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A system thinking approach to desirable changes in the supply chain of industrial hemp in Finland

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TABLE OF CONTENTS

LIST OF ABBREVIATIONS, TABLES AND FIGURES

Abbreviations

CAP: Common Agricultural Policy

CBD: Cannabidiol

CEO: Chief Executive Officer

DFS: Diversified Farm Systems

EIC: European Innovation Council

EIHA: European Industrial Hemp Association

FIMEA: Finnish Medicine Agency

SSM: Soft System Methodology

SUPD: Single Use Plastic Directive

THC: Tetrahydrocannabinol

VBSC: Value Based Supply Chains

Figures

Tables

ABSTRACT

Agroecosystems are complex systems, where interactions between socio-ecological and ecological processes take place. Modern agricultural systems tend to externalize costs of production and deplete the Earth's resources. Diversified Farm systems (DFS) can contribute to providing ecosystem services and mitigate some of the adverse effects of modern industrial agriculture. Hemp is a resilient and fast-growing crop, that can be used for a multitude of purposes. It holds a strong potential for economic and industrial development in Europe. Soft system methodology, encompassing action-oriented research, participatory and qualitative methods, as well as system thinking is applied to address the problematic situation. A case study in Finland serves as the foundation for a systems inquiry into the supply chain of industrial hemp, where six categories are used to understand different aspects of the case. It is proposed that changes can be made to improve the current situation to reach a desired future situation. The current situation for supplying hemp is limited to a small established market for hemp seeds, and a developing market for hemp biomass. A desired future scenario for the supply chain of hemp includes a network of farmers, collaboration across industries and more industrial equipment for hemp harvest and processing, which will result in higher quality material and reliant supply. Transparency and trust across the supply chain may support the transition, whereas lack of funding and a competition mindset may hinder the transition. It is desirable to establish a network of farmers, which can contribute to knowledge sharing and new innovations in the supply chain. Making change in the current system requires a collaborative effort between key stakeholders and is influenced by supportive policy implementation.

1 INTRODUCTION

According to the IPCC report published in 2019, land areas have warmed 1,5 degrees Celsius since the industrial revolution and shows that 22 percent of anthropogenic emissions arise from agriculture, forestry, and other land uses. The report emphasizes, that we must change our current cultivation and processing system, if we want to reduce the amount of greenhouses gases in the atmosphere (IPCC, 2019). Furthermore, geological studies show that the anthropogenic use of earth resources are causing a mass extinction of biological diversity, calling for severe conservation strategies and the reduction in the use of fossil fuels (Barnosky et al., 2011). Biodiversity and ecosystem functions are degraded by the expansion of conventional agricultural intensification and undermines the natural foundation on which agriculture is built. The practices of industrial agriculture, including cropping practices such as monoculture, intensive tilling, applying synthetic fertilizers, using irrigation systems, applying chemical pest and weed control as well as genetically modifying plants and animals are part of the reason why industrial agriculture is not sustainable (Gliessman, 2015).

One of the first definitions of sustainability was made in the Brundtland report published in 1987, where sustainable development is defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” It takes account of different stages of economic and social development, and the interrelationships between people, resources, environment and development in different countries (Brundtland, 1987). Presently, the term sustainability is being challenged in the face of climate crisis, involving many complex problems and an unpredictable future. The sustainability concept has many faces and is loosely defined with moving targets (IPCC, 2019).

1.1 CURRENT STATE OF AGRICULTURE AND PRODUCTION OF NATURAL FIBERS

Globally, industrial agricultural production contribute to the depletion of natural resources and pollution of the atmosphere with greenhouse gases (Gliessman, 2015). As the population on Earth has increased, so has the need of available resources such as food, clothes, medicine and living space. This often comes at cost of the natural environment and is a part of the anthropogenic alternation of the earth’s surface (Vanbergen et al., 2020).

Agroecology has since its emergence in the 1970’s proposed different measures to understand and work with agriculture, in a way that meet the standards of the Brundtland definition of sustainability in all parts of the food system. It offers socio-economic pathways for sustainable agriculture to meet the need for more ecological farming systems, while acknowledging the need for change on a political and economic level (Gliessman, 2018). Agroecosystems are by Conway defined as “ecological systems modified by human beings to produce food, fibre or other

agricultural products." He continues to define them as complex systems where interactions between socio-economic and ecological processes define the complexity (Conway, 1987). For an agroecosystem to be resilient, it is necessary that the social structures provide a security network for severe climatic events. An example of a strong social network is the rural movement 'La Via Campesina', an international movement with chapters in 21 European countries, underscores the ability of a bottom-up approach to facilitate change in current economic and political structures (Altieri et al., 2015). These approaches may impact farming systems to become more socially just and environmentally friendly.

1.1.1 Diversified farm systems as part of the solution

According to (Kremen et al., 2012) Diversified Farming Systems (DFS) are systems that are designed to intentionally incorporate functional biodiversity with practice from either traditional farming knowledge or agroecological scientific knowledge. DFS can be seen as social-ecological systems, that enable ecological diversification through social initiatives, which both involve governmental and non-governmental bodies (Kremen et al., 2012). To reach a DFS, several methods can be used including a) smallholders with diversified farming systems resisting large-scale commercial agriculture, b) social movements supporting locally grown food and local farmers and c) national efforts to support smallholders and DFS to achieve food sovereignty and justice (Kremen et al., 2012).

Diversified Farm Systems aim to optimize ecological processes at farm and landscape level to provide ecosystem services to the surrounding environment. The greater the structural and functional similarities an agroecosystem has to a natural ecosystem in the same biogeographic region, the more sustainable it will be (Gliessman et al., 1998). Ecological intensification can promote productive and environmentally friendly farming systems. Integrating ecological principles, which are found in natural ecosystems can increase supporting, regulating and providing services from agroecosystems (Bommarco et al., 2013). Furthermore, cultivating plants in polycultures can increase both the biological diversity in the agricultural landscape, and increase yield (Iverson et al., 2014).

Internalizing environmental costs includes designing systems, where energy comes from renewable sources, and a better balance between the energy used to maintain the system and produce a yield for export (Gliessman, 2015). This may come with a cost, as the costs of production are internalized, resulting in a higher price of the product. However, products from DFS can make consumers more aware of production and bring them closer to the origin of their food, fuel, or fiber (Kremen et al., 2012).

1.1.2 Sustainable production of fiber crops

Multifunctional plants can contribute to the livelihoods of people and provide them with necessary resources without depleting the Earth (Rehman et al., 2021). It has shown difficult to upscale the production of hemp and natural fibers in a European context, despite efforts of continuous research (Amaducci et al., 2008). This can be due to an array of different socio-technical difficulties (Meynard et al., 2018) as well as market demand, and other aspects. It is necessary to address the need for sustainable agroecosystems, which can sustain the current and future needs for food, fibre and feed.

Currently, much of the textiles produced today come from either synthetic fibers or cotton. Both these means of production are not very sustainable. The production of cotton is taking the lead in the consumption of insecticides, pesticides and water as compared to other cultivated plants (Gedik & Avinc, 2022). Synthetic fibers are the most prevalent fibers on the market, but are unsustainable in their nature. Produced at factories from fossil fuels they pose an environmental threat as a non-degradable fiber (Gedik & Avinc, 2022). Hemp is a promising eco-friendly alternative to cotton and synthetic fibers are natural fibers (Montford & Small, 1999), which can be used in new promising innovations such as fiber-reinforced composites, insulating products, textile and non-woven soft materials (Moussa et al., 2020)

1.2 DISCOURSE ON HEMP SUPPLY AND UTILIZATION

1.2.1 Role of hemp in history up until now

The first signs of hemp cultivation have been traced back to 6000 years ago in China. It has played an important role in the agricultural landscapes of our ancestors and contributed to many different usages, including food, textile and medicine (Li, 1973). Hemp has spread all over the world, thanks to its adaptability to various climate conditions and soil structures. Hemp cultivation was introduced in Europe around the 1500s, where it played an important role as a source of fiber, where maritime countries used hemp to produce canvas and cordage for naval applications. (Gedik & Avinc, 2022). However, declining needs for fiber and competition from other plant fiber sources began to reduce demand for hemp (Fike, 2017).

Many people link cannabis with the plant cultivated for its psychoactive components, even though this is only one of its many qualities. It can in many ways be categorized as a stigmatized plant with a long history of being illegalized and banned from the global market (Fortenbery & Mick, 2014). In 1937, the United States imposed the Marijuana Tax Act, which illegalized the usage of hemp and thus restricted hemp agriculture (Fike, 2016). In 2023 the new Common Agricultural Policy (CAP) went into force, recognizing the possibility for farmers to receive direct payment for hemp varieties containing up to 0,3% THC as compared to 0,2%, which has previously been the requirement of industrial hemp in Europe (EIHA, 2021b). However, it can be argued that the

nomenclature and regulation of the plant are arbitrary due to blurry boundaries among hemp products, as well as pharmaceutical speculations in the medicinal properties of cannabis (Levy, 2018). Even though we have reached a new level of common understanding, that hemp can be a useful and profitable plant (Gedik & Avinc, 2022), there is still resistance towards accepting the beneficial human-cannabis relation (Levy, 2018).

As more products with hemp emerge on the market, so does the consumer awareness of its benefits and many purposes. However, there are examples of supermarkets withdrawing hemp products due to allegedly high levels of the psychoactive compound THC (Gore-Langton, 2021). The lobbies for hemp, specifically the EIHA (European Industrial Hemp Association) work to counteract this tendency by defending the safety and positive health properties of hemp products (EIHA, 2021a). This example shows as recent evidence, that even though we have come a long way regarding the common perception of cannabis sativa, there are still forces working against the public knowledge and awareness of hemp as a safe and multipurpose plant.

1.2.2 Cultivation and usage of hemp

Hemp (*cannabis sativa)* has a multitude of utilization purposes in commercial products, such as textile, paper, medicine, food, animal feed, paint, biofuel, biodegradable plastic, and construction material, which can create economic and environmental benefits in a multitude of professions (Robinson, 1996). Hemp is a resilient and fast-growing plant, that does not need pesticides or insecticides (Duque Schumacher et al., 2020). It also produces a high biomass, and has an ability to grow under differing conditions such as in the Nordic regions (Rehman et al., 2021). Hemp fiber can be a sustainable alternative to cotton cultivation and reduce land and water use up to 3 times as compared to the current conditions in cotton production. Additionally, cultivation of hemp would counterpose the need of chemical input at farm level, which in cotton production amounts to the biggest usage of pesticides and insecticides in the world (Duque Schumacher et al., 2020). Hemp is a valuable crop in crop rotations due to its positive effect on subsequent crops, particularly benefiting wheat yields. Hemp's rapid growth makes it competitive against weeds, making it well-suited for organic agriculture. Furthermore, the deep root system of the plant is known to improve soil structure (Amaducci et al., 2015).

Hemp is an annual angiosperm plant in the Cannabaceae family, which grows tall and slender. Monoecious varieties have been selected in modern agricultural production systems due to its enhanced qualities regarding seed harvest, fiber quality and reduced yield loss. Morphologically, the stem consists of different parts, including primary and secondary fibers as well as a woody core. The quality of the fiber varies along the stem, with coarser fibers at the bottom and finer ones in the top. Less technical information is available on the woody core, consisting of wood-like fiber, which is also known as hurds or shives (Amaducci et al., 2015). In this paper, the woody core will be referred to as shives, and the bast fiber will mainly be referred to as fibers.

Harvesting time for hemp can be determined based on plant phenology. It is said that late harvest in Nordic countries may decrease the quality of the fiber due to humid conditions. When hemp is grown for purposes like pulp and paper or bioenergy, harvesting time has less impact on the biomass quality. Spring harvest may be useful for hemp biomass used in solid fuels, as the biomass naturally dries during the winter, although some biomass may be lost. The choice between autumn and spring harvests has little energy-related significance, with some studies suggesting a higher energy return for spring harvest (Amaducci et al., 2015). To separate the bast fiber from the woody core, a process called 'retting' is required, which relies on environmental microbial populations to break down binding components. Factors like crop maturity, retting method, environmental conditions, and microbial populations affect retting (Schluttenhofer & Yuan, 2017).

1.2.3 Economic and industrial aspects of hemp cultivation

The current economic system has led to concerns in terms of environmental and social sustainability (Raworth, 2017). Resource use, habitat destruction and externalized supply chains, where working conditions are undermined, impact both the environment and society negatively (Skene, 2022). As short supply chains have stretched across the globe, the aspect of accountability has been pushed aside, leading to resource exploitation and externalization of environmental costs (Hofmann et al., 2018). Hemp production can be a viable sustainable alternative to cotton because it is economically competitive. Agricultural costs of hemp fiber are on average 78% less than those of cotton fiber. As a low-input agricultural plant, the agricultural costs of producing hemp fiber can be down to 1/12 of the price of cotton fiber (Duque Schumacher et al., 2020). However, cotton has mass economies of scale to support its production (ibid.)

To offer a viable market alternative to the large commodity markets of scale, Value Based Supply Chains (VBSC) have been a suggested framework to provide viable marketing channels for farmers. It can potentially provide mid-scale producers market access, that meets their size of production through direct markets and customer relations (Lerman, 2012). The economic profitability of hemp can be seen on global markets, but there is still a lot to do within different sectors to promote the cultivation, processing, and supply of hemp (Burley, 2017). Value chains can be considered a web of interconnected stakeholders in a non-hierarchical relationship, that aims to achieve common goals. The value of the web itself is often not considered, whereas the product outcome is the main decided value of the value chain. Value webs can be an example of value-based and action-oriented collaborations, which constitute the value chain in a specific industry (Block et al., 2008).

There is a lack of innovation and industrialization of hemp fiber production, which leaves opportunities for improvement in the different stages of processing and marketing the plant

(Duque Schumacher et al., 2020). New applications for hemp fiber requires treatment of the bast fiber, which can break down the lignocellulosic component of the natural fibers in order to make them soft and applicable (Moussa et al., 2020). Hemp can be used for building materials, where local carpenters and entrepreneurs can be a part of developing new processing companies for hemp. In the production of textile, hemp has mainly been blended with cotton and synthetic fibers due to barriers in the industrial process of the production of full-hemp based textiles (Kostic et al., 2008).

Due to a lack of innovation in the industrialization of hemp fiber production, there are imposing opportunities for improvements in the different stages of production. Materials, such as cotton, has been industrialized for many years, making it the leading natural fiber and suitable for economies of scale, but also limits the likelihood of process improvement. Demand for product quality requires high operational production to ensure profitability (Pecenka et al., 2012). It has been identified that a range of socio-technical aspects can be the cause of this, including lack of collaboration in industry across different sectors. Furthermore, economic support from funds such as the EIC (previously known as EIP), can promote hemp cultivation (Meynard et al., 2018). Some authors also emphasize the need to use holistic approaches to finding challenges and opportunities for hemp in a socio-economic perspective (Lima & Montagna, 2021).

1.2.4 Prospects of industrial hemp in Finland

In a neo-liberal economy, competition is driving industries to market their products at the lowest price possible. To meet market demands and a consumer culture, industries externalize environmental costs of production and destroy natural cycles, depleting natural resource, leaving too much waste in nature's sink (Raworth, 2017). On a worldwide basis, the demand for hemp is steadily rising, driven by the rising demand for hemp fiber, shives and seeds in application industries such as food and beverage, animal care, construction to personal care (Research, 2023). In Europe, it is currently France that has the biggest production of hemp, which amounts to 12.000 ha (Crini et al., 2020). This amounts to 70% of European hemp supply and is followed by the Netherlands (10%) and Austria (4%). (European Commission, 2022). The European Union has recently launched a hemp cultivation program, that promotes the cultivation of industrial hemp and encourages the member states to increase the amount of arable land used for hemp cultivation in Europe (European Commission, 2022).

Processing plants for hemp are underdeveloped, and in need of more research to become economically viable (Pecenka et al., 2012). Hemp has not undergone the same level of agricultural research and development as major crops have in the last 50 years. However, there is a growing interest for hemp as a multipurpose crop in European countries, particularly for the combination of fiber and seed, which can be profitable (Tang et al., 2016). In studies on the cultivation and production in hemp systems, results have indicated that it takes research and

development of an innovative production system for hemp, which uses multidisciplinary knowledge from cultivation technique to the development of end products (Amaducci et al., 2008). Now, hemp is seemingly returning to the market and being recognized for its many uses, also going beyond the traditional rope, cordage and canvas, reviving interest in the crop. Even in the US, where hemp has seen a notable growth of production, there are still many things to learn about how to make it a viable crop competitive with other commodities (Fike, 2016).

In a study on the obstacles for minor crops to emerge in agriculture, it has been found that an array of socio-technical hinders are restricting the development. From upstream to downstream the obstacles are in the seeds and pesticide supply, farming practices, harvest collection and storage as well as processing and distribution (Meynard et al., 2018). This reveals a need to further analyze the current system and come with suggestions for systems change.

1.3 SOFT SYSTEM METHODOLOGY TO ADDRESS COMPLEX SOCIAL SITUATIONS

Systems thinking is an approach to address complex problematic situations in human constructed systems, where several layers exist (Bawden, 1991). Food production systems, processing and marketing, economic and political decisions, and consumer habits in society are all related to each other across spatial and temporal scales in complex ways (Wezel et al., 2009). It is needed to address the complexity of the problematic relationships between agriculture and the environment with a science and praxis of complexity. Not all improvements in the name of productivity coincide with principles of sustainability (Bawden, 1991). Action-oriented research need to address the farming system across different hierarchical levels in the value chain for the system to become ecological, economic, and social sustainable. (Gliessman, 2016). To make change in farming systems, an action-oriented research approach involving can be used (Francis et al., 2003). Action research emphasizes the importance of participatory and collaborative processes, promoting a shared understanding of the issues and solutions. The researcher being part of the system, should aim for being analytical at a distance in this research approach (Levin & Ravn, 2007). Case studies are commonly used in an array of scientific epistemologies and can be useful for understanding complex social phenomenon (Yin, 2014). Doing a deep investigation into a single case, can yield a holistic and real-world perspective on the situation. It is suitable to use a case study, when there are many variables and processes in play, that one cannot acquire data about elsewhere (ibid). Giving suggestions for desirable and feasible change in the value chain of industrial hemp in Finland requires using a system thinking approach. The inquiry process is guided by 2nd order cybernetic thinking, where processes across temporal and spatial scales are integrated.

1.3.1 Systems thinking to facilitate systemic change

In order to work against the worst effects of environmental and climatic change, a transformative and systemic change is needed. Systemic change varies in their reliance on nature and technology and is facilitated across different socio-economic, ecological and political settings (Vanbergen et al., 2020). For this to take place, it is necessary to dive further into the cybernetic layers of the system itself (Bawden, 1991) to understand the interconnectedness and interdependence of different components and actors within the system and their relationships with the environment and other realms (Bawden, 1991). In this way, systems thinking can be used to identify and address underlying causes of problems, rather than just symptoms, by taking a holistic perspective (Stroh, 2014).

This includes dimensions on the sociological paradigm wherein we identify and make decision about the agroecosystem. The study of the whole food system including both natural and social sciences, emphasizing systems thinking and ecological principles are necessary to create long-term resilient solutions to the current state of agricultural landscapes (Francis et al., 2003). This requires a transdisciplinary approach and methods, where different properties of the production system are examined across the value chain, including processing and marketing, economic and political decisions as well as consumer habits in society. These properties are not directly linked to a specific scale, but are interrelated to each other across various spatial and temporal scales (Wezel et al., 2009). The SSM proposes a holistic and integrated way of thinking about these complex social systems (Bawden, 1991). Five stages with activities have been proposed as a method to deal with a perceived problematic situation. These five stages can aid the inquirer to map changes, which can bring improvement to the situation (Checkland & Poulter, 2006). The five stages can be seen in the model below.

