generally share infrastructure?
      iii. Can the infrastructure easily be used for other innovations if the innovation is unsuccessful?
      iv. What are the challenges regarding storage and transportation?

   d. Which other resources does the sector lack?

7. Counteracting resistance to change (10 min)
Rise and Growth of interest groups and lobby actions

   a. How does your company/the industry receive support from the government to pursue developments related to grass-fibre innovations?
   b. How does your company receive support from the industry to pursue developments related to grass-fibre innovations?
        i. Does the sector have platforms that lobby for change or better regulations?
       ii. Can you name them?
      iii. Have these platforms or activities increased or decreased over time? Can you give examples?

Closing Questions (5min)
1. Is there anything else you think I should know about the development of grass-fibre innovations over the past 10 years?
2. Do you have any further questions?

This interview guide was initially designed to analyse the complete TIS but then the interview design changed.

My name is Jannah Sonnenschein, I am a Master student at Utrecht University studying Sustainable Business & Innovation. For the coming six months I have to work on my thesis and I have decided to focus on identifying success and failure factors of grass-fibre innovations. This research topic comes as a request of BVOR.

According to literature, for an invention to be successful it is dependent on the ecosystem in which it operates. With this interview I hope to get some insights on your company and the system surrounding the grass-fibre innovations over the past 10 years.

This interview will only be used for research purposes and will not be publicly disclosed. It will only be available to academics from Utrecht University. Do you give consent for this? Is it okay if we record the interview? I do not anticipate that there are any risks associated with your participation, however you have the right to stop the interview or withdraw from the research at any time.

Introduction (10min.)
1. Can you tell me a bit about your background?
    a. How long have you been at [COMPANY NAME] ?
    b. What positions have you had at [COMPANY NAME] ?
    c. How long have you been involved with grass-fibre innovations in particular?
2. What is the role and interest of [COMPANY NAME] when it comes to grass-fibre innovations?

TIS function indicators (20min)

1. **Entrepreneurial experimentation**
Fibre (applications) projects

    a. Which fibre application projects has your company been involved in?
        i. Can you tell me something about the aim of these projects?
        ii. When did these projects take place, (start/stop)?
        iii. Overall, which innovations/projects would you consider successful or unsuccessful?
        iv. Also overall what were the main challenges the projects and your company in particular faced?
            1. Competing interests for the resource (roadside space or berm gras)?
            2. Knowledge development / Technology?
            3. Technology - Cost Price of the fibre production or fibre products?
            4. Guidance of Search - Regulations/legislations/lobbying?
            5. Markets?
            6. Resources (finances) for the innovation?
            7. Resources Infrastructure?
        v. How did you (try) solve these challenges?

2. __Knowledge development (10 min)__
R&D Projects, $ Investments in R&D, # of patents

    a. Which knowledge institutions (universities/research institutions) do you work with?

    b. Have the number of R&D projects increased or decreased over time in your company and/or in the sector?

        i. If so, when did you recognize this shift?

        ii. If not, why not?

    c. How have investments in R&D changed over time both in your company and/or the sector?

    d. How many patents related to grass-fibre innovations does your company have? When were they registered?

        i. What are reasons for patenting/not patenting for your company?

3. __Knowledge exchange (10 min)__
of workshops and conferences; network groups

    a. Has [COMPANY NAME] been joining (or ceased to join) network groups over the past 10 years?

        iii. Is there a special focus for these groups?

        iv. When were they established?

    b. Are there many networking activities such as workshops and conferences being held regarding grass-fibre innovations?

        v. Has this been happening for years or is this a more recent activity?

        vi. Do companies communicate with actors further up and down the value chain on what should/could be changed?

        vii. When did grass-fibre innovations start looking beyond their own gate?

    c. Do companies share their knowledge on their (un)successful innovations only with their partners or more general?

        viii. How is this for [COMPANY NAME]?

4. __Guidance of search (10min)__
Targets by Government or Industries, # of articles in professional journals

    a. Do you feel that the government is encouraging, either directly or indirectly, the development of grass-fibre innovations?

        i. What type of encouragement is this?

        ii. When did this encouragement start/stop?

        iii. Has the government set any specific targets regarding the production of grass-fibre/ processing of organic waste?