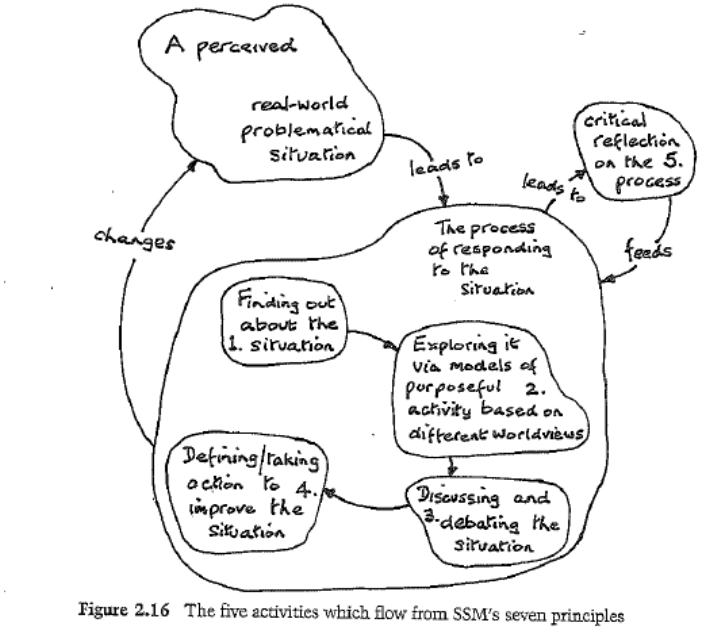

Figure 2.16 The five activities which flow from SSM's seven principles

Figure 1. The different stages in the Soft System Methodology. Source: Checkland and Poulter (2006).

The model depicts five actions, which can lead to a better understanding of a problematic real-world situation. It proposes a framework for action-research and consist of: 1) finding out about the problematic situation; 2) Formulating relevant purposeful activity models that are relevant to exploring the situation; 3) questioning the situation using the models, in order to a) find desirable and feasible change and b) the accommodations between conflicting interests; 4) defining action steps to change the situation for the better; and 5) reflecting about the proces (Checkland & Poulter, 2006).

1.3.2 Action-oriented research

Action research emphasizes the importance of participatory and collaborative processes, promoting a shared understanding of the issues and solutions. The involvement of multiple stakeholders and the integration of diverse perspectives can lead to more effective problem-solving and the creation of more sustainable and resilient food systems (Armson, 2011; Kurt, 1958). Additionally, these methods can be used as a framework for promoting sustainable agriculture and addressing complex problems in food systems (Francis et al., 2003).

Farming systems can be understood as purposeful human activity system producing a yield. To understand the value chain of a product produced in the agricultural sector, it is important to understand the means of cultivation at the farm level, as the farming system is upstream the value chain, only exceeded by the supplier of inputs to the agricultural system, such as seeds, pesticides or fossil fuels(Meynard et al., 2018). It has been argued for a long time, that it is needed to use new methods to address the complexities of change processes within the agricultural sector, and that the transition towards new forms of collective action, networks of stakeholders, consultation methods, controversies, modes of building and running socio-technical norms, developing markets, public sector action, etc. requires a new approach to research (Hubert et al., 2012). Action research in agriculture seeks to create a change in the agricultural system by proposing action steps for change. Action research brings together action and reflection, theory and practice, with the engaged researcher as a part of the research process. Action research aims at providing practical solutions to issues of concern to people internal to the system. The issues can also be understood and analyzed in a wider societal context (Lieblein et al., 2012).

1.3.3 Case study approach

Case studies can be used to generate knowledge for more generalized situations. It involves in-depth analysis of a specific situation, with the goal of understanding the underlying processes and factors that lead to the outcome. By examining a specific situation in detail, it is possible to develop a deeper understanding of the factors that influence outcomes, and use this knowledge to develop more generalizable theories and frameworks (Armson, 2011).

Case study research may be an applicable research method in many different situations, to contribute to our knowledge on individual, group, organizational, social, political, and related phenomena. Case studies are commonly used in political science, anthropology, business and community planning, but is also seen in studies in economics and in investigations about the structure of a given industry or the economy of a region (Yin, 2014). Using case studies as a method is useful when there is a wish to understand a complex social phenomenon. Case studies allow for a deep investigation into a single case, that can shed light on an impendent situation yielding a holistic and real-world perspective. Case studies are suitable, if there are more variables and processes in play, that one cannot acquire data about elsewhere (ibid).

The starting point for this thesis was the farm system at Korkeaoja farm in Finland, where hemp is being farmed in polycultures with alfalfa and oat. The understanding of a the farm system as sustainable is in relation to the definition of diversified farm system, where both the biophysical properties of the farm is explored on spatial scale as well as the socio-economic dynamics of the farm in its context. In relation to DFS, it has been emphasized that new research should be holistic and integrated, considering various aspects of the farming system. This approach aims to identify management systems that can leverage potential synergies within the system (Kremen et al., 2012).

1.3.4 Research questions

The specific research objective in this thesis is to find out what desirable and feasible changes can make the current supply chain economically profitable, socially just an environmentally friendly. The inquiry process was guided by the SSM and the five stages proposed by Checkland & Poulter presented in chapter 1.3.1. The overarching question address the root definition of the project and the four sub questions are nested in the first four stages related to exploring the situation and defining actions to bring improvements, which involved 1) mapping the current situation; 2) creating models to understand it; 3) discussing and debating the situation; and 4) defining actions that can improve the situation. The system inquiry process is strongly connected to a temporal aspect, which can be seen in the model below.

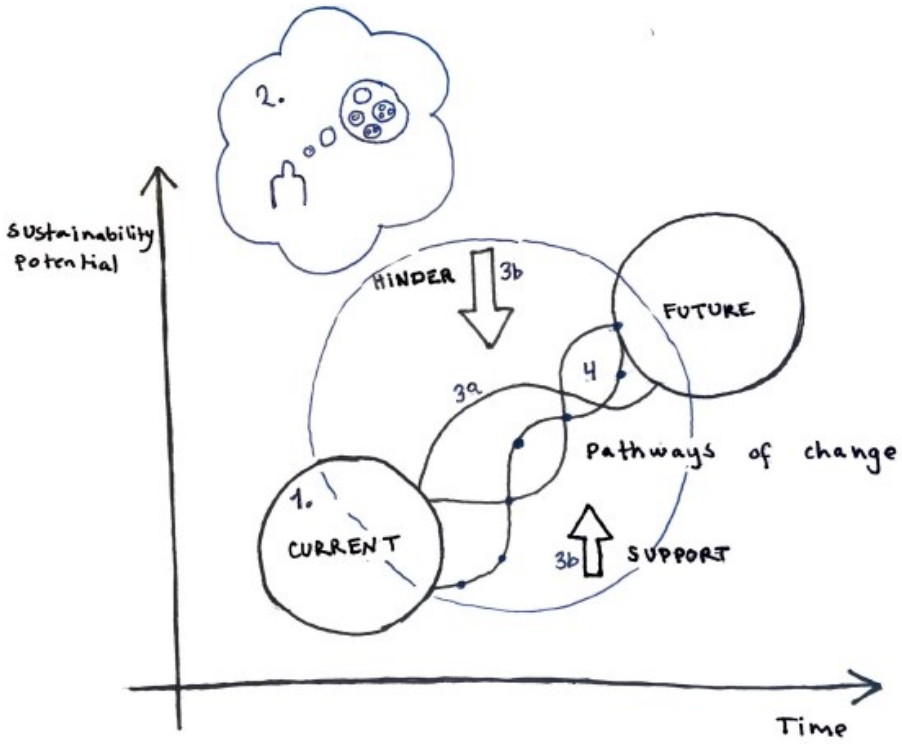

Figure 2 Roadmap to research questions. The blue line refers to the SSM methodology and the numbers refer to the different stages described in in chapter. 1.3.1. The black line refers to a model adapted by Park and Seater (1996), which is elaborated in chapter 2.1.1.

The first stage addresses the current situation of hemp supply in Finland (stage 1, Q1). The second stage implies using tools and systems models to understand the situation. To further discuss and question the situation, elements, mechanisms, and regulators in a desired future situation are identified (stage 3a, Q2). Moving from the current situation to the future is a function of time and actions, where supporting and hindering forces are impacting the transitional pathways (stage 3b, Q3). Proposing action steps, which can bring improvement to the situation by defining a specific project, which can be regarded as a sustainable pathway (stage 4, Q4).

The overarching question

What desirable and feasible changes in the current Finnish supply chain of industrial hemp would make it economically profitable, socially just and environmentally friendly?

The overarching question takes in consideration the complexities of the supply chain of industrial hemp and acknowledge that changes can be made to improve the current situation to reach an economically profitable, socially just and environmentally friendly future situation. It is rooted in an understanding that there are some problematic issues in the current situation, which can be addressed by using SSM to create desirable change.

The sub questions

1) **What is the perceived situation among the stakeholders in the supply chain from growing to marketing of industrial hemp?**

This question aims to find out about the current situation of supplying and farming hemp through the stakeholders in the supply chain of industrial hemp, as they have intimate knowledge on the current situation of the supply chain.

2) **What is a desired future for a well-functioning and sustainable supply chain in Finland?**

This question aims to address desirable elements, mechanisms, and regulators of the future supply chain, enabling a debate about what desirable and feasible changes can be made to improve the current situation.

3) **What is supporting and hindering the transition from the current to the desirable future?**

This question aims to debate the supporting and hindering forces, which influence the transition from the present to the future situation. It also involves a discussion about conflicting interests across the stakeholder network.

4) **What purposeful actions to bring improvement to the current system can be implemented?**

To move from the current to the future situation, purposeful actions must be taken. The change process is a function of time and actions, where supporting and hindering forces are influencing the impact of each action. Aiming at being action-oriented research, this questions gives suggestions on purposeful actions, which may improve the situation.

2 METHODS AND MATERIALS

This chapter gives an overview of the methods applied during the research leading to this thesis, where soft system methodology is the overarching method that has been applied to address the research questions. With the use of soft system methodology, the writer of this thesis should be considered an internal actor and observer participating in systems learning. The SSM is both applied as a conceptual framework for thinking about the case and applied to analyze and interpret the elements interacting in the system. A mental model for making change in social systems has been used to map the current and future situation, as well as the supporting and hindering forces. As the research questions address a transition from the current situation to a future situation, action-oriented research was used to give suggestions to actions leading to change. These methods have been supported with systems thinking framework, where different dimensions of the system have been identified and analyzed.

A case study was used to gain insight into a specific situation in order to learn about the specific parts of the system and how they interact. Korkeaoja Farm is the case of interest, and methods developed upon in the systems thinking theory have been used to learn about the case and understand the complexities within it. The boundaries of the system of interest were developed based on the six categories and a preliminary literature review. Qualitative and participatory methods were applied during the engaged research to obtain data from the stakeholders related to the hemp supply chain in Finland. The systems thinking framework was applied in a practical manner for the analysis and interpretation of the findings. Furthermore, action steps were developed according to Checkland's methodology.

2.1 SOFT SYSTEM METHODOLOGY AS CONCEPTUAL FRAMEWORK

2.1.1 Making change in agricultural systems

To develop a viable future scenario for the supply chain of hemp and the farming systems within it, the mental model from (Park & Seaton, 1996) has been used to guide the research process. The model considers sustainable pathways to land use changes and provides policy makers with information to base their decisions upon.

The mental model of sustainable pathways to encourage change as described by (Park & Seaton, 1996) has been adapted to this study to structure the research questions. It is at the core of the methodology and encompasses four key elements, which are the present situation, the desired future situation, the supporting forces that aids the transition from the present to the future and the hindering forces the transition.

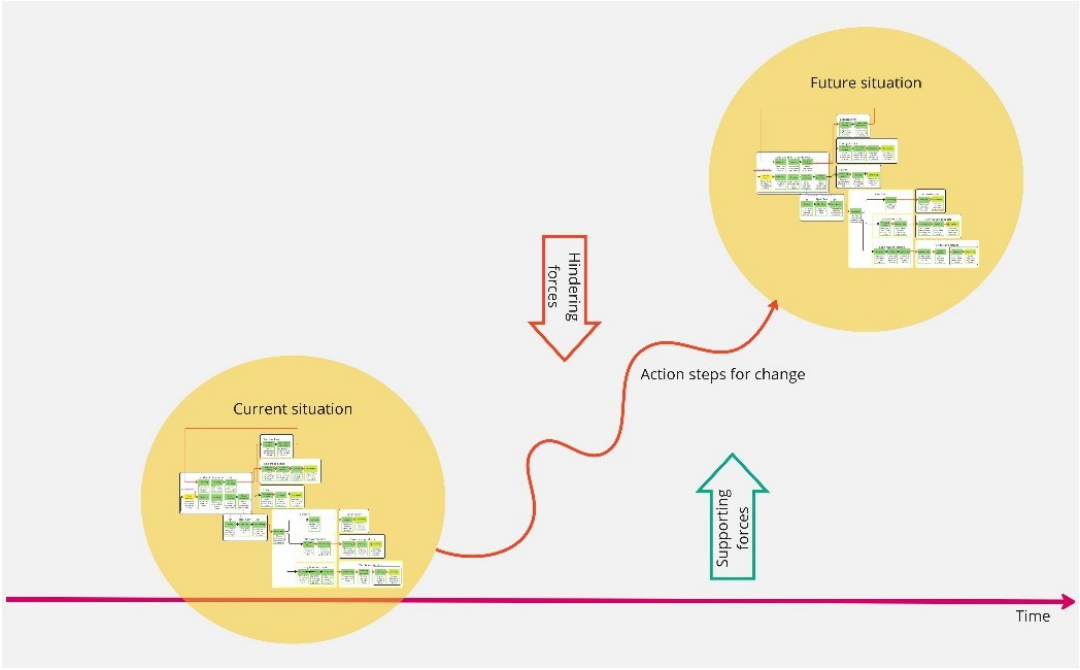

Figure 3. Mental model for mapping the value chain in the current situation, the desired future situation and the supporting and hindering forces influencing the transition. Action steps are implemented in the continuum between the current and future situation to realize the transformation. Adapted from Park and Seaton (1996).

2.1.2 Using action-oriented research

In March 2023 I started the work with the thesis. I had decided to use an action-oriented research strategy to make applicable research results, that may be of use in industry. When going into action-oriented field work, I used the methodological framework of engaged research as described by (Levin & Ravn, 2007). Engaged research praxis requires more than just knowing the theory, it is in the situation that knowledge is acquired. In this context being alert and able to monitor, assess and improvise in the moment are important skills.

Having this in mind, while conducting interviews and speaking with relevant actors, I aimed to be open for emerging themes and ask questions, that could give further information about the topic. I kept a journal to keep track of my experiences and reflect on the things I learned. This helped me recognize themes and topics, which were repeated as well as remembering small details I could bring with me to the next stakeholder. If I heard an interesting statement from one stakeholder about a policy that affected production, I would ask the next stakeholder about the same policy to get a more holistic view of the situation. This is especially relevant for the information gathered about the legislation of side-streams in forest industry and how it can be useful in relation to hemp production.

2.1.3 Using a participatory and qualitative approach

Participant observation is understood as one role a social scientist can take in order to study the qualitative aspects of social life (Bernard, 2017). There are varying degrees of understanding others, where empathy emerges as a key concept in engaged research. (Levin & Ravn, 2007).

This research project was conducted with a participatory and qualitative approach, where participation and observation at the farm level have been part of the process. As a participant in the field, the skill in acting or 'phronesis' became useful concepts for me during my field work, as I had to make choices about my behavior, questions posed and way of interacting with different stakeholders in the moment. To adapt to the range of different stakeholders required my full attention on what worldview I was stepping into and how to interact with the stakeholders to obtain the most valid and useful data as possible(Levin & Ravn, 2007). Researching the value chain of hemp has shown to encompass a wide range of stakeholders, from individual farmers to multinational companies noted on the stock market.

The fieldwork was scheduled to last one month from 26th April – 19th May. The reason the fieldwork was planned in this time, is the high intensity of the work schedule in the spring at the farm. Since Aapo is harvesting the fiber crop in the spring before seeding season, many activities that are relevant to observe are happening in this period. According to Robert Yin, one of the most important sources of evidence is through qualitative interviews. The interviews should according to Yin resemble guided conversations, rather than structured queries, which is also known as unstructured interviews (Yin, 2014).

During the interviews I was able to visit the headquarters of each stakeholder giving insight into their means of production, product samples and building philosophy through observation of field sites. Based on the farm system in Korkeaoja and Aapo's collaborative partners I made contact to relevant stakeholders, that could serve as informants in the research project.

2.1.4 Dealing with messy problems

Rich pictures, themes and systems maps are tools, that are useful in dealing with complex, intractable and interconnected messy problems (Armson, 2011) and can help the researcher understand and interact with the situation in a useful way, which stays true to the phenomenological approach.

Before entering the participatory fieldwork, I made an illustration including different stakeholders, regulating bodies, information flows and flow of matter. The drawing was something in between a rich picture and a system map, serving as a foundation for system understanding. In the first week of the engaged research, I drew a category map with different themes, which was the starting point for exploring different categories of the system. Assumed interconnections between themes were mapped, giving indications about interesting synergies and expected interactions. When returning from the action-oriented field work, I drew a rich picture encompassing all the stakeholders, the themes that had emerged, specific problematic situations, market mechanisms and driving forces impacting the situation (see appendix 8.1.1). System maps throughout the process have served me in my understanding of the situation. They have been used to map different stakeholders, their worldview, the processes that take place, the mechanisms affect

them, and the regulating forces on the system. See appendix 8.1.2 for an example of a messy system map.

2.1.5 Organizing information in six categories

Six categories have been defined and function as a guideline to understand the system and how the different parts are connected and interact. These categories function as perspectives to perceive the problem situation and give indications on what elements interact with each other and the causal relations between the elements interacting. The categories break down the socio-economic and ecological concepts into smaller compartments, as the complexity within the system need further detailed analysis.

Agricultural practices: Refers to the farm system and the processes performed at farm level, which may impact environmental processes or market outlooks.

Environment and climate : This category refer to the natural environment and climate and mainly touches upon the interactions between the farming system and the surrounding environment.

Market and Production: This category refers to stakeholders external to the farm system, market mechanisms such as demand and market outlook for the supply chain of hemp.

Policy and legislation: This category is considering the national and international regulating bodies, that influence the supply of hemp.

Socio-ecological dimension: This category informs about the worldview of stakeholders and beneficiaries relating to hemp supply.

Technology and innovation: This category lists anything that can be seen as innovation or technological development potential in the supply chain.

The categories were constructed in an iterative process based on previous academic work with system models and are based on emerging themes from literature and the pilot study. These six perspectives also serve as the foundation for the literature review, the analysis and interpretation of data.

2.2 CASE STUDY AS RESEARCH METHOD

2.2.1 Finding a case of interest

To address the complexity of the properties of an emerging supply chain of industrial hemp, a case study approach has been chosen to obtain a holistic view of the situation. Systems thinking is in this regard useful as it can be used to understand and analyze the case from different perspectives and give tools to understand the complexities within the system and how some of the parts interact. The case study offers detailed information on actors in the supply chain and

mechanisms influencing their choices. These elements can be helpful for generating new knowledge about hemp supply chains in other places, and the key findings may be applicable for other industries as well.

To start out with, a pilot study was conducted in the summer of 2022. I went to Korkeaoja Farm to make the first initial drafts of a system map and understand the factors having influence on the cultivation system at the farm. The initial discussions about the theme of industrial hemp circled around the viability of farming, the technical challenges of production and the potential market outlook. Based on these observations and discussions with Aapo, a thesis proposal was written. The case farm was chosen because of its unique combination of innovative knowledge, ecological thinking and as a prominent forerunner in the business development of fiber hemp.This was observed in the cultivation system entailing polycultures of hemp, alfalfa and oats in single field plots. The innovative thinking was observed through local treatment of hemp fibers, which was used as insulation in the farm barn from 1927.

2.2.2 Korkeaoja Farm and the farming system

Korkeaoja Farm is located in Satakunta Region in the Southwestern part of Finland. It is nested in between the two rural villages of Kokemäki and Harjavalta, being 17 km from the nearest supermarket or township. The village of Korkeaoja holds a rich village life, where a summer theater and a village newspaper keep the village spirit alive.

Korkeaoja Farm is at the center of the village as a 300-year-old family-owned farm of 50 hectares. Aapo Korkeaoja, the owner and farmer of Korkeaoja farm took over the farm and farmhouse from his father Juha Korkeaoja in 2015. The farm has been cultivated without plowing since 2000 and was converted to organic cultivation in 2012, when Aapo and his parents established a joint company in the effort to farm ecologically. The current system encompasses crop rotations with grain, oat, grass, and hemp, where the fields are cultivated with polycultures to induce ecosystem services and prevent pests and weeds. These polycultures encompass hemp and oat in rows, under sown with alfalfa. Hemp is cultivated with the purpose of providing biomass in the form of fiber and shive, as opposed to being an oil crop. The hemp fields take up 20 hectares at the moment, with plans of expanding the cultivation area over the next five years. Presently, the fields with hemp are not rotated, as Aapo wish to build a stable market and need to cultivate a certain amount of hemp before a market is established. Cover crops such as alfalfa is cultivated under the main crop and helps prevent weeds from emerging. The fields are only lightly harrowed in the spring for direct sowing of the planned crop. In Aapo’s farming system there are not any animals, which means there is a need for fertilizers from outside. The fertilizers used are a combination of cow and chicken manure, which is obtained from a neighbor farmer. The cultivation system is solely dependent on rainwater, without an installed irrigation system. As the ground is thawing during spring, the fields are too wet for any machines up until late spring. The sowing of crops is

normally planned for late May when it is warm enough and the fields have dried up. However, the cultivation of hemp is in the incipient phases, and the farming procedures for the harvest still requires development. As such, the sowing was delayed due to technical difficulties leading to the sowing of all crops only being done the 9th of June 2023. In the spring season, it could be helpful to have a farmhand, that can contribute to the work processes at the farm, so that the important tasks will get done in time. The customers of Aapo are located in near proximity to the farm system, expanding to the local municipality of Pori, where hay and grain are delivered to local farmers.

2.2.3 The stakeholders relating to the hemp supply chain

I used the snowball sampling technique (Bernard, 2017) to find relevant informants relating to the supply chain of hemp. The initial sample took the starting point at Korkeaoja Farm with Aapo Korkeaoja as the main stakeholder and used his collaborative partners to find actors relating to the supply chain. Furthermore, relevant stakeholders were found in the durance of the fieldwork. Stakeholders range from farmers using hemp in their farming systems to producers and companies that use hemp in their production or aim at doing so.

Most hemp farmers work with a contract farming company that buys and retails the farmers' produce. Aapo started to cultivate hemp as a contract farmer for HempRefine, 8 years ago. HempRefine was a company buying and retailing raw hemp biomass but went bankrupt in 2020 and closed their business. Now Aapo is independent of any contract company and is developing the customer relations to establish markets for the raw material. Aapo has customers and collaborative partners relating to the hemp production in local proximity to the farm. Biolan is a composting company, which is the main customer of shives. They use shive in their composting products and in bedding material for animal husbandry. Hemka Oy is a collaborative partner, who's ambition is to establish five hemp refining factories, that transform hemp raw material into processed outputs. Furthermore, Aapo is establishing partnerships across the value chain to find more customers, who have an interest in using hemp in their products. One of the potential customers relating to the production of hemp is Suominen, a multinational company, that produces non-woven fabrics for the medical industry. Suominen has recently made product trials with hemp, which they obtain from a hemp refining factory in Germany producing cottonized hemp. Sampo-Rosenlew, formerly a Finnish owned family company, now sold to a Chinese investor, produces agricultural and forest machines in accordance with the needs of industry and farmers. Sampo-Rosenlew shows interest in hemp farming and machine development. In addition, Aapo has established a partnership with NOVIA School of Applied Sciences, where students attending a 15-credit course about natural fibers, get introduced to the cultivation and harvest procedures in hemp farming.

Hemp production includes two main streams of end products, where one is seed production and the other is biomass production. The market for seeds is dominated by the contract farming company TransFarm, which is the only company in Finland buying and retailing hemp seeds from farmers to food industry. This component of the hemp supply chain has been explored independently of the farm system at Korkeaoja Farm, as the customers and stakeholders are not related to the fiber production as such. A contract farmer Ari Illota, who also works at the agricultural vocational school informed about the farmer's perspective on hemp seed farming and teaching protocol. TransFarm takes up an important role in the supply chain of hemp seeds, and it was considered insightful to further investigate the role of their company in relation to the supply chain of hemp in Finland. Furthermore, a retailer of construction- and bedding materials with hemp is present on the Finnish market. Kuitua retails end-products with hemp, which are imported from other European countries. However, it was not possible to obtain an interview with this company.

Stakeholder	**Informant**	**Stakeholder role**	**Context**	**Supplying**
Korkeaoja Farm	Aapo Korkeaoja, CEO	Farmer and entrepreneur	Korkeaoja Farm as a DFS cultivating hemp and Aapo working to develop supply chain of hemp	Raw hemp shives and fiber
OSARA Agricultural college	Ari Illota, teacher	Farmer and teacher	Ari farms hemp and teaches machinery at OSARA Agricultural College	Hemp seeds to contract farm
Hemka Oy	Ville Sarelainen, CEO	Entrepreneur and start-up company for industrial hemp	Ville is the CEO in Hemka Oy, which is a start-up company impending to process raw hemp material.	Impending supply of processed hemp fiber.
TransFarm	Satu Pura, Manager, marketing of hemp products	National contract-farming company for hemp seeds	TransFarm has monopol on sales and distribution of raw hemp seeds from the farm	Processed hemp seeds to food industry
Biolan	Hannamaija Fontell Director, R&D and Business Development	Producer of ecological and biobased products	Biolan uses hemp shives to produce compost medium.	Composting medium and gardening products with hemp shive
NOVIA	Ulrika Dahlberg, administrating course on natural fibers	Educational institution	NOVIA has recently started a 15 ECTS course centered around natural fibers.	Offers education and knowledge on natural fiber production in Finland

Sampo-Rosenlew	Kalle Pärkö, R&D Manager	Manufacturer of combines	Production and development of new machines and harvesting equipment.	Combine and forest machines
SUOMINEN	Mari Rahkola Senior Manager, Business Development	Manufacturer of non-woven fabrics	Imports processed bast fiber from Germany	Retails non-woven fabrics to industry

Table 1. Overview of informants/ stakeholders relating to the supply chain of industrial hemp in Finland.

Map of South-western Finland

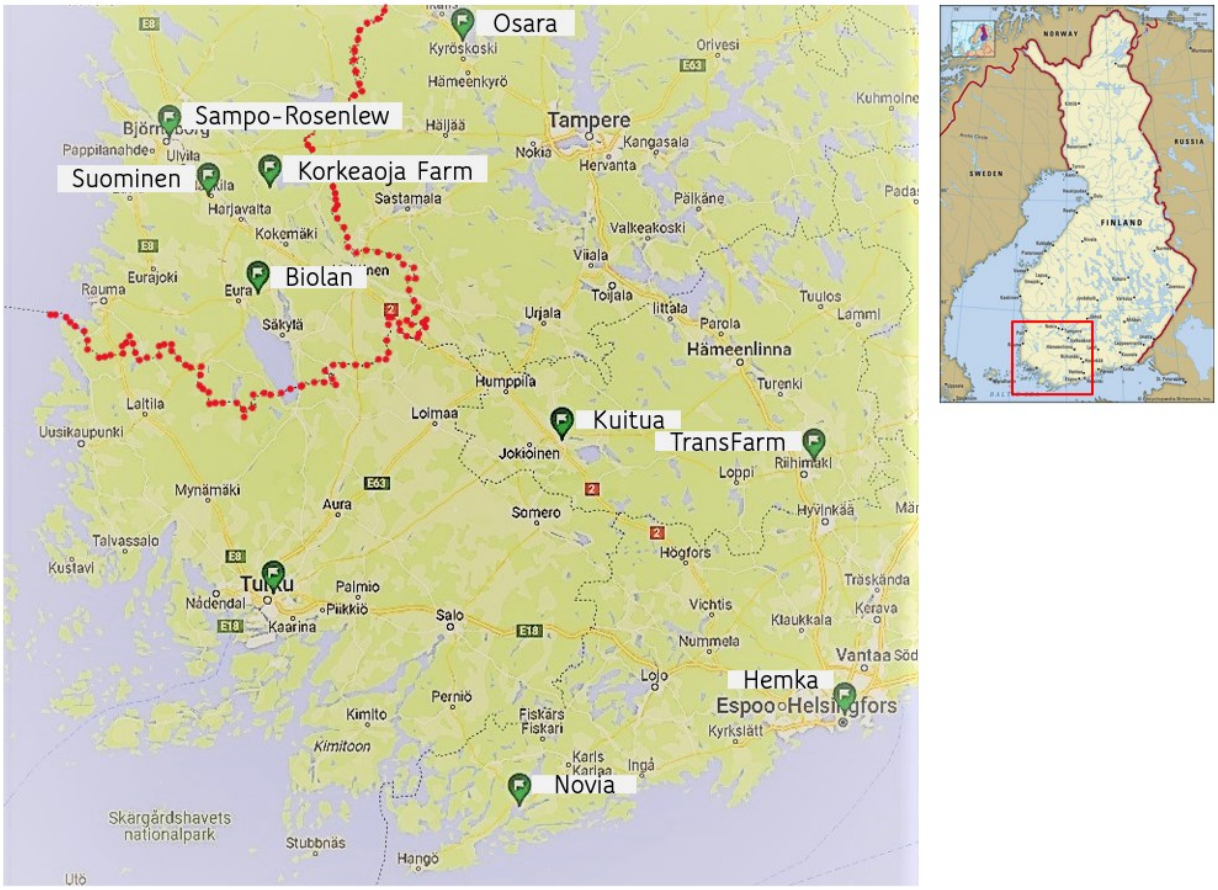

Figure 4. Map of Southwestern Finland showcasing the location of each stakeholder and marking the Satakunta region with red. Map origin. Left: Google maps with saved locations and modifications by author. Left: Encyclopædia Britannica Inc.

2.2.4 Defining system boundaries

The literature review and preliminary talks with Aapo assisted me in identifying the knowledge gap and discourse in the field of knowledge. It also served as a foundation for my understanding of the topic and the different aspects I wanted to focus on in my system analysis. Through a literature review in the beginning of the process, information on missing knowledge and state of the art was acquired. The literature review should not be seen as an exhaustive review that encompasses all knowledge on hemp, as there are many technical specifications, that are

described in literature, not relevant to the holistic approach of this thesis. Scientific papers engaging with themes such as agronomic practices, technical development, socio-economic aspects and improving environmental conditions have been reviewed in relation to hemp production. Furthermore, focus has been on identifying challenges and opportunities for hemp as a minor crop and what ecosystemservices that may deliver to the local council. This was done to include relevant information and include already established relevant knowledge relevant to this paper. If the reader is curious about certain aspects of hemp, it is recommended to find specific knowledge on those aspects in published literature.

2.2.5 Inquiring informants about the current and future situation using the categories as a source for questions.

The interview guide was iterated two times to fit my final framework of exploring the current situation and the future situation with a system thinking approach. Two slightly different versions were made to acknowledge the different position of stakeholders in the supply chain, resulting in one interview guide for manufacturers and producers and one for farmers and educators. It was structured according to the inquiry process, taking in consideration the current situation, future situation, supporting and hindering forces and the actions that may lead to a change in the current situation (see appendix 8.2).

2.3 SOFT SYSTEM METHODOLOGY FOR ANALYSIS AND INTERPRETATION

Analyzing and coding has been done according to the six categories and thinking systemically about the parts and how they interact. Supporting and hindering forces have likewise been separated into different categories to create a better overview of the elements interacting in the whole. Action steps have been developed based on Checkland's methodological approach.

2.3.1 Analyzing interviews according to time and categories

After having gathered data from the stakeholder visits through unstructured interviews, product samples, observational work at the farm, and the continuous informal talks with Aapo, it was time to analyze the data. The interview data is the primary source of information, which has been used to build this thesis upon. The interviews were recorded during the interviews and transcribed after the fieldwork. The interviews were then analyzed in Word, where each important quote was marked yellow and extracted to Excel, where it was further analyzed. In Excel each quote was summarized to a condensed meaning unit and assigned a color code according to what category it belonged in. Furthermore, a note on whether it was a supporting or hindering force was made and, in some cases, it was also noted how the meaning of it would impact elements in other categories (see appendix 8.3).

As the research questions are structured from a temporal perspective of the current and the future situation, it was decided to keep this structure in the summaries to better make sense of the data

in relation to the results. Each meaning unit from the Excel was then transferred to a word file, where a congruent summary was written taking in consideration the six categories, to further sort the information available. This summary of each interview is in appendix 8.4, enabling the reader to trace the information from the result section and finding out more about the viewpoints of each stakeholder and how it has affected the results.

2.3.2 Placing supporting and hindering forces in categories

Initial assumption about the supporting and hindering forces in the transition from current to future were mapped in six categories, which can be seen in the table below. The work of making a system model with categories served as a basis for generating these assumptions. This framework was then used after analyzing the data to again map the supporting and hindering forces for the overall situation of improving the value chain.

Category / Forces	**Supporting**	**Hindering**
Socio-ecology	- New educational programs - New generation – new mindset - Local jobs - Entrepreneurial capacity	- Public prejudice and fear - Stakeholders lacking social skills - Debt
Agronomic practices	- Farmers' innovative capacity - Diversified farm systems - Hemp as a new crop in crop rotations	- Lack of buyers - Lack of money - Lack of equipment - Agro-industrial competition - Lack of knowledge
Market and production	- International market - Latent demand - Versatile end-products	- Demand for raw material is low - Lack of investors - Agro-industrial competition
Technology and innovation	- Innovative capacity - Versatile material	- Lack of trust - Lack of money - Lack of investors - Lack of vision - Business confidentiality
Policies and legislation	- European legislation - Economic support programs	- National legislation restrictive - Difficult application procedure - Hemp oil crops receive higher compensation
Environment and climate	- Hemp influence environment and climate positively - Natural processes in Finnish climate facilitate retting	- None identified

Table 2. Assumptions about supporting and hindering forces were mapped according to the six categories and used to guide the development of interview questions and in the search for information.

This served as a basis to understand some of the interactions in the value chain, leading to a discussion about conflicting interests in the stakeholder network.

2.3.3 Defining action steps for purposeful activity models in the supply chain

The methodology for creating change in complex social situations entails some essential activities, that take in consideration the whole rather than the parts. Action steps for a specific scenario have been developed based on the four stages as described in the SSM (Checkland, 2000). The four stages have been adapted to fit the setting of developing action steps for a defined project and is elaborated upon below in five phases.

Phase 1: A root definition for the project

A specific project has been chosen and a root definition of the project has been made. This enables further planning and finding solutions to the overarching problem situation (Checkland, 2000).

Phase 2: Ensure that the project meets the criteria.

To asses that the project meets the criteria, the quality criteria from (Wiek & Iwaniec, 2014) has been modified and simplified to encompass four criteria, identified in the NAPS test. The four chosen criteria are then, if the project is New, Attractive, Possible and Sustainable. These criteria are in accordance with the activities defined by (Checkland, 2000), who argues that it is necessary to debate if the project would improve the current situation and if it can be regarded as desirable and culturally feasible.

Phase 3: Identify keys actors and their roles.

The key actors and their roles have been identified. Furthermore, it has been elaborated how each stakeholder can profit from the project. This framework draws on the Input-Transformation-Output (ITO)- model described by (Armson, 2011). The model is used to specifically describe the input of each key stakeholder and what they will receive in return of their input if they agree to take part in the transformation process.

Phase 4: Identifying hindering & supporting forces.

To give an overview of what is supporting and hindering the implementation of the specific project, the supporting and hindering forces for the described root definition have been mapped in the six categories. These are useful when establishing action steps and thinking about the role of each stakeholder.

Phase 5: Establishing action steps and a timeline.

To further concretize the action plan, overarching steps have been identified, which can lead to the establishment of the given project. The action steps have then been implemented on a

timeline, which showcase the progress of the project in a temporal perspective. This will give the key actors an overview of the action steps and future outcomes of the project.

2.4 RELIABILITY AND ETHICAL CONSIDERATIONS

Objectivity is something to strive for in social research, but there will always be a subjective perspective depending on which person you ask about the perceived problem situation. The norms in the Finnish society influence the stakeholders and hence the mechanisms of the supply chain. This study should thus be considered context specific regarding perception of stakeholders but can be generalizable in the sense that the there are some driving mechanisms in our global society, that are similar across the world.

When conducting research about business proceedings, it is crucial to keep a level of transparency in regard to what you publish and how you process data. A data management plan was made using SIKT – Norweigan Agency for Shared Services in Education and Research to keep track of planned activities and means of handling data. When conducting the interviews, the informants were promised to get a chance to review the summary of our conversation before publishing. This left them the chance of omitting specific details on sensitive business proceedings. I received comments from external employees in Hemka, the CEO in TransFarm and the communications department in Suominen. Aapo Korkeaoja commented personally on the interview. The summaries were edited according to their comments, while keeping faithful to research objectivity and transparency. Biolan, Ari Ilottu and Novia did not have noteworthy comments. See appendix 8.4 for extractive summaries of stakeholder interviews, leaving the reader the opportunity to explore the stance and worldview of each stakeholder.

2.5 LIMITATIONS AND BOUNDARIES

The themes developed upon in this thesis may function as an overview of some of the most important factors to consider when developing a local value chain with industrial hemp. The case study provides a unique combination of factors and variables, that may be translatable to more generic situations.

As it is an action-oriented research approach, the fieldwork could have lasted much longer, than just one month. It should be considered that the preliminary work with the thesis started 1,5 year prior to the research project enabling a trustful relation to Aapo. Being a 30-credit master thesis, the time and resources for conducting a full-bodied action research project have been limited to seven months for one researcher. The action plan is based on my interpretation of what would be the most impactful action in the given situation and sticks with the overarching actions that would be enable change. More aggregated planning and action plans will be necessary to develop among the stakeholders wishing to further engage in creating collaborations across the supply

chain. Further limiting the data collection, the retailer of building materials, Kuitua, did not find time to participate in an interview, which is why results from their viewpoint is missing. Furthermore, Also, TransFarm did not wish to publish the exact acreage used for certified seeds and food grade seeds respectively, which is why a comprehensive graph was omitted.