5. __Formation of markets (15min)__
of new niche markets, specific tax regimes, new favourable environmental standards

    a. What are the new niche markets for grass-fibre?

<ol type="i" start="1">
What inhibits these (new) niche markets from developing? (Cost, quality, etc. ?)
Are there any quality standards from buyers that make the process more challenging/expensive?
What does [COMPANY X] do to improve the quality?

<ol type="a" start="2">
Have you come across or do you know of any favourable or unfavourable legislations or regulations, like tax regimes or procurement regulations, regarding grass-fibre innovations that inhibit or stimulate the formation of markets?
<ol type="i">
Which are they and when were these implemented/ceased?
Why did they cease?

Are there environmental standards that help or prevent the formation/development of (new) markets, technology? E.g. car pollution
<ol type="i">
When were these environmental standards introduced?

6. Mobilization of resources (10min)

Physical resources, Human resources, Financial Resources:
Sufficient human resources/capabilities, Subsidies, investments for grass innovations, Biomass streams quantity allocated to project, Biomass streams quality allocated to project, Infrastructure

<ol type="a">
Are there sufficient people with relevant skills available in the field? This includes further up and down the value chain
<ol type="i">
Is/was this a barrier for innovation?
How has this changed over the past 10 years?

Are there sufficient financial resources throughout the innovation process? (R&D, scale-up?)
<ol type="i">
Where does the money usually come from? Subsidies/private investment?
Do you see an increase or decrease in available funding over time?

Are there physical resource constraints that hamper technology diffusion?
<ol type="i">
Is the physical infrastructure well enough developed to support the diffusion of the innovation?
Do companies generally share infrastructure?
Can the infrastructure easily be used for other innovations if the innovation is unsuccessful?
What are the challenges regarding storage and transportation?

Which other resources does the sector lack?


7. Counteracting resistance to change (10min)

Support from government, industry

a. How does your company/the industry receive support from the government to pursue developments related to grass-fibre innovations?
b. How does your company receive support from the industry to pursue developments related to grass-fibre innovations?
   i. Does the sector have platforms that lobby for change or better regulations?
   ii. Can you name them?
   iii. Have these platforms or activities increased or decreased over time? Can you give examples?

Closing Questions (5 minutes)
a. Is there anything else you think I should know about the development of grass-fibre innovations over the past 10 years?
b. Do you have any further questions?
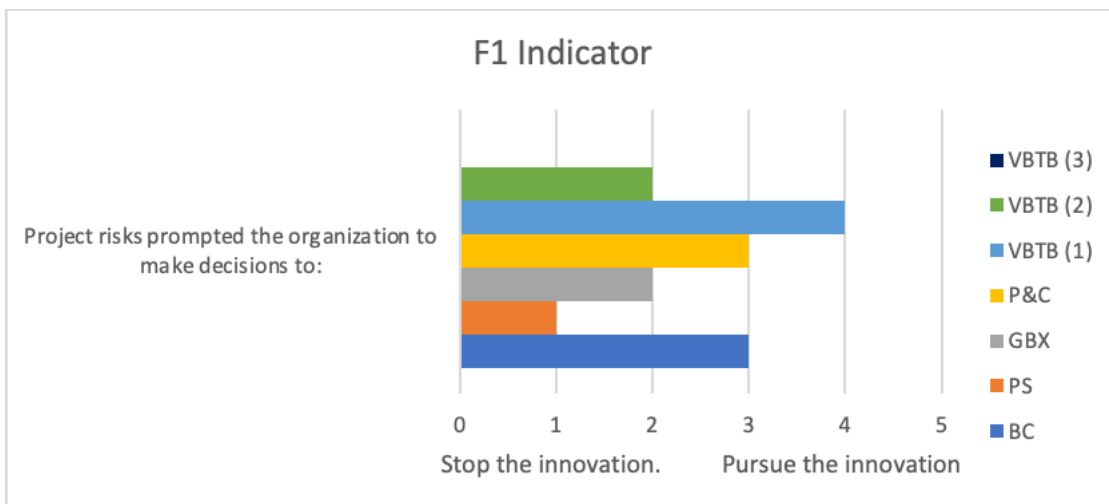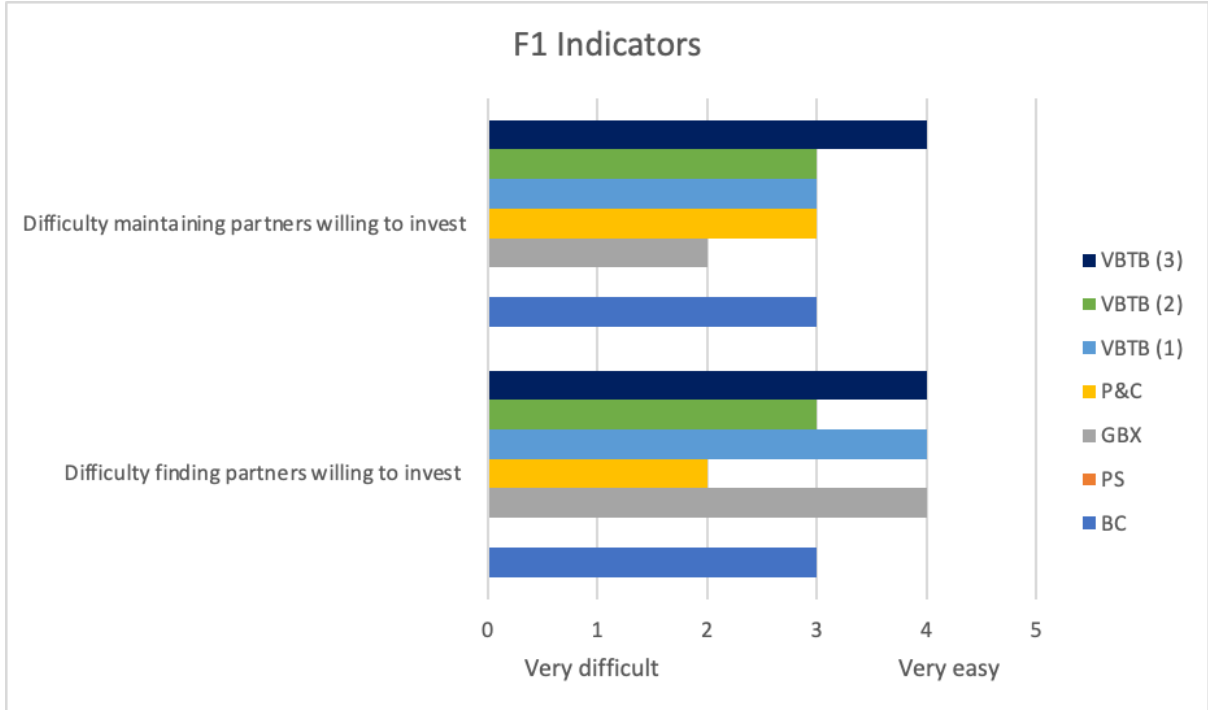
Case\motivation	Financial			Environmental			Social		
	Engage	Disengage	N/A	Engage	Disengage	N/A	Engage	Disengage	N/A
BC	■			■					
PS		■		■					■
GBX		■		■			■		
P&C				■			■		
VBTB (1)			■	■			■		
VBTB (2)		■		■					
VBTB (3)		■		■					■

| Case	Other motivations to:			
	Engage	Disengage	N/A	Motivation explained
BC	■			Circularity
PS			■	
GBX	■			Resourcetransition
P&C	■	■		Sustainble (economic) business model; independent from subsidies; value for end user
VBTB (1)			■	partners can profit from in the long term
VBTB (2)		■		Commitment in the value chain became brittle, 1-way
VBTB (3)	■			Image & shortage of raw materials