3 RESULTS

The results encompass a rich description of the current situation as perceived by stakeholders in the supply chain of industrial hemp. It presents the main results in six different categories assisted by illustrations and maps to understand it. A desired future situation is depicted taking the starting point in an illustration showing the stakeholders, the exchanges and production outcomes of the situation. It is based on different elements, mechanisms and regulators mentioned by stakeholders, which are further explained and defined in the six sub-chapters. The supporting and hindering forces to enable the transition from the current to the future explains conflicting interest and proposed interactions, that may hinder or support the transition. The last sub chapter touches upon a specific project, where action steps are elaborated to support stakeholders in visioning the future and taking action to get there.

3.1 CURRENT SITUATION

In this chapter the perceived situation for farming and supplying hemp is depicted according to the stakeholders in the supply chain. The current situation is described through six the categories ‘Agricultural Practices’, ‘Environment and Climate’, ‘Market and Production’, ‘Policy and Legislation’, ‘Socio-ecological’ and ‘Technology and Innovation’. The descriptions are accompanied by illustrations that highlight the processes relating to cultivation, processing and marketing of hemp. The illustrations can be seen as models, that are used to explore the current situation and explain certain aspects of production.

The model below is a system map depicting the flow of hemp in the Finnish supply chain. The farm system in the inner circle on the left shows the starting point for hemp biomass production. It is placed within a Finnish ecosystem, enabling natural processes to take place assisting the crop to mature. The smaller circle within the natural ecosystem represents farming systems producing hemp seeds. The socio-economic realm it is a part of and interacting with, is the bigger circle on the right, where the stakeholders are presented according to their place in the supply chain. Exchanges between stakeholders are marked by connecting lines with a small arrow showing the direction of the exchange. Influencing forces, such as EU policy and science is marked as fat arrows impacting the system. The boxes on the right show the end products, that are produced in the system.

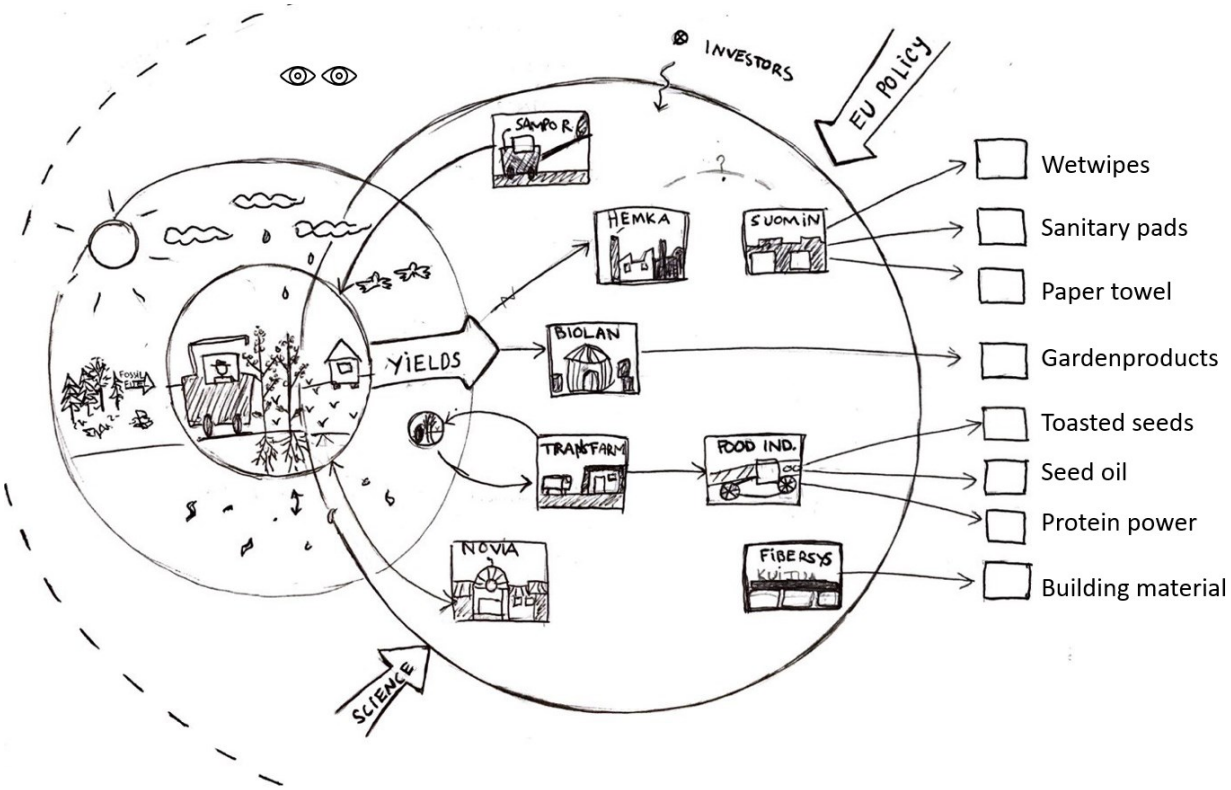

Figure 5 The system model depicts the different stakeholders, mechanisms and directional flows that are dominant in the current situation for supplying hemp products.

3.1.1 Agricultural practices

In this chapter, the farm system and the activities related to hemp farming and processing are described. It gives an overview of the situation of the farmer, key processes performed by the farmer, and the interactions between the crop and the environment.

Operating farms

Agricultural systems involving hemp amounts to almost 2000 hectares in Finland, where approximately 600 ha is linked to fiber production. Hemp and linen emerge as the most vital natural fiber crops within an agroecosystem. Of the two, hemp stands out due to its remarkable yield and ease of cultivation. Prioritizing high-yield crops like hemp and green peas on rich soils is necessary for profitability. Farmers who own combine machines must account for operating costs that often exclude environmental costs. Traditional farming methods prevail in Finnish agriculture, primarily carried out by solo private farmers. Larger farms have better chances of self-sustainability, while smaller farmers often require supplementary income from other jobs. Family farms are prevalent in Finland, with relatively few corporate-owned farms. Cereal crops dominate, and bailing machines are uncommon. Managing fiber crops proves challenging, lacking easy and cost-efficient procedures. Ari engages in contract farming for seed production with TransFarm, purchasing and selling seeds directly to and from them. Hemka, on the other hand, utilizes

contract farmers for the majority of fiber hemp cultivation in Finland. Their fiber hemp harvest is done in spring and starts in the last week of May.

Spring Harvest

Nordic countries, with their cold winters, are well-suited for spring harvesting techniques, which can be an environmentally sustainable approach to fiber cultivation. In warmer climate zones, the hemp is left to dry on the fields after harvest. This method can be challenging in Finland, as the wet autumn would lead to mold in the fiber, thus requiring indoor facilities to dry the biomass. Additionally, the freezing temperatures will partially separate the fibers as lignin and pectin break down. Furthermore, strong spring sun bleaches the fiber, reducing the need for bleaching chemicals later in the refining process. Although technically imperfect at the moment, spring harvest offers benefits like conserving water and reducing chemical use during the retting process. However, retaining long fibers through this method remains challenging. Ensuring the traceability of biomass proves even more crucial than obtaining organic certification. Locations as far north as Oulu, with 24-hour sunlight, provide an efficient growth season for hemp.

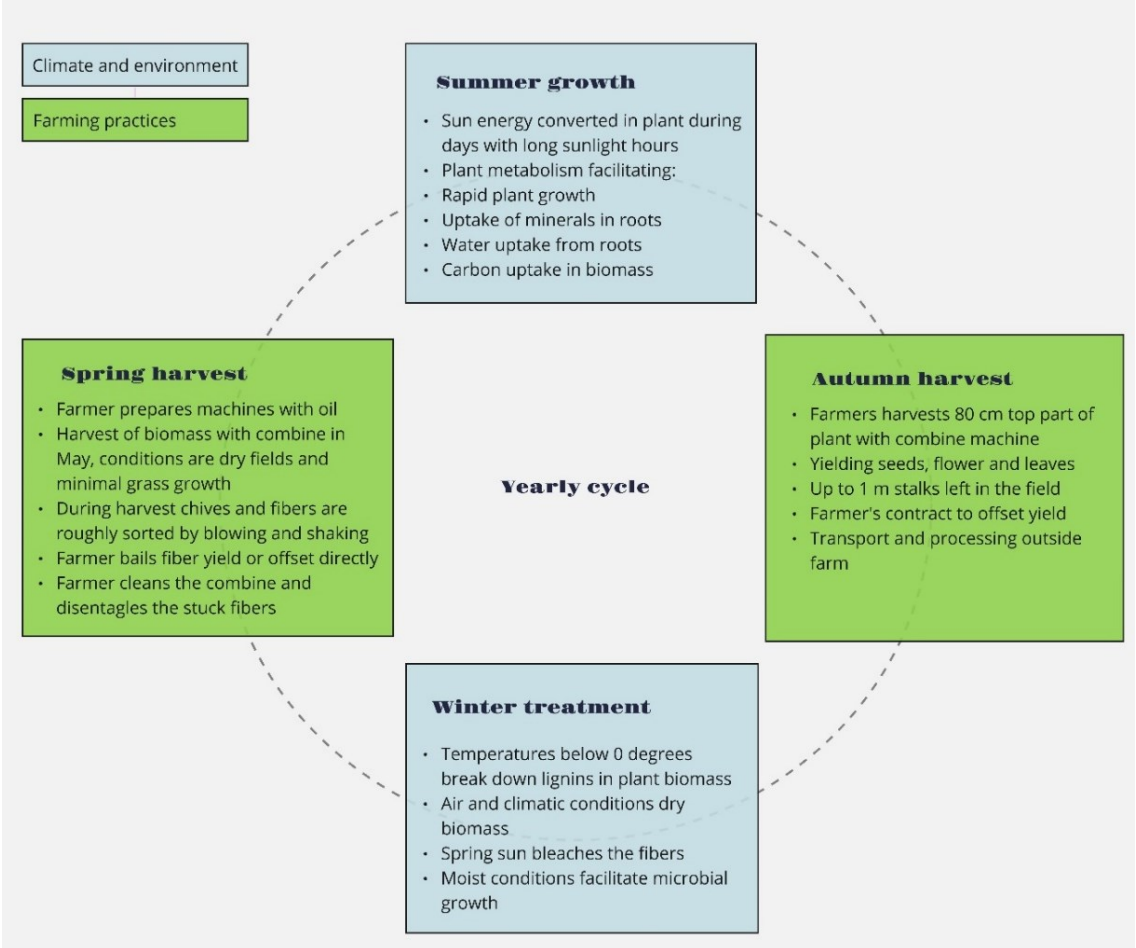

Figure 6 The diagram represents the natural processes occurring during summer and winter season and the agricultural practices related to harvesting procedures, either in autumn or spring. Autumn harvest yields seeds and spring harvest yields biomass.

Harvesting

The most significant challenge in production is the harvesting process, which is currently plagued by issues such as machine fiber blockages and time-consuming procedures. Improving both the yield quality and speed of the harvest is essential. Ideally, the process should be smooth and efficient, free from major problems. In 2022, a wet spring and grass growth hindered the harvest procedures due to muddy soils and machine blockages. For seed farming, up to 80 cm of the hemp stalks are left in the field after autumn harvest due to lacking hemp harvest machinery and logistical difficulties. Despite the potential to utilize the entire crop, economic incentives are lacking.

Separating fiber and shive

Optimal profitability involves separating fiber from shive during harvesting. Biolan, a shive customer, demands high-quality shive free from any fiber strands, necessitating separation of fiber and shive at farm level. While approximately one-third of Aapo's yield, representing shives, is sold directly to customers, the remaining two-thirds, comprising valuable fiber, is baled. Refining the fiber is essential to enhance quality and marketability. Aapo Korkeaoja highlights the importance of refining and upgrading the fiber for better market prospects.

Interacting with climate an environment

Scaling up hemp production is advantageous due to its minimal chemical requirements in both the industrial refining process and at farm level. Biolan has long recognized hemp's potential in agriculture. Natural materials' quality varies due to environmental factors. Hemp production offers farm diversification and contributes to circular farm systems. Novia emphasizes preserving traditional knowledge and fostering innovation and technology. Agricultural production extends beyond food, encompassing fiber and material production, impacting sustainable development in industries. Hemp cultivation enhances environmental diversity and can reduce peat extraction in wetlands, as it is a useful alternative to peat in product development. However, hemp cultivation poses numerous challenges, making traditional crop choices more tempting.

Interacting with industry

Growing and processing hemp can boost the local economy, offering a more sustainable alternative to synthetic fibers. Meeting industry expectations requires proper separation of shive from fiber during harvesting, ensuring a continuous transition to the production line. Inconsistent material quality, excessive moisture, and notable quality disparities between fiber and shive need to be addressed. Proper separation benefits both farmers and customers, aligning interests in delivering high-quality products to the industry. Its agricultural nature results in less stable supply compared to synthetic fibers. Proper fiber cleaning is crucial before sending it to manufacturers to remove impurities.

3.1.2 Environment and climate

This section showcases the interactions the farming system has on the environment and climate in which it is embedded in.

Benefits in agriculture

Hemp proves to be a suitable and sustainable crop for the Nordic climate largely unaffected by pests. While some varieties may not produce seeds due to insufficient summer warmth, hemp cultivation offers versatility and supports more circular farm systems. It contributes to both environmental and farming diversity. Additionally, hemp cultivation can help conserve wetlands by reducing the need for peat extraction as it functions as a useful substitute to peat products. Hemps environmental benefits are crucial in addressing climate change by preventing erosion, nutrient runoff, and providing a circular crop system that replenishes soil nutrients and sequesters carbon.

Environmental benefits in industry

Agricultural production extends beyond food to encompass fiber and materials, impacting sustainability across various industries. Hemp stands out for its lower water and chemical usage in industrial processes. According to Suominen, sustainability lies at the core of their strategy, encompassing raw materials, energy consumption, water usage and social considerations. Their sustainability strategy focuses on introducing products with sustainable fibers, emphasizing conscious raw material choices. Social dimensions also matter, an can be proved with textile certifications like Oeko Tex.

3.1.3 Market and production

This section describes the requirements from stakeholders external to the farm system. It touches upon demand mechanisms and information flows present in the socio-economic reality, which the farm system is embedded in.

International markets and production of hemp

The global industrial hemp market is experiencing significant growth, particularly in Northern America. Hemp has been cultivated for more than two decades in Finland, resulting in a thriving market for hemp seeds and oil. TransFarm plays a crucial role in this market, exporting planting seeds to 30 countries, primarily within Europe. They are the main distributor of the FINOLA variety in Europe, with 25% of their production dedicated to certified planting seeds and 75% for food-grade seeds. Suominen, a stock listed company, currently imports cottonized hemp but is open to local collaboration if a local company can meet their quality standards of bleached, anti-microbial and refined fibers.

Sustainable product development

Hemka aims to provide a sustainable alternative to man-made fibers and cotton by leveraging hemp. While Suominen is in the early stages of developing hemp products, they face pricing challenges, as hemp is more expensive than alternatives like viscose. However, they hope that increased commercial production will eventually lead to more competitive pricing, making hemp products more accessible.

International quality standards

BastFibre Technology holds certifications for sustainability, providing assurance to customers like Suominen, that they meet sustainability criteria. Another valuable certification is the SWAN label, contributing to environmentally conscious product choices.

National market for natural fibers

The market for natural fibers is on the rise and could expand further with advancements in harvesting equipment. Finland has successfully marketed natural fibers, thanks to legislation related to side streams in the forest industry, which will be elaborated upon in 'Policies and legislation'. Hemp, however, faces marketing challenges due to a lack of awareness among both buyers and sellers about its origins and production methods.

Demand for Hemp Seeds

TransFarm initially focused on hemp seed production and later diversified into food-grade hemp products, capitalizing on a growing market. They process hemp into various end-products, including plant-based protein and healthy oil, which aligns with market trends favoring such products.

Demand for processed biomass material

Biolan has faced supply challenges due to a shortage of hemp. They've made agreements to secure a local supply, emphasizing the importance of maintaining quality. Consistency in quality is crucial, especially when transitioning to biodegradable materials. Some customers prefer large quantities from Asia due to concerns about varying quality from European sources.

Demand for animal husbandry

Biolan's use of hemp for bedding materials, composters, and dry toilets is in high demand among hobby gardeners and professional horticulturists. Hemp's versatility makes it suitable for a wide range of end-products.

Farmer's demand for stable income

Global food market price fluctuations can be frustrating for farmers, who often lack control over crop prices. Some Finnish farmers are exploring fiber crops due to stable prices and lower input costs. Farmers' choices regarding crops are influenced by market prices, with some shifting to fiber crops for price stability. The development of new crops and machinery depends on market demand, with some challenges associated with hemp harvesting technology.

Required Skills and Knowledge in Agricultural Supply

Farming activities demand knowledge about what crops are viable and the choice of crops depend on the ability to sell them for a profitable price. Hemp is an attractive crop due to its easy adaptability and high yield. However, harvest procedures are challenging. The market for raw fiber hemp is limited and previous actors in the value chain have closed due to economic difficulties, which affected other stakeholders in the supply chain relying on their supply. Small scale entrepreneurs and farmers find it difficult to enter the market at an industrial level, even though there is an established market demand.

Investing in a New Industrial Production Line

Entrepreneurship in companies developing novel inventions can be challenging, as investors typically seek results and proof of concept before committing significant resources. Renewcell, a Swedish company with a clean and complex process, serves as a successful example of investment in sustainable technology. Hemka benefits from strategic partnerships in Sweden and collaborates with institutions focused on textile innovation.

The Wood Industry

The wood fiber industry is a major player with substantial investments, capable of processing large quantities of straw. Hemka, as a medium-sized company, seeks partnerships that align with its size and investment needs compared to larger companies in the industry like Spinnova and Infinited Fiber.

Overview of the value chain

On the next page, an overview of the current supply chain can be found. It can be seen as a model to explore and understand the current situation, and depicts the different processes, that hemp undergoes in the supply chain. Three main streams define the market: hemp for seeds, hemp for shives and hemp for fiber. The processes relating to seed distribution is well-established and dominated by TransFarm. The processes related to shives is established but holds potential to be expanded. The industries relating to fiber production is lacking in Finland, but as manufacturers and retailers import refined hemp from the global market, they can be found on the value chain map.