Survey results F2

F2 Indicators
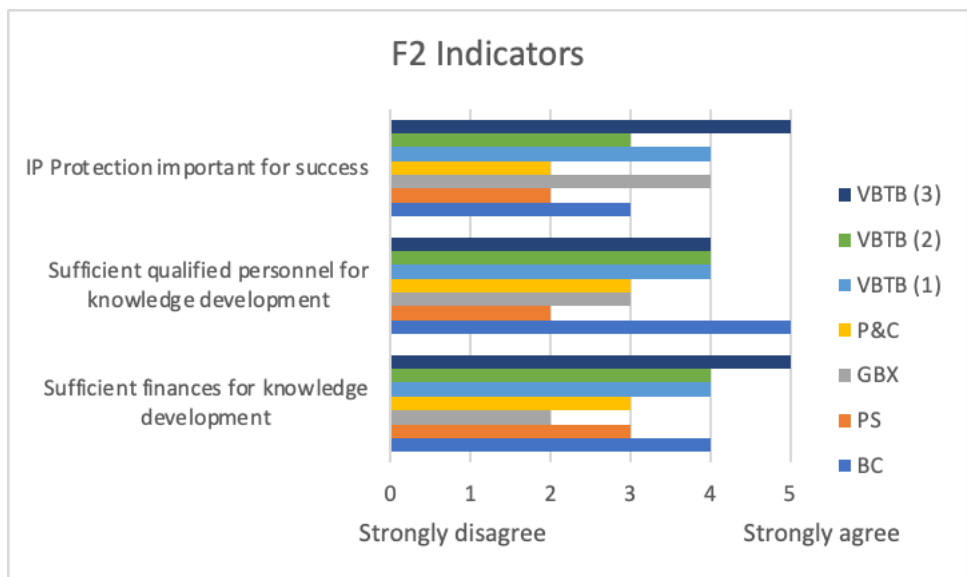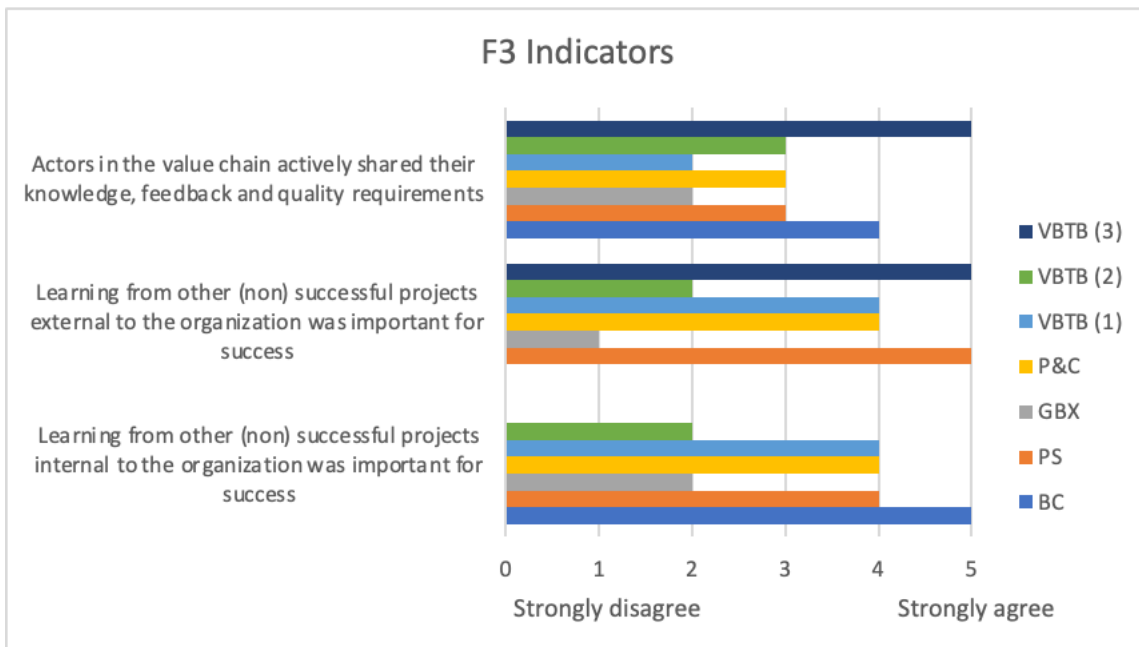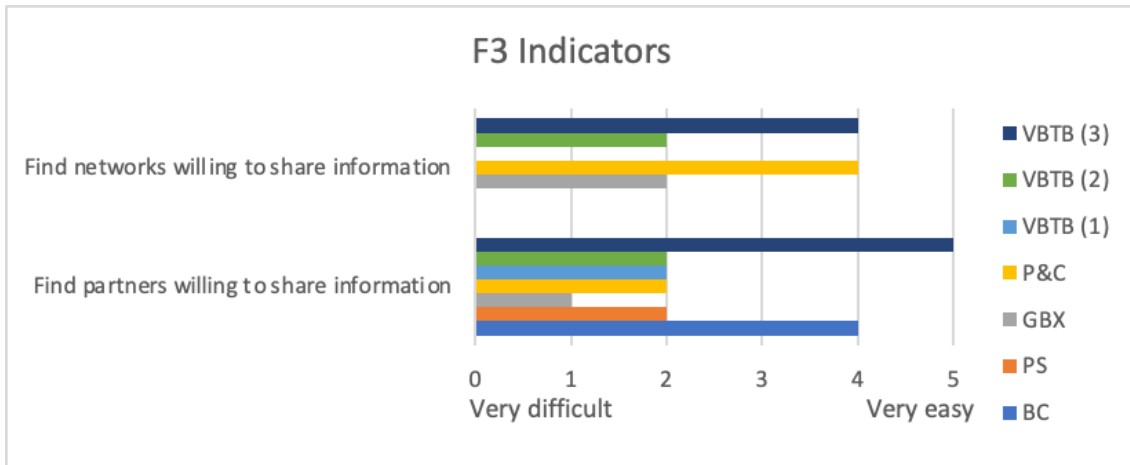
Survey results F3

Survey results F4
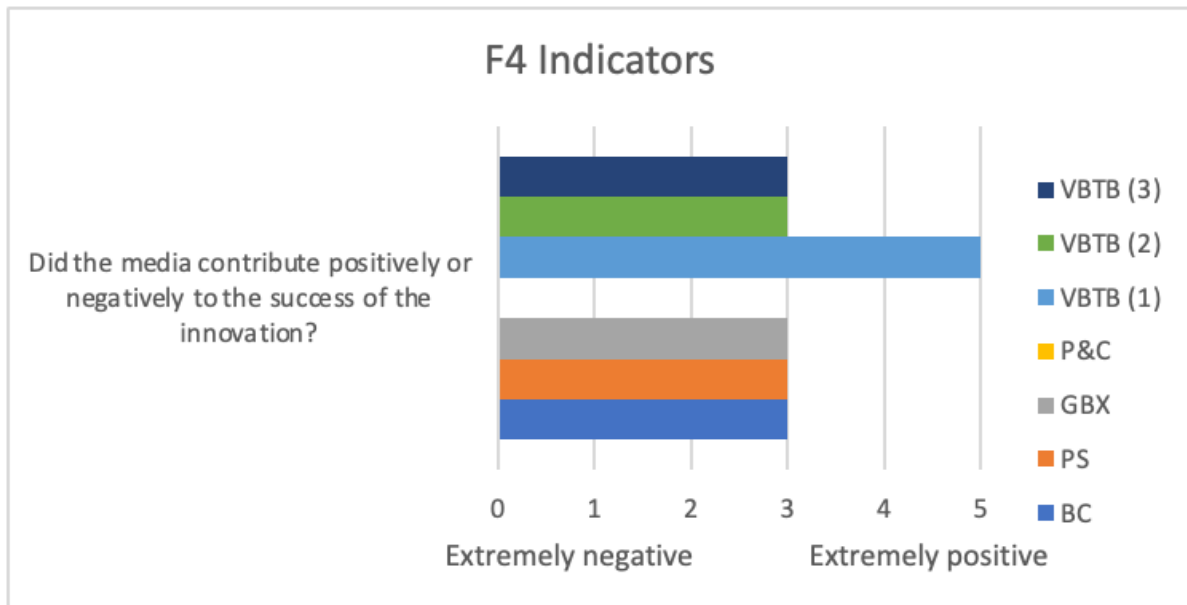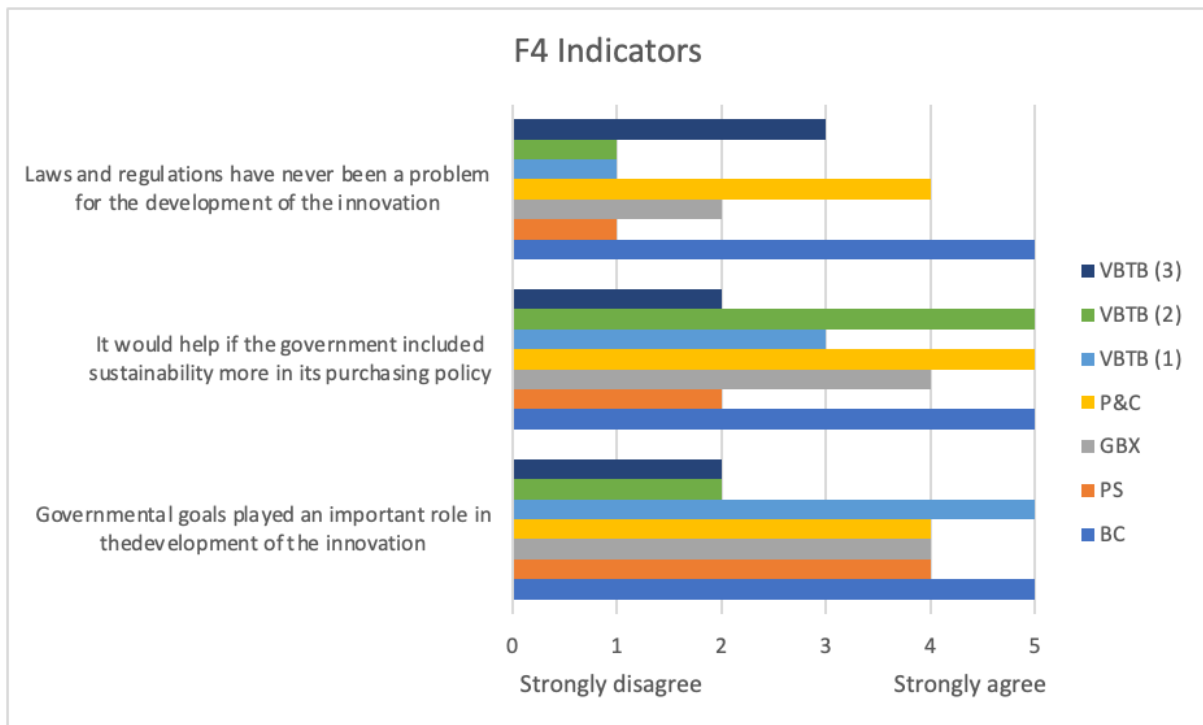
Survey results F5