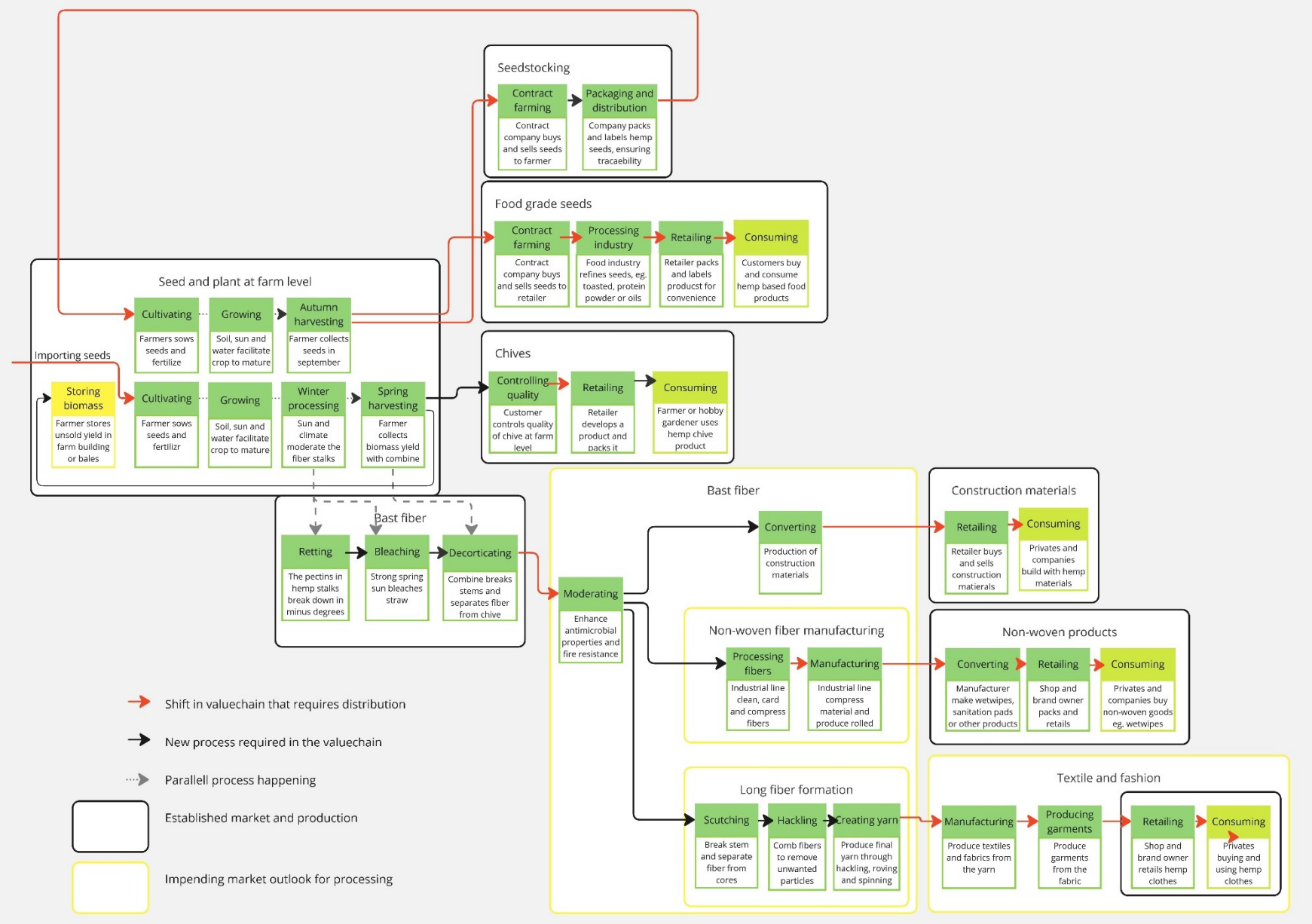

Figure 7.

The illustration shows the processes related to hemp from seed to product downstream the farm in the value chain. The model has been developed using informant knowledge and literature (Duque Schumacher et al., 2020) .

3.1.4 Policy and legislation

This section gives an overview of the policies and legislations that influence the farm system and supply chain of industrial hemp in Finland.

Supporting development of technology

In Finland, individuals engaged in start-ups and sustainable industry research and design can access unemployment benefits provided by the government. Legislative measures are promoting the adoption of cutting-edge technology by offering additional subsidies. Linen and hemp, previously overlooked in the wake of industrial developments, are gaining renewed attention with the European Green Reform, backed by available funding. Industries are taking steps to facilitate the transition towards more biobased materials.

Inducing better use of side streams

Legislation encouraging the utilization of side streams in the forest industry has led to the development of various products from pine, including recyclable packaging, eco-based diesel, and biodegradable plastics. Collaborations between companies emerged due to European legislation prohibiting waste disposal on-site. “Business Finland” initiated a business ecosystem project, bringing together major players in the forest industry and potential side stream users. This collaboration proves valuable due to its consistent supply, reflected in sustainability reports. Political decisions can regulate markets, as demonstrated by legislation promoting more energy-efficient use of side streams in industry.

Towards less peat

European funding programs are supporting the shift towards reduced peat usage. In Finland, domestic energy production has traditionally relied on burning wood and peat. Peat extraction played a significant role in the economy, serving as a source of heat and a component in gardening products and fuel. Initiatives to phase out peat extraction in Finland could create favorable conditions for hemp farming.

Environmental legislations

The European Union backs governmental payment schemes and focuses on making requirements to protect nature, encompassing regulations on non-cultivated areas and landscape parameters. These environmental regulations are determined by Common Agricultural Policy (CAP) policies and administered through the Ministry of Agriculture. In Finland, there’s an ongoing debate about whether farming emissions should be considered in calculations, highlighting the absence of a comprehensive method for demonstrating farming sustainability beyond the current organic/non-organic classification.

Legal status of hemp

In Finland, hemp production falls under the jurisdiction of the food safety authority. The Finnish Medicine Agency (FIMEA) regulates the CBD market through legislation, while liberalizing the legal status of hemp has opened up new market opportunities. Changes in legislation in the 1990s led to the development of the Finola variety, which gained popularity in Europe and expanded into the United States. TransFarm initiated CBD product prototypes but halted research and development due to existing legislation.

Separation of biowaste

European regulations mandating biowaste separation have driven household composting, resulting in high demand for composters and a thriving market in Finland. Biolan is the sole producer of bedding material using hemp.

Single Use Plastic Directive (SUPD)

The European Commission implemented the Single Use Plastic Directive (SUPD) some years ago, requiring products containing plastic to display a logo with a sinking turtle. This directive influenced customer preferences, creating a demand for plastic-free products. The SUPD has pushed the industry to take action, with discussions about potential legislation against deforestation also emerging.

3.1.5 Socio-ecological dimension

This chapter refers to the culture and world view of people relating to the farm system or supply chain of hemp either as active stakeholders or as beneficiaries of it.

Finnish farming culture

Finnish farmers predominantly work independently, utilizing machines of varying quality. Collaborations and the establishment of local markets are relatively uncommon. Differing mindsets and income levels can influence the capacity to invest in new technology. There’s a rich history of natural fibers in Finland and the Nordic countries, emphasizing the importance of cross-industry collaboration and knowledge exchange, particularly from the successful partnerships, regarding better use of side streams, between the forest industry and other sectors.

Agricultural school focus

Agricultural schools in Finland predominantly teach organic farming, with a focus on business management. Hemp is a new crop, and its integration into the curriculum may take time, similar to other emerging crops like corn and alfalfa. Novia University has introduced a course on natural fibers, aiming to influence regional development in Rasebori and Osterbotnia. Expanding to international students and offering various natural fiber courses is a goal. However, finding students who can commit to a 1.5-year course has been challenging. Novia's teachers see untapped economic and environmental potential in hemp and its by-products.

Students' interest in hemp

Students' interest in growing hemp is limited due to inefficient machinery and the labor-intensive combine cleaning process. They prefer machine maintenance over cleaning. Students generally need exposure to the crop to develop an interest in it.

Public opinion and mindset

Over the past decade, there has been a shift in public mindset, and growing hemp is no longer seen as unusual. Government declaration stickers provide assurance of hemp's legality. European legislation on separating biowaste has prompted changes in composting practices. Companies like Biolan participate in public debates and engage with customers to raise awareness of raw materials and their potential uses. Discourse on sustainability in the clothing industry encourages sustainable choices and considering the life cycles of clothes. Consumers were affected by HempRefine's closure, leading to discussions on social media platforms.

Knowledge exchanges

Novia's module brings together various societal groups, including advisors, companies, entrepreneurs, farmers, and researchers, facilitating knowledge exchange and collaboration. The creation of a natural fibers reference group at Novia has generated interest from experts across different fields, fostering collaboration and knowledge sharing.

Competition in a neoliberal economy

Understanding the roles of each player in the value chain is essential for transparency and trust. Suominen's Sustainability and New Fibers Seminar in early 2023 provided a platform for customers to meet producers and gain a deeper understanding of materials, fostering better collaboration and competition within the neoliberal economy.

3.1.6 Technology and innovation

Referring to information flows constituting technical know-how and the exchange of money and the proposed outcomes of these interactions, based on informant knowledge. The regulators having influence on these interactions: political regulatory frameworks.

Machinery for Harvest

Challenges exist in harvesting hemp, notably its varying quality from farm to farm. Buyers seek consistent quality in raw materials, which is currently challenging in European production, leading them to favor larger quantities from Asia. Novia pursues a balance between preserving traditional knowledge and embracing innovation and technology. Aapo's 20-year-old machine by Sampo Rosenlew serves as a foundation for development. Sampo Rosenlew is interested in collaborating with farmers to enhance combine equipment. Different combine settings can affect fuel costs, with additional elements in the harvest procedure increasing fuel expenses. Newer combines excel in harvesting by cutting higher, reducing branch entanglement. However, they leave 80 cm of stubble in the field, complicating spring sowing. Motivation for investing in new machinery often depends on cultivating a significant amount of land, and farmers need assurance of revenue.

Hemp Refining Factory

Currently, there are no hemp decortication or refining factories in the Nordic or Baltic regions. Aapo has sent a hemp fiber sample to France, where a major company expressed interest in assessing fiber quality. Non-woven and cottonized processes are the preferred means of refining hemp fiber, given the spring harvest's limitation on retaining long fibers. The challenge lies not in the harvesting machine but in meeting high hygiene standards for end products. Straight-from-the-farm raw material isn't feasible, necessitating a decorticating industry that comprehends industry requirements. Failing to meet these standards poses significant risks for companies.

Side streams in fiber production

Side streams have seen increased utilization, with numerous fiber innovations in Finland focusing on the wood industry, a dominant player in the Finnish market. This may explain the relatively underdeveloped hemp industry in Finland compared to countries like France, where wood industry influence is less pronounced.

3.2 FUTURE SITUATION

A desired future situation in 5 years is described based on the informant's knowledge and is assisted by an illustration, which depicts stakeholders, interconnections between them and regulators of the system.

Starting at farm level, there are more diversified farm systems including hemp in their crop rotations. The cultivation is done in polycultures with no tilling to optimize ecosystem services, as seen on Korkeaoja Farm. The farm systems encompass both fiber and seed farms, with a significant increase in fiber farms. The farmers are collaborating in regional networks, exchanging knowledge and ideas for innovations at farm level. The network also secure stakeholders downstream a reliant supply, as there are more farmers supplying hemp spreading the risk for a bad harvest. They have started a fruitful collaboration with the machine supplier Sampo-Rosenlew, who is now producing harvest machinery developed specifically for hemp harvest. Some farmers are even experimenting with hemp as multipurpose crop, where both fiber and seed is used, even though it still needs development. The farmer network is collaborating with NOVIA, where they exchange ideas and knowledge to educate students and future farmers of hemp. There is a strong collaboration with Hemka, who has established the first hemp refining factory, where they process raw material from farms. They produce cottonized hemp, which is sold to local stakeholders, including Suominen. New collaborations with entrepreneurs using the cottonized hemp in their products, eventually results in more end products.

Some farmers within the network have started a collaboration and established a start-up focusing on developing building materials, which doesn't require complex processing. They now collaborate with Fibersys Kuitua, who are retailing their products, but they also have direct contact to customers in their local region. The hemp industry has made a new certification proving the sustainability of fiber farming, where the biomass can be traced back to farmers, in specific regions farming with a set of sustainability principles.

More investors are supporting hemp entrepreneurs and the threshold for receiving funding to make a startup has been lowered, as the market demand is apparent. EU legislation has implemented policies aiming at supporting the production of hemp for biomass production to internalize environmental costs of production and strengthen the European economy. At a national level, the government is encouraging decisionmakers in the regions to support hemp businesses. Science is continuously supporting the development and participate in the development with action-research and bottom-up initiatives. On an overall level, the perception of hemp is very good, and people support the product development and are willing to pay extra for the materials and products produced with hemp, because of its high quality and certified circular farming procedures.

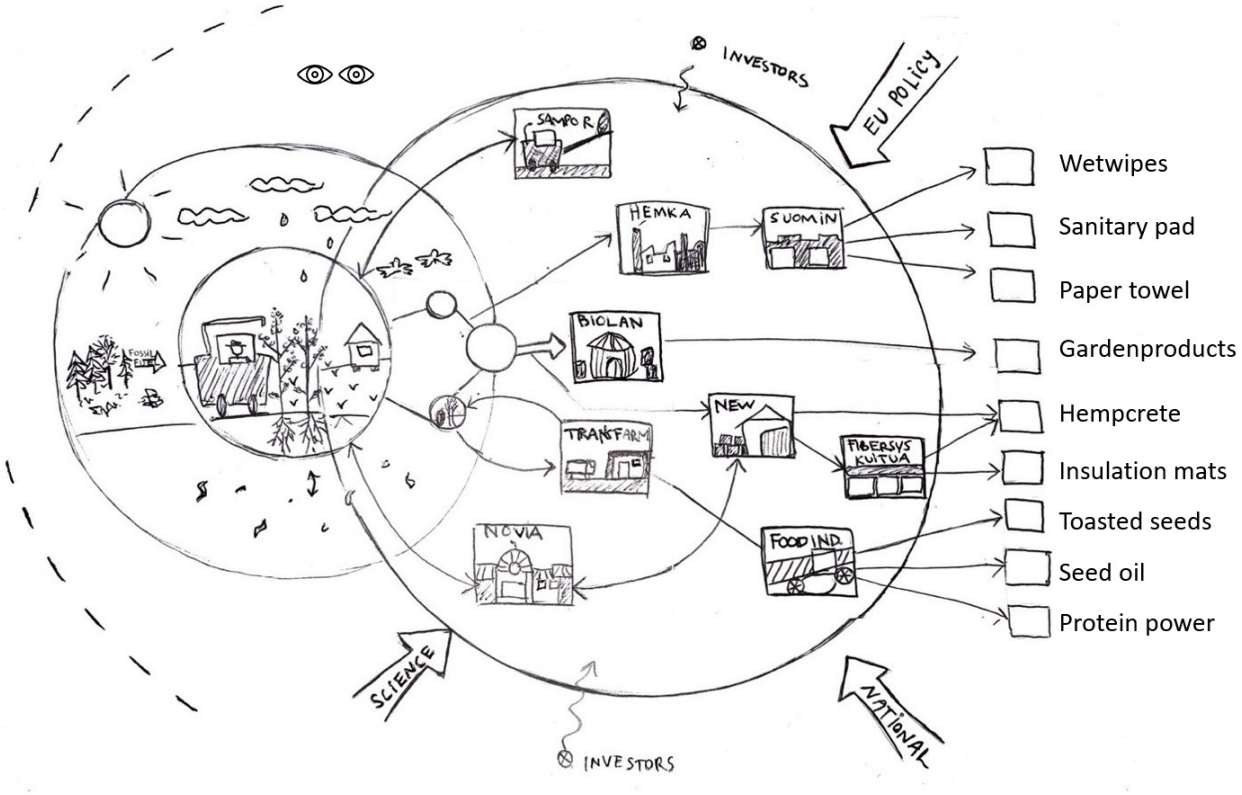

Figure 8. A desired future situation for supplying hemp in Finland.

3.2.1 Agricultural practices

Harvest machine

A critical step in establishing a robust hemp supply chain is developing cost-effective and practical harvesting methods. A well-functioning harvesting machine has the potential to decentralize the hemp market, benefiting local businesses and development. This stands in contrast to large-scale global fiber production plants that may disrupt farming activities. Local cultivation and harvesting of high-quality hemp can be cost-effective for customers, potentially stimulating demand if harvesting procedures are enhanced. Optimizing harvest techniques involves maintaining long, straight fibers for textile markets or shorter fibers for non-woven products. Machine suppliers prioritize efficient material collection from the field, whether keeping fibers long or short. Securing funding is the initial step, enabling the development of machinery that can harvest big amounts. For a farmer wanting to engage with hemp and, an investment need would range from 10,000 to 20,000 Euros.

Network of Farmers

Creating networks of farmers is essential for driving change, particularly on a local scale promoting circular economy principles. Farmers could grow hemp for self-sufficiency in bedding material while improving soil quality, offering a profitable venture by reducing material costs and generating income from fiber sales. These producers can either sell to intermediaries or package and sell directly to local customers. Encouraging farmers to cultivate hemp is a crucial step, with transparency and sustainability in production being key. Financing hemp crop production poses a challenge, but profitability and access to the necessary machinery can drive increased hemp production.

3.2.2 Environment and climate

More farms will incorporate hemp in their farm systems and apply ecological principles for cultivation, which promotes ecosystem services. Ecological intensification of farms will lead to natural control of pests, higher agrobiodiversity and more interactions in the biophysical realm. Polycultures are dominating field plots and crop rotations take in consideration the overall diversity of the farm. No tilling method is applied on all farms, facilitating a porous soil structure and rich soil biota. The increased cultivation of hemp will lead to increased use of natural fibers in end products, resulting in decreased use and production of polymers fibers, benefiting the environment.

3.2.3 Market and production

More stakeholders in the supply chain

Entering the hemp market involves selling your idea, finding customers, and forming strategic partnerships. Preliminary agreements with customers can demonstrate business feasibility, attracting initial investors. However, marketing the concept and securing investors can be challenging, as investors often prioritize a compelling narrative over technical details. While the market for food-grade hemp is growing, there's also potential for fiber hemp. The remaining stalks from seed production could serve as fiber material, if harvested properly. One challenge in the hemp industry is the lack of support for individual companies looking to work with hemp. Developing new hemp-based products could potentially accelerate production at the farm level, but a more comprehensive market analysis is needed to identify customer demand, whether locally in Finland or on a global scale.

Establishing a refining Factory

Setting up a refining factory is crucial to expanding the hemp market further. Establishing a clear business goal and building a strong network are essential for this to happen. Hemka's goal includes building multiple plants with substantial capacity to experiment with different end-products. Upscaling production is a multi-year process, involving trials, securing raw materials, and finding appropriate machinery, all while ensuring a customer base. However, this process has faced challenges in attracting investors.

Expanding seed and flower production

TransFarm is poised to remain a strong player in the certified seed market while focusing on variety development. They plan to expand their food-grade hemp activities, including CBD product production, leveraging their existing equipment. TransFarm is well-positioned to expand its hemp-related activities due to its capacity for industrial investments. However, they do not plan to invest in harvesting equipment, as it's typically the responsibility of individual farmers in Finnish farming culture. Their role in the value chain sets a precedent for other companies entering the hemp market.

Localized supply chain

A local, organic production can be compelling for customers demanding hemp. In this regard, traceability of biomass can be an important factor. Transparency and certifications, such as FSSC22000, contribute to building trust and credibility in the hemp supply chain. Hemka aims to build its business on analytics and biomass traceability. Biolan, prefer local collaborations and are looking for continuous, sustainable farming partners to fin sustainable alternatives to peat in their products. However, logistics remain a challenge due to Finland's vast size and lack of logistic arrangements. The involvement of more contract farming companies in hemp cultivation could lead to improved crop prices for farmers. Currently, Hemka is the only company offering contracts to hemp fiber farmers and occupies a significant position in the market. The viability of hemp farming for individual farmers depends on competitive pricing structures that can support their livelihoods. Offering competitive prices to farmers encourages hemp cultivation and reduces the need for imports.

International cooperation

Collaboration between Nordic and Baltic countries could enhance various stages of hemp production. As refining options are limited in Finland, farmers must consider whether to send hemp to other European countries for processing or continue to explore processing opportunities locally. The international market for hemp is experiencing rapid growth, driven by the shift towards sustainable business practices. Big businesses are increasingly investing in hemp-related ventures, with a notable presence in the USA, Germany, and Finland.

3.2.4 Policy and legislation

European legislation

Hemp production aligns with global sustainability agendas, receiving political support in Europe and globally. However, it also faces numerous challenges. Companies require support from external stakeholders, including the EU, national governments, and unions. Subsidies play a crucial role in shaping the industry's direction, and it's the EU, rather than individual member countries, that must take the lead in implementing reforms.

National legislation

Government involvement in hemp start-ups can influence funding approaches. While many industries have lobbying services advocating for their interests, hemp lobbying in Finland is relatively limited compared to the European scale. The Farmer's Association has influence in national politics, impacting subsidies and cultivation requirements. Pro-Agri, a Finnish agricultural organization, plays a role in providing information to farmers and representing their perspectives. Sustainable and ecological reforms will encourage value-based businesses. Regarding CBD, TransFarm expects more open legislation in the next decade, which can open new market opportunities.

3.2.5 Socio-ecological dimension

Value based supply chains

Consumer mindsets are shifting towards sustainability, demanding cultural change in production, favoring natural, durable fibers over plastics and peat. This transition can be aided by Green Reforms and the sustainability movement. According to ecological minded stakeholders, including Biolan, NOVIA and Aapo, the status quo is no longer acceptable, calling for change. A clear distinction exists between large-scale multinational firms in the global market and small-scale local companies and cooperatives catering to their communities. This reflects cultural preferences and choices. Movements like Fibershed Finland can promote local and circular production. During the pandemic, demand for sheep wool increased (consumer choice) altering market prices. This witness, that public opinion can affect product popularity and market mechanisms.

Informing and educating consumers

Educating customers about hemp's health benefits can boost demand, incentivizing farmers to grow it. TransFarm, a leading Finnish company, educates the public about hemp's health benefits and uses. They aim to work at the European level, influencing the European Parliament, legislation, and hemp advocacy. They want to educate farmers and the food industry on hemp

cultivation best practices, especially focusing on crucial activities like harvesting. Additionally, students can contribute to shifting mindsets by educating their families about new crop possibilities.

Education promoting knowledge networks

Knowledge exchange, networking, collaboration, and innovation are vital aspects of supply chain development. University studies can enable change but require time and diverse solutions. Research and collaboration with educational institutions is beneficial in building a stronger foundation for change. Producer, processor, and researcher networks play essential roles. Students participating in innovative forums surrounding natural fibers, often return with successful initiatives, integrating them into various institutions. Establishing programs and increasing awareness in agricultural schools can furthermore enhance the supply chain's quality.

3.2.6 Technology and innovation

Innovation emerging from collaborations

A collaborative network of small-scale hemp producers in a specific area can lead to new innovations. The role between the farmer and customer is a key consideration, especially in cleaning and storing fluffy, cottonized hemp fibers. Innovation should prioritize improving the production line for fibers while considering side streams as additional benefits. Scaling up production from traditional small-scale methods to a more streamlined process with appropriate equipment is essential. Establishing a joint consortium involving machine suppliers, farmers, and stakeholders can create a validated demand for the factory.

Innovations in machine supply

Developing harvesting equipment capable of preserving the length and quality of hemp fibers necessary for the textile industry is essential. There's potential in using tractors for hemp cultivation, offering a low investment opportunity with products ready for direct sale from the field. Innovation, particularly the development of combines that can harvest the entire hemp plant, is seen as crucial for business improvement.

Establishing a refining factory

A small-scale factory to refine hemp fiber into more processed products is a viable option. Establishing refining factories is a collective effort, requiring pre-engineering, cost analysis, and identifying raw material buyers. Drawing inspiration from old linen factories can help determine the required machinery for hemp fiber refining. Repurposing old textile factories and adapting existing machinery are potential paths for innovation.

Innovation to optimize material quality

Maintaining consistent raw material quality, despite weather fluctuations, is crucial. Biotechnical applications aim to optimize the retting process, making it more time and water-efficient compared to current standards. Enzymatic treatments and pH adjustments are potential modifications to enhance fiber application and processing efficiency. Leveraging existing technology for hemp can increase its value and improve material processing. Exploring energy side streams from production can reduce waste and lower production costs.

Regulation to induce innovation

Government involvement can influence funding approaches to innovation and incubators like Business Finland can provide funding for various business ideas and projects.

3.3 FORCES SUPPORTING AND HINDERING THE TRANSITION

The supporting and hindering forces are organized according to the six different perspectives, to give an overview of what should be taken in consideration, when aiming at transitioning from the current to the future situation. It should be seen as general themes, that can either hinder or support the change process on an overarching level. If stakeholders have specific projects within the development of the supply chain, these forces should be mapped according to the specific project to give a more specific overview of the situation.

3.3.1 Supporting and hindering forces in six categories

	Supporting	**Hindering**
Agronomic practices	- Farming traditions in Finland promote small scale and diverse farm systems	- Farmers work alone and are not used to establishing networks and direct markets
Socio-ecological system	- More than 20 years of hemp cultivation in Finland - Change of mindset to sustainable and biodegradable materials - Educational institutions promoting networks of scientists, farmers and companies	- Traditional farming culture hinders investment in machinery at farm level - Economic mindset and competition in value chain hinders trusty collaborations (Skene, 2022) - Lack of trust and clarity of role in value chain hinders collaboration

Policies and legislation	- Legislation for usage of side streams in forest industry induced cross-industrial collaborations. - SUPD giving companies incentives to move towards biobased materials - Environmental legislation regulating peat mining, household biowaste and plastic usage.	- Lack of governmental support programs incentivizing cultivation and processing of hemp - Legal status of hemp is hindering the side stream production of CBD products. - No certification to promote the sustainability of farming practices beyond organic
Technology and innovation	- Existing knowledge on processing plants for hemp - Old linen factories can be a useful source for inspiration - Machine supplier interest in farmer collaborations	- Logistics of harvest (equipment) and transportation of raw material to processing plant - Ensuring reliable high-quality fiber from agriculture - Receiving funding from investors
Market and production	- Established market for hemp seeds for reference. - Transparency in supply chains and traceability of biomass can contribute to value-based markets (Lerman, 2012). - Existing demand in industry for hemp biomass material - Consumer demand for circular and sustainable products	- Most actors in supply chain refer to farmers as starting point for developing market - Creating new industry demand high investments and pre-engineering work (Pecenka et al., 2012) - Industrial production require high input of raw material
Climate and environment	- Cultivation of hemp promote agrobiodiversity, reduces need for pesticide and weed control, improve soil structure (Amaducci et al., 2015)	- Economies of scale may externalize environmental costs in upscaling industrial processing line of hemp (Skene, 2022)

Table 3. The table lists supporting and hindering forces in six categories. It is a synthesized review of informant knowledge and is supported with statements from literature.

3.3.2 Conflicting interests and potential interactions

Collaboration in industry

A dominant feature of market economy is competition. To make a shift towards more biobased materials, it takes a collaborative effort to make the change. According to Suominen it would require a consortium of machine suppliers, farmers, and entrepreneurs to establish a hemp refinery in Finland. Here collaboration across the value chain could also be beneficial for a coherent development of material, so that all stakeholders get to express their needs in regard to the material quality and supply. The customers of hemp fiber and shive today, disengage with

responsibility regarding cultivation and processing of hemp and points at the farmer as the starting point for development. This can be a big challenge to overcome for a single farmer, who is already burdened by low prices of regular crops and long working days. Some innovative farmers, like Aapo Korkeaoja, may find the courage and stamina to pursue innovation in the value chain, but in perspective to other farmer's livelihood, not all have this capacity.

Incentives for farmers to choose hemp

The market for hemp has various streams of end-products. Currently the market for seeds is well-established, but there are significant differences between food industry and fiber production entailing different challenges for establishing. The similarities in the two production systems, lie in the mechanisms regulating agricultural products. Hemp seed growing started in 2006 in cooperation with Dr. James C. Callaway, who is the breeder of the FINOLA variety. Dr. Callaway holds an important role for enabling cultivation and marketing of hemp seeds in Finland. The new variety induced collaborations across the supply chain of agricultural food production. With TransFarm as a contract farming company ensuring trust and stability for farmers who choose hemp as an oil crop, it can be looked to as an example on how to establish a market and encourage farmers to cultivate industrial hemp.

There is a development potential in the market for hemp biomass, where several companies are working and investing in the development. Most stakeholders working with hemp biomass points to the farmer as the starting point for developing the value chain. However, initiating a new industry of industrial hemp entails great investments and risks, that a single farmer cannot necessarily engage in. Improving the whole requires that people feel safe sharing information that is relevant and accurate (Stroh, 2014). It is necessary to improve the relationships between the stakeholders engaging in the hemp fiber market, while also optimizing their opportunities to thrive as individual parts.

Creating shared visions

It has been found that challenges for moving towards circular raw materials in the textile industry entails 1) having similar future visions among collaborative partners in the value chain, and 2) enforcing trust in existing supply chain. Having a shared vision for a circular project, was found to be essential for establishing innovative partnerships. (Franco, 2017). This witnesses the importance of involving all relevant stakeholders in the supply chain of hemp products to create fruitful collaborations with a shared vision.

For this to take place, it is recommended to proceed with visioning workshops, that include the relevant stakeholders, which can enable them to converge their actions into the desired direction. The visions should live up to a set of quality criteria to be fully sustainable as described by Wiek and Ivaniec. These criterias are set as visionary, sustainable, systemic, coherent, plausible, tangible, relevant, nuanced, motivational and shared (Wiek & Iwaniec, 2014). The stakeholders can use the outcomes of this thesis as a starting point for their workshops, and further take ownership of the ideas that emerge in the process. The interview summaries (see appendix 8.4) can be used as a starting point for learning the needs of each stakeholder. Moreover, the identified processes and mechanisms influencing the system inform the stakeholders about the nature of the system (Reed et al., 2009). The practical outcomes should be shared visioning and involvement in decision making processes about the development of the supply chain. The involved stakeholders may use this document to gain an insight in each other's viewpoint, which can enable the group to appreciate the legitimacy of each other's views and see new ways of working together (Forester, 1999). This understanding can help build trust among stakeholders and motivate partners to build stronger collaborations.

3.4 ACTION STEPS FOR CHANGE

To bridge the gap between the current situation and the future situation, a set of action steps have been developed. These action steps refer to a specific project within the overall goal of improving the current supply chain to become economic profitable, socially just and environmentally friendly. They can be seen as purposeful activities to bring improvement to the current situation but should not be considered final or as the only option.

3.4.1 Root definition: Creating a farmer network for hemp biomass production

To start out with, a root definition of the specific project, that will lead to change in the supply chain has been made and is further outlined below.

A system to create a localized well-functioning supply chain, by establishing a farmer network for fiber hemp cultivation to create reliant supply and develop biomass material at local level with low investments.

A well-functioning supply chain entails a safe environment for farmers to engage in cultivation of industrial hemp without major risk and with a reliant customer to off take yield. By establishing a farmer network it is possible to build up capacity to further invest in a hemp refining factory. The network will provide proof of concept and ensure a reliant supply of raw material. It can be seen as a system that supply raw hemp material to the local community, and also as an incubator for small scale entrepreneurs to start working with hemp.

3.4.2 Meeting the project criteria

The following section describes how the project meets the criteria of being New, Appealing, Possible and Sustainable.

New: The project will entail a network of farmers and stakeholders related to the production of hemp, It is different from the existing structures, as the current fiber farmers are on a contract with Hemka, and do not share knowledge or develop new ideas internally among the farmers.

Appealing: It is appealing as it can facilitate new synergies and open up for collaborations, which can lead to emerging properties, such as new customer networks for direct sales, better quality of raw fiber material and inventions in the network, which all stakeholders in the supply chain can profit from.

Possible: The possibilities of establishing a farmer network depend on the key actors in the supply chain, and if they are open for the idea. There are hindering forces for establishing such a network such as logistics of transportation and communication, lack of trust and a competition driven market, that may influence stakeholders in establishing new collaborations. These hindering forces are further described and balanced out by a set of supporting forces described more in detail below. As such, it is possible to establish a fiber farmer network, but it will require an investment of time, better coordination among the key actors and a change in mindset to open up for a new collaboration.

Sustainable: The network could lead to an economically viable situation for fiber farmers if they manage to establish channels for direct sales and improve the quality of the raw material with help from innovation funds and governmental support. It can be socially just, as farmers will have more sovereignty of their produce and take ownership of the production and development of the material. It is environmentally friendly, as it creates possibilities for more farmers to join the network and become hemp farmers, which would lead to an outscaled production of hemp. This would lead to a bigger supply, which would later be able to processed further in an industrial line, and lead to developments in the industrial production and further enhance the economic viability.

3.4.3 Key actors and their roles

The key actors and their roles are defined to give an overview of what input is necessary from the actors involved. The supporting and hindering forces for this specific action plan will be identified.

Key actor	Role (input)	How they profit (output)
Aapo Korkeaoja	- Key actor in establishing hemp biomass farmer network - Host and planner of vision workshop at Korkeaoja Farm - Leader of network	- Collaborative partners to achieve vision - Sharing knowledge and resources to create end product. - Stronger voice and creating shared demand
Hemka Oy	- Co-leading the hemp farmer network - Provide contacts for other biomass hemp farmers - Contribute with biotechnical knowledge. - Help with innovation and design of fiber materials	- With an established network of farmers, fiber production is stable every year. The network will attract other farmers by showing the profitability of the crop, inducing more farmers to cultivate hemp. Hemka will thus have access to more material, when the hemp processing plant is built. - Can use the established farm level production as argument to investors in the profitability of the material
NOVIA	- Facilitate learning seminars for farmers. - Arrange meetings with advisors, companies, entrepreneurs, farmers and researchers - Arrange student visit to pilot plant and action workshops	- Contribute to the development of natural fibers - Maintain and develop role as an educational institution to contribute positively to society
Farmers	- Cultivate fiber hemp - Participate and interact in farmer network. - Some farmers will be more engaged than others, the ones with innovative capacity can take leading roles	- Shared knowledge and direct offset of yield - Gain an income - Actively participate in the transition of agriculture with a bottom-up approach
Sampo-Rosenlew	- Contribute with research and design for new machinery specific for hemp harvest	- Return of investment in 10 years, when the growing demand for hemp combines is established.

		- Potential to export machine equipment to other Nordic countries.
Satakunta region	- Distribute resources to farmers' network - Allocate money for research and design process of fiber usage - Collaborate with Novia on knowledge sharing network	- According to the regional plan 2050 of Satakunta region, supporting the hemp fiber farmer network can contribute to the following goals: - Smart specialization in industry, development of competence within the region and entrepreneurship and employment
Local community and farmers	- Buy building materials from farmer network - Choose hemp shives for animal husbandry	- Profit from healthy breathable building materials - Profit from high quality and healthy animal bedding

Table 4. Overview of stakeholders role and input to achieve the vision and the expected outcomes of the collaboration.

3.4.4 Identifying hindering & supporting forces

Hemp farming systems are more resilient to pests and weed growth (Amaducci & Gusovius, 2010), which is supporting farmers to cultivate this crop. Moreover, the crop gives profitable yields, working as an incentive to cultivate hemp. Shared equipment and facilities can improve farming procedures, however transport across the region may be difficult. Collaboration between farmers can yield new innovations, but farmers may find it difficult to find time to participate in workshops. Also, farmers and stakeholders in the network may perceive each other as competitors resulting in lack of trust and hindering knowledge sharing in developments. To address this problem, it is necessary to establish clear objectives and conditions for the collaborations. Established markets for hemp seeds can facilitate easy marketing of fiber and shives, as demand for raw material exists. Companies demanding return of investments prior to project completion can hinder the successful implementation of new innovations, as there is a shared responsibility of investing in new developments. European agenda is already supporting hemp cultivation and innovation, which may influence Satakunta region to collaborate in this sector to develop the hemp industry, even though there might be a high threshold for implementing new legislation at a national level.

3.4.5 Establishing action steps and a timeline

To understand what steps are necessary to reach the desired future, a timeline has been developed with the necessary action steps placed accordingly to a time frame of 3 years.

Building the foundation between key actors

- Initial meeting between Hemka, Aapo and NOVIA (and me?): setting a common goal, define the role of each actor, create conditions, make a SWOT analysis.
- Vision workshop with Aapo, Hemka and Ulrika: Make a shared vision for the farmer network and the wished outcomes of collaboration.
- Third meeting: Further define scope of the project- determine purpose and functionality of farmer network. Make an action plan for further progress.

Inviting hemp fiber farmers

- Reach out to hemp fiber farmers in Satakunta region and invite for workshop introducing shared fiber farmer network
- Facilitate vision workshop and build common ground in network
- Distribute responsibility and learn strengths and weaknesses of farmer network participants

Reach out to external stakeholders and make learning seminars

- Establish a collaboration with Satakunta region for innovation and strengthening of industry;
- Host regular seminars on hemp fiber farming with experts, farmers, related industries;
- Create platform for direct contact with customers;

Establish smaller cooperations within the network

- Smaller groups within the network can establish work groups for local processing;
- Find local customers to create direct sales;
- Invite Novia students to participate in practical workshops making construction materials with hemp.

Write project proposal to EIC

- A collaborative effort in the network to receive EIC funding;
- What is the goal, what is the investment, how should the network develop.

Create a shared demand for new machinery

- Contact Sampo-Rosenlew with project proposal;
- Write contracts ensuring reliability and conditions;
- Start engineering, make blueprints and pilot machine.