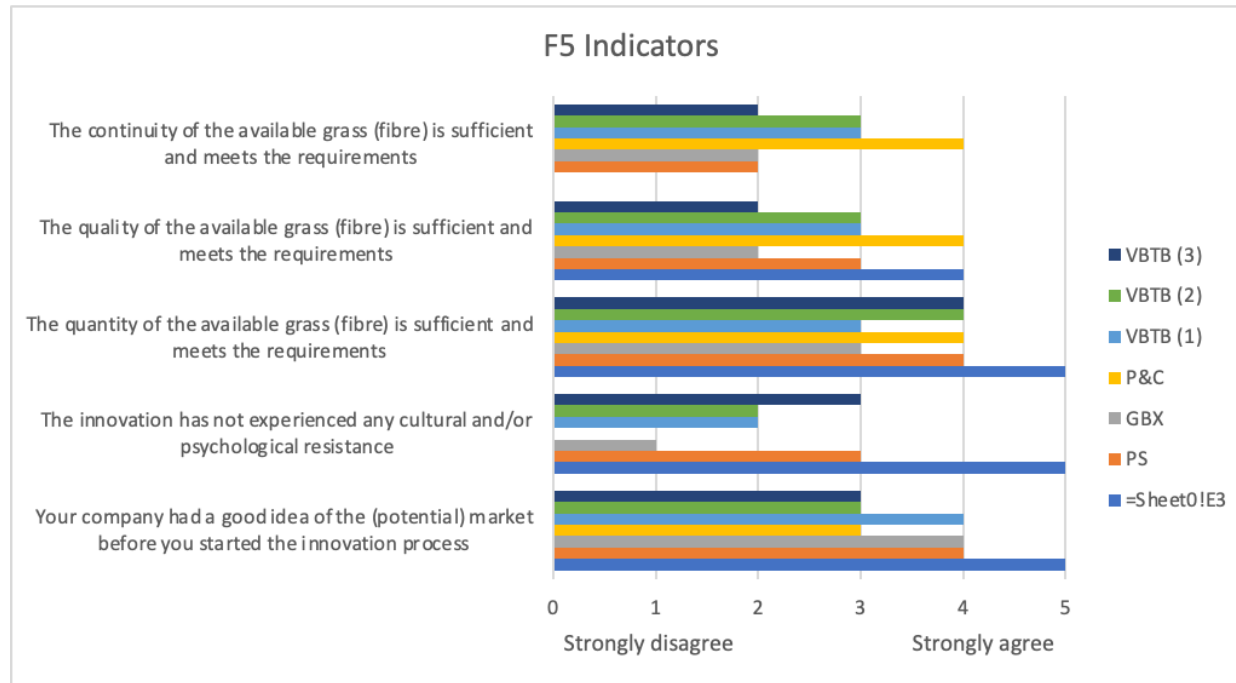
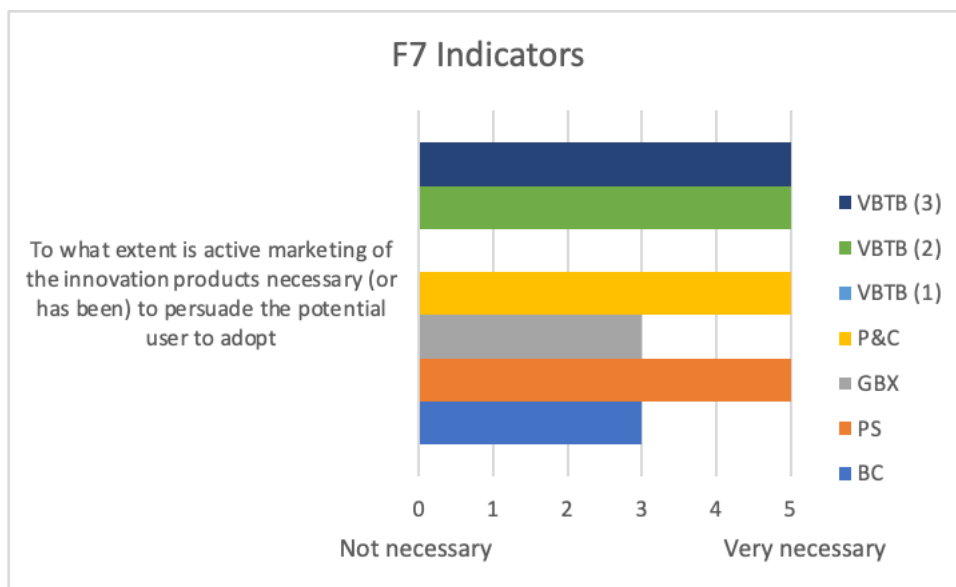