Timeline for action steps

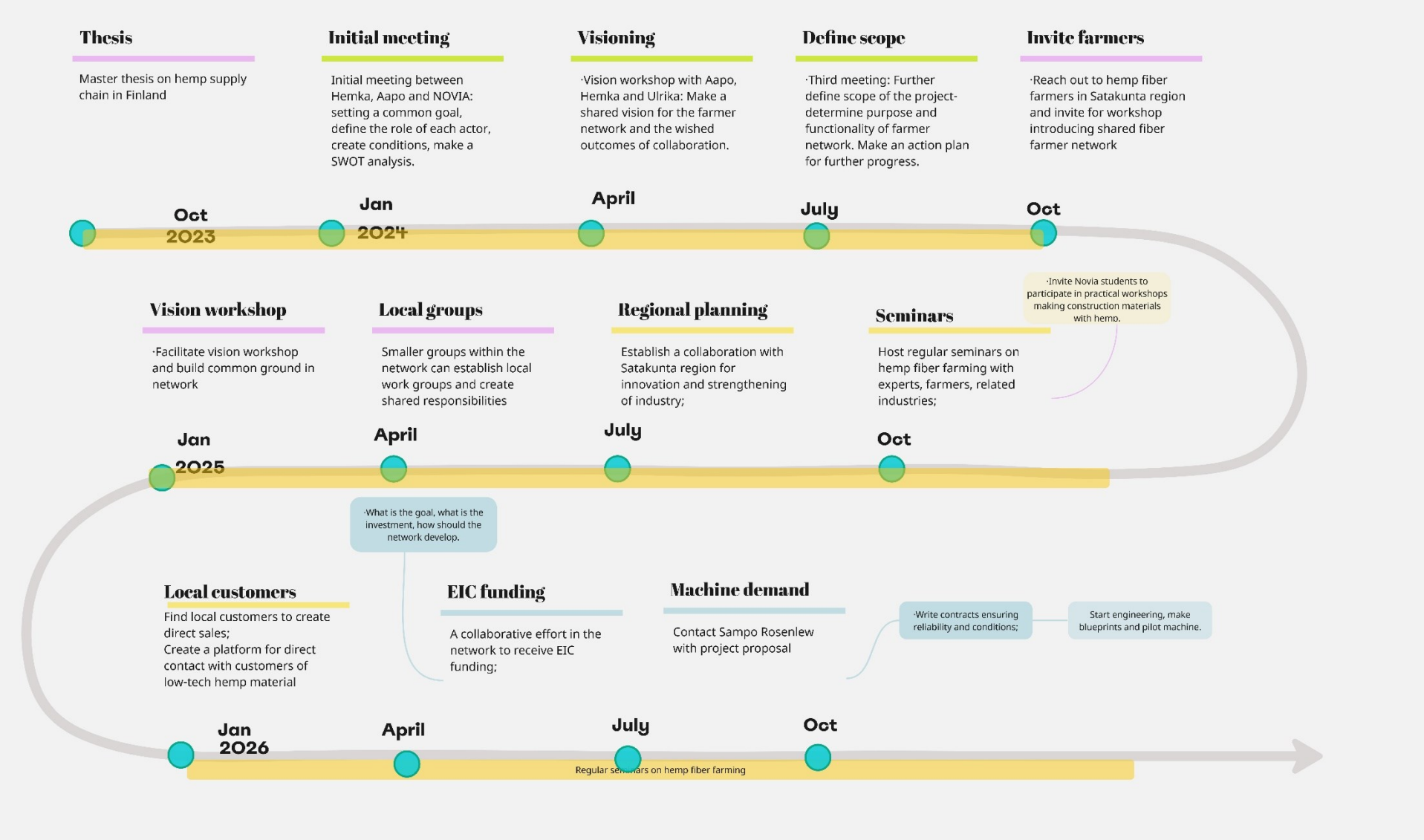

Figure 9. Timeline in the next three years showing action steps to create farmers' network.

3.5 DESIRABLE AND FEASIBLE CHANGE

To summarize the above content, the main question is answered in the following section. It contains changes related to the specific action plan elaborated upon in the previous chapter, but also goes beyond and discuss the overall changes, that would make the supply chain of industrial hemp in Finland economically profitable, socially just and environmentally friendly.

3.5.1 A localized value chain

To establish a well-functioning chain of hemp production, processing, and marketing by inducing collaboration between a wide range of stakeholders in order to create an economically profitable, socially just and environmentally friendly hemp supply chain. To develop a localized value chain of industrial hemp, by building collaboration across educational institutions, suppliers, machine suppliers and other industries it is possible to create new synergies and interactions, which may lead to a more well-functioning supply chain. It is necessary to build trust between key stakeholders to succeed with establishing a network, where all stakeholders feel that their work is appreciated and that they can profit from the collaboration.

Studies have shown some of the same results pointing to more collaboration and interactions between stakeholders in the value chain. In Value Based Supply Chain (VBSC), the market outlet for farmers should provide greater access to markets and provide a premium price through product differentiation by values associated with production, location and farm identity (Lerman, 2012). This would necessitate traceability of biomass in the production line if each farmer should be portrayed in the end product of the processed fiber.

With the outlook of supplying a high-quality material form several producers, the market potential of offering more end-products is present. The current customers and potential customers of hemp biomass are interested in bigger volumes and their demand is not yet met by the national supply. For this reason, the current actors n the market should not be afraid that their product won't have market when there is a collaboration between the actors. The synergies and interactions will lead to a more established production upstream in the value chain, and enable a bigger market to develop, where even more actors will be able to enter and contribute to the development of new end-products.

3.5.2 Establishing a farmer network

When the farmer network is established and there is a reliant supply, the material can furthermore be used in the hemp refining factory. When a local market has been established and the hemp refining factory has been built, it is possible to scale up the inventions to an industrial level. This would include reaching out to other stakeholders in the value chain, who are interested in using hemp in their product recipes and create a shared vision on how

industrial hemp can play a more prominent role in their product development. The market for materials such as insulation panels, garden mats and other construction materials have good prospects on the market, as these end uses does not require soft fibers and certified hygienic properties, as is the case with end products such as wet wipes or sanitary pads.

Furthermore, a well-functioning supply chain, where farmers can rely on a customer to take off the yield, a decortication factory should be built. This would entail a stakeholder, who has the capacity to make the necessary market analysis, find investors and do the pre-engineering. Hemka has been working on the initial steps of establishing a decortication factory, which can open the market further. The farmers can be involved as shareholders, but should not have key responsibilities in the production or establishing processes, as they need to focus on their farming activities. By developing better harvest equipment and conduct further research on the spring harvest method, it is possible to enable farmers to refine hemp at the farm level. This can be useful as the farmers will be able to offset their yield more easily, while they wait for the decortication factory to be established. Hemka will eventually also benefit from this development, as the material they obtain from the farmers will be more processed and of higher quality, when they receive it at the factory, enabling a smarter and more price-efficient process.

3.5.3 Governmental regulations and support

Governmental support in the form of legislation that induce industries to collaborate can be essential for the development of the industrial line of hemp. The legislation on more efficient use of side-streams, implemented by the European Union, realized a big change in the value chain of wood based fibers. Since the legislation was implemented many different industries have profited from new collaborations and have made use of material, that was otherwise wasted. This kind of incentive and support from regulating bodies can implore companies to make change in their current ways of production to go towards more efficient use of their resources. However, the wood industry and the agricultural sector are different in their nature, and other initiatives are needed to stimulate the production line of industrial hemp. Hemp production can be supported through regional programs, that support the building of industry in the hemp sector. This could be a new certification label, that certify biomass production in diversified farm systems. Furthermore, it is necessary to have a procedure for the traceability of biomass in order to trace it back to these farming systems living up to environmental and social just parameters.

The European Innovation Council (EIC) supports game changing innovations throughout the lifecycle from early-stage research, to proof of concept, technology transfer, and the financing and scale up of start-ups and Strategic Market Creation (SMC). This program hold potential to support the innovations in the production line of hemp and can be distributed at a local level to

the farmer network, for specific project proposals from entrepreneurs that build on the capacity, that has been founded in the network.

Satakunta region also plays a role in supporting the local development of a strong and innovative forum for fiber farmers, that work towards a well-functioning supply chain and industrial line of hemp. As the development is in accordance with their strategic goals for the region, they could profit from new innovations in the industry and the reputation of positively engaging with farmers to promote sustainable material development.

4 DISCUSSION

4.1 PROSPECTS OF INDUSTRIAL HEMP IN FINNISH AGRICULTURAL SYSTEMS

4.1.1 It takes a collaborative effort

The findings show that better collaboration among stakeholders and transparency in the supply chain may improve the current supply chain. Altieri et al. (2015), states that a bottom-up approach with farmer networks can facilitate change for more environmentally friendly and social just supply chains. These properties of farming and supply systems are closely related and interact in the development of action steps in section 3.4.5.

To overcome the socio-technical challenges in mainstreaming minor-crops, it takes more than just individual investments, it requires a collective effort. Three main levers have been identified for a diversification of the value chain to emerge. It is a) the adaptation of quality certifications, b) good coordination between stakeholders, that allow for fair distribution of added value and a fluid share of information, and c) combination of genetic, agronomic, technological and organizational innovations, that can ensure crop development (Meynard et al., 2018). These findings suit well with the findings of this thesis, where knowledge exchange and social networks are suggested to encourage the development of the supply chain. In relation to good coordination between stakeholders, trust is an essential element, which need to be encouraged. In a case study on the values among stakeholders in a value chain, it has been identified that trusting relationships in the value chain require transparency in operations and granting partner firms access to information that previously was considered confidential (Block et al., 2008). The role of key actors described in section 3.4.3 indicate similarities in the findings. To transform the system, a new input is required to obtain a new result. An important input is that of information, which can be shared among key stakeholders. By doing so with

trusting spirit, the outcome may be beneficial for all partners in building value beyond the current situation.

4.1.2 Industrial requirements

The different perspectives elaborated upon in this thesis, describe conflicting worldviews and how they can be a part of hindering fruitful collaborations. Economies of scale puts pressure on production systems, and encourage extraction of Earth resources beyond the planetary boundaries (Raworth, 2017). Also industrialized agricultural systems trade-off other ecological services, and is responsible for negative environmental impact and social costs (Kremen & Miles, 2012). Shifting from the philosophy of the liberal economy as a main driver for product development and offsetting yield, it may prove successful for producers and farmers to build upon values-based-supply-chains (Lerman, 2012). Re-structuring the sales channels to become more direct and encourage local innovations, may serve as the foundation for new industrial inventions in the longer run. Furthermore, it can serve as the foundation for more diversified farm systems integrating hemp in crop rotations, resulting in emergent ecosystem services enhancing the farm systems and social justice (Kremen & Miles, 2012).

The industrial requirement for a high input of material in the processing line is in contradiction to the current situation, where hemp fiber extraction has long processing lines related to high investment costs (Pecenka et al., 2012). This can be seen as a hindering force in the development of a well-functioning supply chain but should not be considered the only obstacle. The worldview of the stakeholders and their stance on collaboration play an important role in progressing from the current situation into a desired future state.

4.1.3 Implications of spring harvest

There are several variables related to spring harvest, that have not been determined yet. The viability of the method should be researched in relation to how much time is spent on harvest and how much material is lost as compared to autumn harvest. Furthermore, the quality of the material can be problematic due to the characteristics of hemp fibers. Bast fibers are made of primary and secondary fibers, where the primary are longer and larger compared to secondary fibers, that are shorter and thinner with lignified cell walls. Secondary fibers are mainly used for cordage, pulp, and recycling additives, whereas primary fibers are desirable for textile use. The presence of secondary fibers increases with plant age, which is why plant harvesting time is essential for increasing fiber extraction quantity (Duque Schumacher et al., 2020). In relation to spring harvest, this may pose a problem in conjunction with extracting primary fibers for textile industry, as the plant is left on the field over winter. However, there has not been conducted any research on the specifics of the fiber quality harvested in spring in Finland.

4.2 THE RELEVANCE OF THIS STUDY

4.2.1 Implications for methodology

The systems thinking approach to address complex problems in social situation work well to identify pathways for change and go beyond the limitations of only finding out about one particular part of the problematic situation at hand. The methods described in soft system methodology have been adapted across many organizational institutions and serve as a way of generating change in private institutions, governmental bodies and in cross-organizational collaborations, such as value chains. The work conducted in this research project has adapted the mental framework for thinking about a complex social situation, where actors, processes and mechanisms are intertwined in complex interactions across hierarchical scales. The categories or perspectives serve as a model to understand different worldviews, but also to organize the findings in order to map interactions and overlaps. The soft system methodology can be used to address situations of complexity within purposeful human activity systems embedded in their biophysical and socio-economic realities. The findings in this thesis correspond to existing literature and go beyond in addressing concrete actions for change. The six categories proved useful in understanding the situation from different perspectives enabling a holistic analysis. The mental framework for action-oriented research has been useful to organize the structure of this thesis and can be used as a model for other studies aiming at making organizational change with a bottom-up approach.

4.2.2 Transferability of knowledge

The farm system and the agricultural practices may differentiate in other locations, as the farm system in Finland is dependent on the socio-economic environment and biophysical reality it is embedded in. The biophysical elements will vary slightly due to climatic differences in other countries. In a global and industrialized society, the socio-economic realities we experience are starting to look the same due to globalized economic trends. The global economy tends to compromise the environmental aspects of production in return of high productivity. This externalization of costs is driving production system to the boundaries of what the Earth can sustain (Gliessman, 2015). The market is dominated by supply and demand, which creates the basis for product development and business management. These mechanisms will most likely be much alike in other cases and result in the same emergent properties as described here. However, there are differences between the agro-industrial landscape in Denmark and the family-owned farms in Finland. These differences will impact the opportunities of creating fiber farmer networks in Denmark as compared to Finland. Nonetheless, it is possible to cultivate hemp in diversified farm systems across many different climates (Amaducci et al., 2015), but it will depend on the people implementing the farming systems and the

governmental support aiming at supporting these systems. It could be beneficial for other Nordic countries to look at the market for hemp seeds in Finland to learn from a well-established supply chain in this direction. The FINOLA variety is developed to suit the Finnish climate, which may be an advantage for other Nordic countries, as they are spatially closely linked and share climatic tendencies. The adaptiveness of the plant variety may be a successful to implement in crop rotations in other temperate climates.

In general, the findings of this thesis point to general problematics of establishing supply chains of biobased material produced in agricultural landscapes. Some of the general mechanisms and interactions found are seen to be the same in other studies. The impacts of this study may lead to actions taken in the Finnish supply chain. It can also be used as inspiration for other researchers wanting to engage with change processes in supply chains.

5 CONCLUSION

This thesis provides a system analysis on the production and value chain of industrial hemp in Finland. It uses action research as a method to acquire data about the system, which may reveal important aspects of system properties, that can help understand the supporting and hindering forces for a well-functioning and sustainable supply chain of hemp. By determining root problems of the current supply chain, this thesis comes with a suggestion for an action plan, which can transform the current situation into a desired future state.

Transitioning from the current situation to a desired future situation involves achieving a shared vision for a circular production of hemp among stakeholders throughout the supply chain. To satisfy the specific demands of each company within the value chain, there is a need to share knowledge and foster collaboration among stakeholders, enabling the development of innovative solutions within the supply chain. Each company have their own agenda in being on the market and can benefit from further development of circular products made from hemp. The establishment of a hemp refinery can benefit hemp farmers by providing a reliable customer for their fiber yield. Similarly, creating a network of farmers can open doors to new opportunities, enabling farmers to engage in discussions and knowledge sharing about hemp cultivation and production. This approach reduces risk for farmers, as they can rely on each other for knowledge sharing and equipment, particularly those in close proximity. For the customers of raw hemp materials, the network of farmers ensures a dependable supply, even in the event of a poor harvest from one farmer. Facilitating knowledge exchange and offering support, both from fellow farmers and from experts and

entrepreneurs, strengthens the connections between raw materials and stakeholders, encouraging an expanded production of hemp. Collaboratively generating demand for tractors and equipment, seeking funding for establishment of new industries, and implementing regional planning for certified diversified fiber production systems are key actions that can contribute to improving the current system.

It is necessary to further research how proper harvesting machines and equipment for hemp farmers look like. Regulations on a European and national level can help the transition towards more partnerships in industry by inducing collaboration towards more circular end products.

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8 APPENDICES

8.1 SYSTEMS THINKING TOOLS

8.1.1 Rich Picture

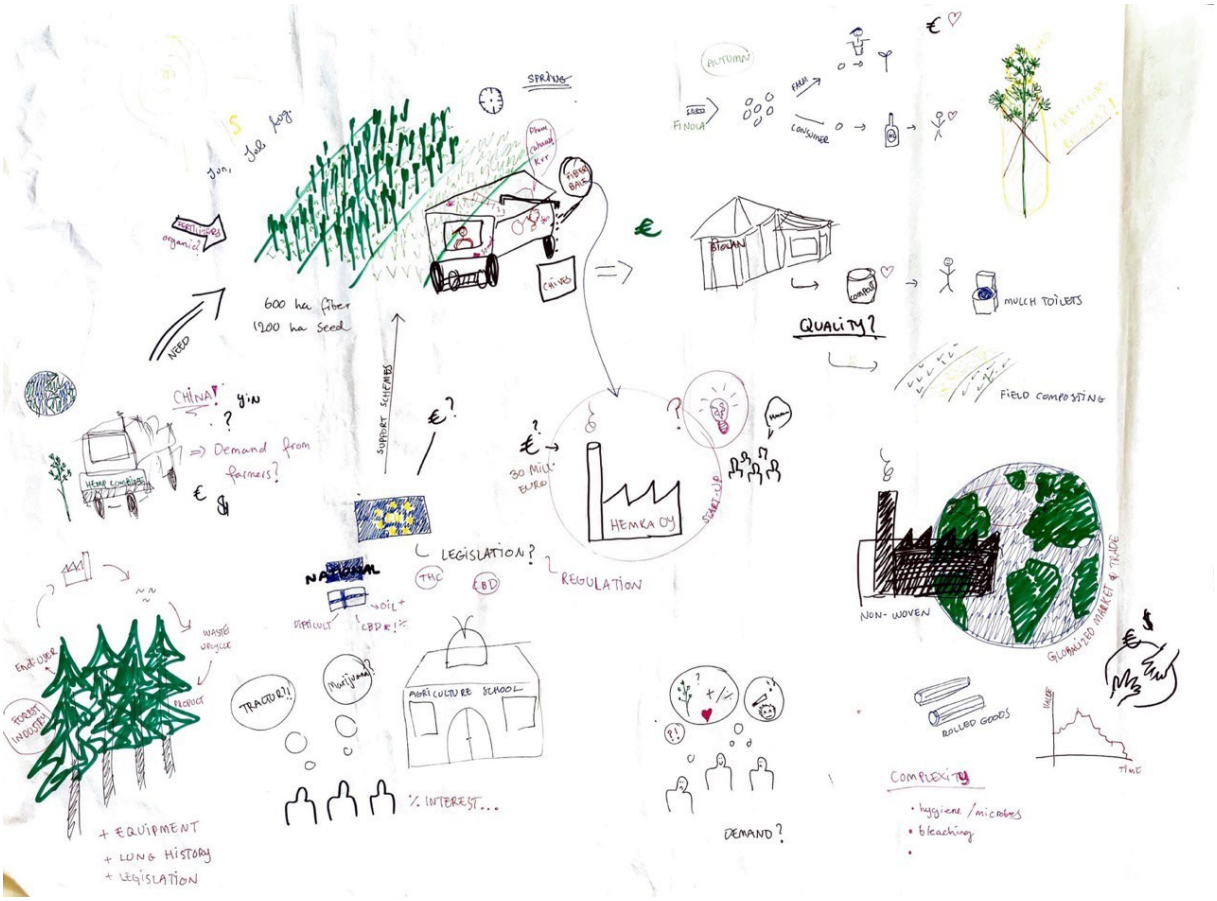

Figure 10 Rich picture depicting different actors, processes interactions and mindsets in a big messy drawing.