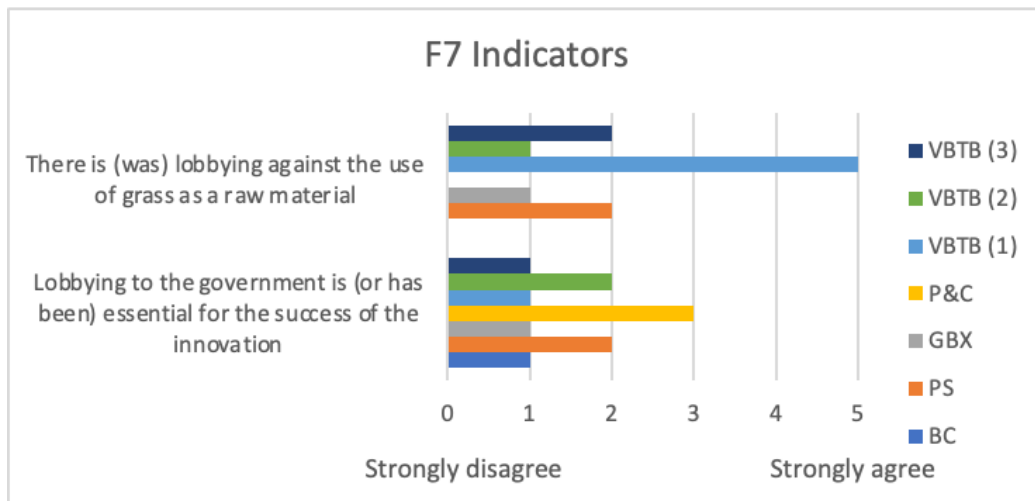The innovation (end-productss) play as follows in current or future markets as follows:

Case	More environmentally friendly	Local	Recycleable	Circular	Cheaper	Equally expensive	More expensive	Better quality	Similar quality	Worse quality	Other
BC	X	X		X							
PS	X		X	X		X			X		
GBX	X	X		X		X		X			
P&C	X	X		X					X		
VBTB (1)											X (everything)
VBTB (2)	X	X		X		X			X		
VBTB (3)	X	X	X			X			X		

Survey results F6
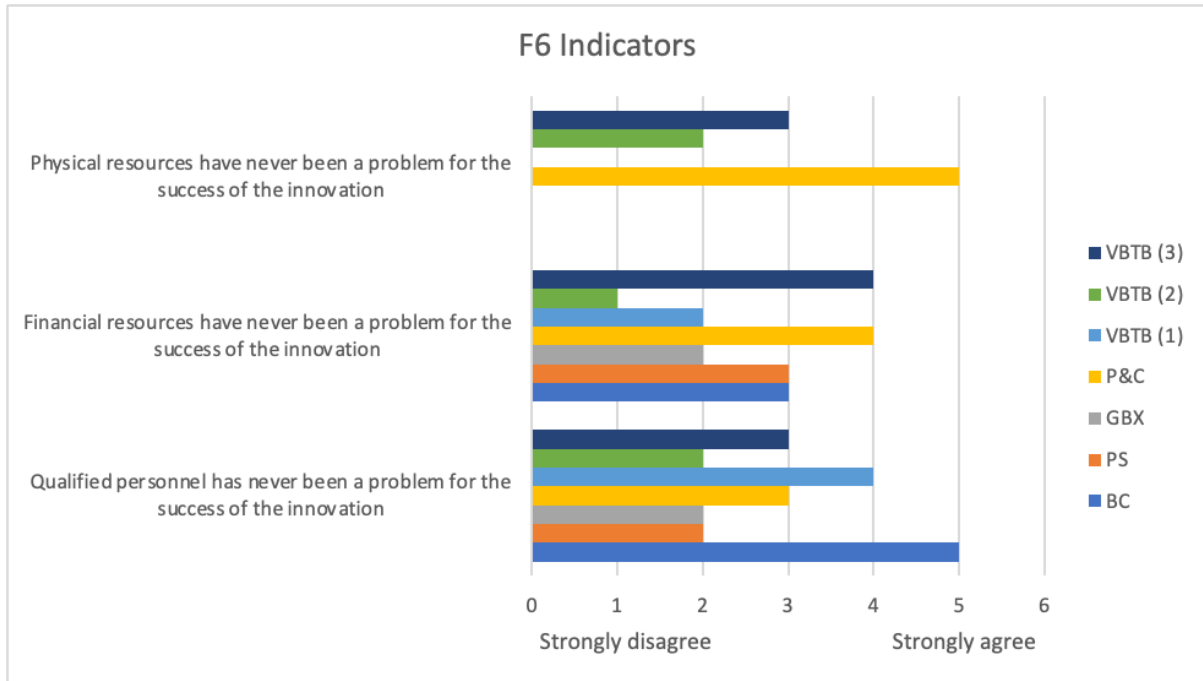
Case	The innovation process mainly used existing infrastructure	Developing and creating new physical assets was an important part of the innovation process
BC	X	
PS	X	
GBX		
P&C	X	
VBTB (1)	X	X
VBTB (2)		X
VBTB (3)		X

Survey results F7

Case	Other important issues that need to be addressed in the interview
BC	
PS	
GBX	
P&C	
VBTB (1)	Role of BVOR
VBTB (2)	
VBTB (3)	The risks of using roadside grass in the papermaking process have not been addressed. Another thing to discuss is the BfR standard