8.1.2 System map at farm level

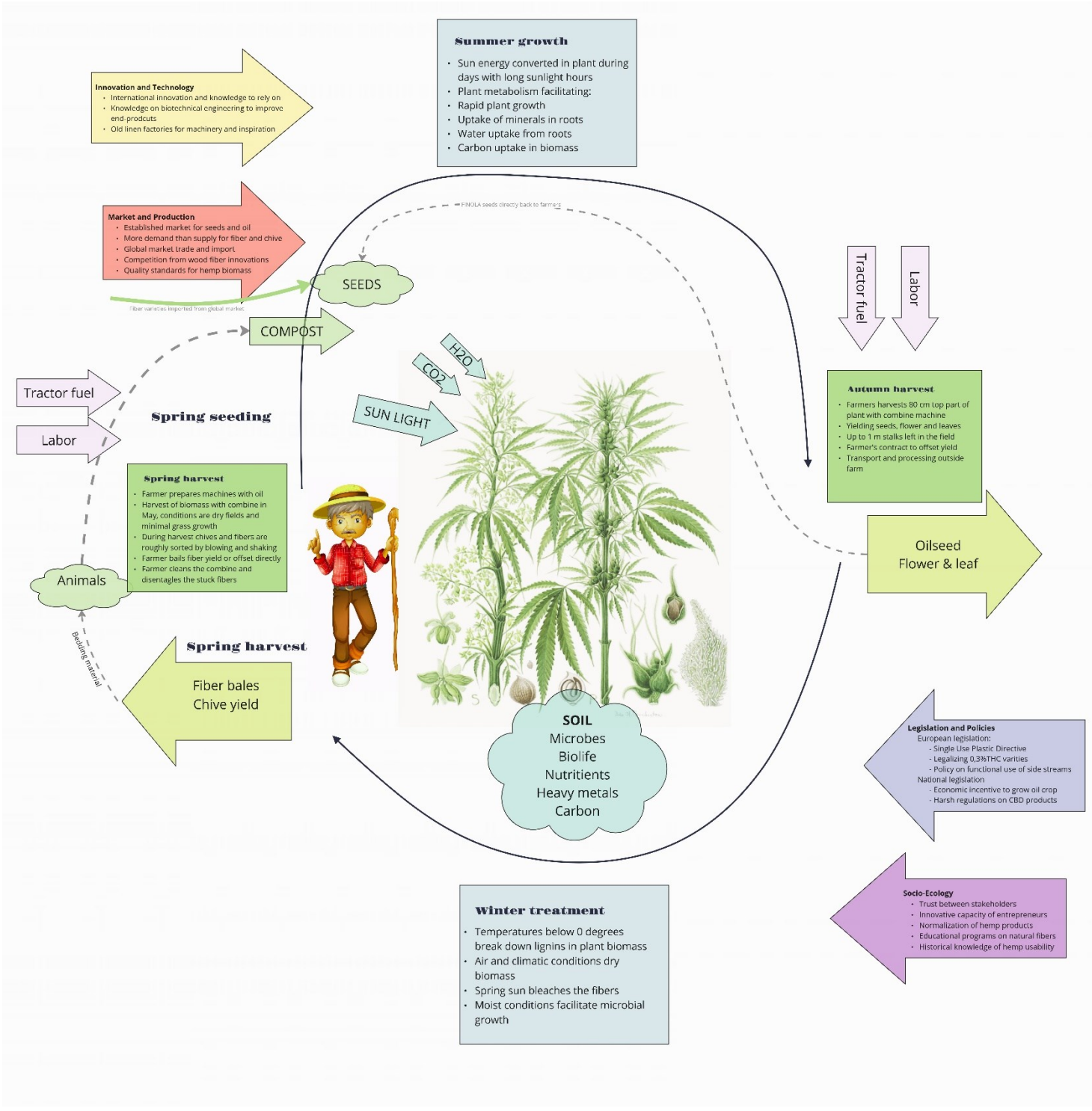

Figure The system map depicts different elements interacting with each other at farm level, where the outgoing arrows represent the material output of the farming system. Green boxes represent processes performed by the farmer and blue boxes represent natural processes taking place in the farming system. The incoming arrows represent impacting factors from different realms.

8.2 INTERVIEW GUIDE

Farmers and educators

Introduction and background
Introduction. Hello, thank you for taking time to talk with me - I am a young researcher interested in hemp, as I know it is very beneficial and provide ecosystemservices for both humans and earth. Hemp fiber and shives are a biobased material, which can provide us with useful biobased products. I know you have industrial hemp as a crop on your farm/ educate about industrial farm as a crop, with the ambition of spreading the word and knowledge about this beneficial crop as well as make a living from it. I am here to ask you a few questions about your work with hemp and the prospects of cultivating and processing hemp in the near future. We will talk a bit about the supporting and hindering forces impacting your company and also how we can pursue the vision of hemp being farmed in diversified farm systems.

Data management and disclaimer
Before we begin, I would like to make clear that I will not publish any content that is related to specific measures on manufacturing or technical aspects of developing hemp equipment. If you have any concerns regarding the interview and the content being recorded or published, please let me know, so I can make sure to keep specific information confidential. I have also printed this data management plan, so you can see how I intend to work with the data I gather.

- Do you have any questions or comments about this?
- Is it okay for you that I record this conversation?

Explore and understand current situation and meaning

Okay, so let's start the interview with some questions about the current situation.

- What impacted your decision to work with hemp? Why do you find it important? (intro)
- What are your current methods to diversify your farm on the plot level?
- On the field level? On the landscape level?
- What external stakeholders are supporting your choices regarding diversification? (eg legislation, market demand, environmental profiting… etc.). How do they support?
- What is currently the most difficult part of being a hemp farmer? (hindering: technology, economy, policies… etc.). Can you give an example?
- When you sell your raw material to a company, what aspects do you find important in collaborations? (system, interrelations)
- What is difficult about collaborating with people? Do you have any examples? (system, interrelationships)

Desired future and vision

Now I would like to talk a bit about the future and what you have in mind for the future of hemp farming and processing. This is more general about how you think hemp will develop in the supply chains in Nordic countries in the next 5-10 years.

- Let's start with your vision for hemp farming and processing in Finland. What do you think will be the biggest change in farming practices and processing of hemp looking into 2030? Agro: field/ plot/ landscape. Processing: development of new technologies, industries, better policies or a more open market?

- How do you think farming education will develop during the next 5 years, when it comes to hemp? (e.g., the development of a new program, technical advancement, etc.)
- What is impacting this transition? E.g., more collaboration with industry, demand from students, policies, or market demand…
- Can you imagine the school establishing new partnerships, if yes, what works well in these partnerships?

Imagine that we are in 2030, and we have reached this vision. The farm/ educational program is growing, hemp is being processed in well-functioning supply chains, and the market for hemp is thriving.

- How did you contribute to this advancement? Specific innovations, ideas or teaching?
- Why is it important for you to contribute to this development?

Let's stay in this place a little bit longer and look back at the seven years that have passed. Now, let's think about the steps that was taken to reach this goal and how it has impacted the value chain of hemp in Finland.

- What do you think were the most important steps towards reaching the vision?
- What enabled the school/ the farm to get to this place of the vision… was it a person, a company, a new legislation or an invention/program that you got sponsored to develop?
- How does your contributions in the development of hemp supply chain affect other stakeholders, that wish to work with hemp?

Thank you for sharing these thoughts with me. Now let's come back to the present and round of the conversation a little bit. It has been very interesting to talk about the visions and prospects for future of hemp in Finland.

- Is there anything you would like to add about your process in developing hempyou're your vision for hemp in the future?
- If something comes to mind, about what works well or is difficult you are also welcome to elaborate on this?

If not, I would just once again thank you for your time and input. I will send you a summary of our conversation, when I have finished this (sometime in June) to ask for your acceptance and if you have any comments on the content that can be published. If you are interested, I will let you know when my thesis is published (in October) and send you a copy.

8.3 INTERVIEW DATA ANALYSIS PROCESS

Current situation	Quotes	Summary/ notes	Supporting force	Hindering force	Impacts --> Related cat
Aapo	if you look at the Finnish farmers, we are kind of alone right now we often own our own machines, which are bad and old and we don't collaborate too much. There is not that much co-operations and we are not really kind of strong collaboration or strong in local markets either	Finnish farmers mainly work alone and on their own machines which don't function optimally. Collaboration is not a cultural asset.		Hindering mindset or collaboration	
	Some kind of Economical is it mindset or situation Is that the Norwegian farmers are not that shy for Investing for the machinery Yeah, so do you have a market in there and it's But maybe it's also because they are more wealthy	Different mindsets and higher income levels can alter the capacity to invest in new technology			
Kalle	This Company gets money for making and selling combines, supporting and service is a small nice things. But if we figure out some idea that we can sell more machines or the machine can be better for the farmer with The reasonable invests we are always interested and	Sampo-Rosenlew's primary activity is to make and sell combine machines, as well as giving service and support to their customers. If we find a way to expand our sales, or we can create better machines for farmers, with a reasonable investment, we are interested.			they are part of the tractor developers
	Aapo's machine is made here 10- 15 years ago and the basic concept for the Aapo's Dressing unit and the machine is so It's pretty similar nowadays, of course, there's come more legislation and comfort, but basic things are still quite the same. So Whatever he is doing there. So might be Quite easily doable. So for the new machines or the other ones Then does it come to some kind of our business or somebody else business, but we are interested what people are doing with our	Aapo's machine is made by SR 10-15 years with the basic concepts of a dressing unit, so it's quite similar to machines nowadays. There are some new legislations now, and comfort requirements, but it is possible to implement changes in the machinery to improve the combine. SR is interested in what farmers are doing with their machines.	It is doable to make a combine		innovation in agricultural equipment can impact farmscapes, which can impact environment and climate
	we did some development with one farmer that how our machine could easily harvest that so some crops are coming.. Some stay some don't stay so but You need to get an idea that	The flux of new crops is transient, some stay some don't, and you need to have an idea of what is doable.	market fluxes		innovation depends on market potential

Figure 11 A template showing how the interviews were summarized and analysed according to the systems thinking framework applied in the research project.

8.4 SUMMARIZED MEANING UNITS OF INTERVIEW TRANSCRIPTIONS IN CATEGORIES

8.4.1 Aapo Korkeaoja, Farmer and Cultural director and Kalle Pärkö, Sampo Rosenlew

Sampo Rosenlew is a manufacturer of combine and forestry machines. Their roots in industrial operations go back to 1853 as a family company. Sampo Rosenlew as it is known today was founded in 1991. Sampo-Rosenlew's primary activity are to make and sell combine machines and give service-support to their customers. Aapo Korkeaoja is a farmer and entrepreneur in hemp farming activities and collaborates with Sampo-Rosenlew in exchanging ideas for new harvesting equipment.

Current situation

Environment and climate: Hemp is a sustainable plant, that fits the Nordic climate, there are almost no problems with pests. Due to the lack of summer warmth, some varieties do not produce seeds.. It's a circular crop system, that gives nutrients back to the soil and can store carbon in its biomass.

Socio-ecological: Finnish farmers mainly work alone and on their own machines of varying quality. To generalize, they don't make collaborations or establish local markets. Different mindsets and higher income levels can alter the capacity to invest in new technology.

Technology and innovation: Aapo's machine is made by Sampo Rosenlew about 20 years with the basic concepts of the machine. Sampo Rosenlew is interested in how farmers use their machines, and are willing to corporate with farmers in developing new combine equipment. The combine machine has different settings, and sometimes the fuel costs are heightened by certain configurations. each element which is added to the harvesting procedure is an additional cost of fuel.

At the moment, there are not any hemp decortication of refining factories in the Nordic or Baltic countries. Aapo has thus sent a sample of his hemp fiber harvest to France, where a big company has shown interest in seeing the quality of the fiber yield.

Side streams have become very utilized and now a lot of fiber innovations in Finland are focused on the wood industry, because it is a big player in the Finnish market. This may be

one of the reasons, that the hemp industry hasn't been developed here, as compared to France, where they don't have as much wood industry.

Agronomic practices: Spring is a busy season, and it is important to get the job of harvesting and seeding done in time. It should be a smooth and efficient process, where you can harvest and collect the biomass without any major problems.

Hemp and linen are the most important natural fiber crops, that can be produced in nowadays in Nordic agroecosystems. Hemp produces the biggest yield out of the two and is easy to farm, which is one of the reasons it has expanded in the market of natural fibers.

Spring harvest is a sustainable way of harvesting because the fibers get out bleached and partly separated. It is all done by nature during the freezing winters, where lignin and pectin is broken down during the winter. It is important to note that winters vary. Nordic countries have good conditions for developing the spring harvesting technique. The technical aspects of spring harvest is not working optimally at the moment, and the method has been underdeveloped, possibly because companies mainly focus on autumn harvest.

It is more profitable to separate fiber from shive directly in the harvesting process. Customers of shive demand a certain quality , where the product is clean from fiber and dust. This could be solved at farm level with technical adjustments to the machine, which would mean the raw material from the farm would respond to customer's demands. Customers of shives are not necessarily interested in the machine that the farmer uses, but mainly the quality of the material.

The biggest challenge of production is the harvesting procedure. There are currently some problems with the machine, where the fiber gets stuck. The harvest procedure takes time, and there is a potential to improve the quality of the yield and make the process faster.

"*Right now we can sell approximately 1/3 of the yield, which is the shive, directly to a customer2/3 of the biomass is being baled, which is the most valuable part of the plant - the fiber. The fiber should be further refined to upgrade the quality and create a market."* – Aapo Korkeaoja

Market and Production: The market has the power to regulate what crops are being grown, as farmers will aim to improve their yield. The flux of new crops is transient, some stay some don't, new farming inventions are determined by fluxes of the market and some new tryouts become viable options in farming systems. Business developments in machine supply is dependent on global market demand. The global market for industrial hemp is growing fast, especially in Northern America. In Finland there has been more than 20 years of experimenting

with hemp, and there is already an established market for hemp seeds and oil, now the market is developing and growing.

Natural fibers will take more place on the market. The market could grow, if the harvesting equipment is developed. Most of the international technology developed for hemp harvesting is based on autumn harvest method. It is also possible to export raw material to Central Europe, but it can be developed locally if the technology allows. Gardening products is easy to produce from agricultural activities, which could be a useful end-product. When the markets grow, new and more refined industries will also emerge.

"If we find a way to expand our sales, or we can create better machines for farmers, with a reasonable investment, we are interested." – Kalle Pärkö

Sampo-Rosenlew doesn't produce any specific equipment for hemp harvest. Kalle doesn't envision a new product design for a hemp harvesting tractor, but the option of making some additional add-ons for hemp specific tractor is possible. Investments shouldn't be too big and payback time for the new machine should be around 5-10 years.

The global food market is affected by fluctuating prices, which can be frustrating for farmers who are not guaranteed a stable income. Right now, farmers in Finland are paid less than farmers in Central Europe due to low grain prices. This can be a driving force for turning to fiber crops, as crop prices of the raw material are high and the fuel costs low. There are examples of farmers that changed their wheat crop to linen, to save the costs of fertilizers and fuel as it requires less input than wheat and has a more stable price.

Policies and legislation: Legislation is supporting businesses to use the latest technology by giving extra subsidies. Linen and hemp have been neglected since the industrial developments took off, but with the European Green Reform, there is funding available, and industries are taking steps to support the transition towards more biobased materials.

As a result of the legislative incentive to use side streams in forest industry, a range of products from pine has been developed such as recyclable packaging, eco-based diesel and biodegradable plastics.

There is a European funding program, which is funding the transition towards using less peat. In Finland the domestic energy production has consisted mainly of burning wood and peat. Peat extraction has been a big part of the economy and used as a mean of generating heat. Moreover, peat is used in gardening products as well as fuel. Just in the Satakunta region there is a pool of money amounting to 7 million euros.

Future situation

Socio-ecological: The future generation will demand change in culture and now the Green Reform is steering the sustainability movement. Sustainable and ecological reforms will induce value-based businesses to develop.

Market and production: Business opportunities in green economies are on the rise, and we see that the stock market for hemp is growing rapidly. It is necessary to make a market analysis before growing a new crop. To find out where the customers are, in Finland or on the global market. There are prospects in hemp industry to collaborate more with other industries, such as textile industry. Since hemp fibers are up to 60 cm long, they can be a valid alternative in the textile industry.

The traceability of biomass depends on the customers and what they want. It is the story behind the product that is important, that the product is produced locally and organically. There should be a manufacturer in the value chain that makes a product that is easy to sell that the consumers need. They need to create a market for something that is a universal commodity.

The first step in developing the supply chain is getting project fundings. From there it is possible to develop the machinery, so that it can work on a bigger scale. Besides developing the harvest machinery, it is also necessary to set up a factory for refining hemp in Finland. It would require making a market analysis to find the customers, which would need funding. Investors have shown interest in the development, but it takes time to make these collaborations.

Agronomic practices: Farmers that own combine machines have operating costs such as fuel and seeds. Environmental costs of farming are externalized. There is a possibility to farm and harvest hemp of a certain quality locally, which would not be too expensive for customers to buy, which would possibly create demand, if the harvest procedure is improved.

The investment for the machine would be around 10.000 to 20.000 Euro, which is what most farmers are willing to invest to start their own business. A proper harvesting machine could decentralize the market for hemp and support local businesses and development. In opposition to largescale global businesses investing in fiber production plant and having to interfere with farming activities.

The machinery should be developed, to enable both short and long fiber production. Short fibers are used for non-woven products and long fibers can be used in textile production. From a machine supplier point of view, the most important part is to collect as much of the material from the field as possible, whether the material should be kept long or short.

Technology and innovation: It requires technological development on harvesting equipment to be able to harvest hemp fibers that retain the length and quality necessary for textile industry.

There is a potential in using a tractor to produce a hemp yield, that can be sold directly to a customer. It means a minimum investment, and a ready-to-sell product straight from the field. Such a scenario would include a collaboration network of farmers producing hemp in small-scale in a certain area. The producers could either sell it to a middleman or pack it themselves and sell it directly to the customers locally. Another option is to invest in a small-scale factory, that would refine the hemp fiber bales from the combine to a more processed product. Old linen factories can be useful for gaining inspiration in what machinery is required in technical aspects of refining hemp fiber.

The machine supplier is not responsible for developing their machines to fit the purpose better. The demand for adjustments in the machines normally come from either the farmer or from the requirements of industry.

Socio-ecology : The Farmer's Association has a power in national politics, as they have a hearsay in what crops will get more subsidies and easier requirements for cultivating.

There's a distinct difference between large-scale multinational firms who are big players on the global market and then small-scale local companies and cooperatives, that produce goods or specialty foods and beverages for their local communities. It is a question about culture and what people choose.

"As a machine producer we don't see ourselves as the driver for making change in the agricultural landscape, this transition is on the farmers side of the table."

Policy and legislation: All industries have lobbying services for their activities. There's not so much lobbying for hemp in Finland, even though there is at a European scale.

Subsidies are important in setting the direction for the industry. The EU has to take the lead in making reforms, it is not going to be individual member countries.

The reform to close down peat extraction in Finland can ameliorate the conditions for hemp farming.

Environment and climate: There is a discussion in Finland, whether farming emissions should be included in the calculation, but at the moment there isn't a way to show how sustainable farming activities are. The current system of classifying farming as organic and non-organic, doesn't show all the nuances of farming activities and how sustainable it is.

8.4.2 Ari Ilottu, OSARA

Current situation

Agricultural practices: His farm is 47 hectares, out of which 7 hectares was used to cultivate hemp in 2022. He uses a semi-automated machine to plant with. The crop rotation plan consists of oats, hemp, beans, barley, green beans for cows and hay, which is cultivated conventional without plowing. Not plowing can save diesel, be less costly and be good for the climate. The soil should be rich in nutrients and organic material to grow hemp. Ari has prioritizes to grow hemp and green peas on his rich soils. It has to be high yielding crops to make profit. (Peat soil is good for growing crops.)

Ari grows hemp for seed as a contract farmer for TransFarm, which means he buys and sells seeds directly from- and to TransFarm. Ari chose to cultivate hemp, because he has an interest for new crops and see it as a profitable crop.

Alfalfa is a new crop, that is being taken up. Maize and hemp are special crops, that still needs to be studied. If climate change is real and will result in a warmer climate, it could change the crops for more warm tolerant species. In climate change we can grow new crops. Cumine, grape and artichokes are new oil crops. Fruit and nut trees are also becoming more popular with the farmers here in Finland. Chestnut and walnut are examples of trees, which can be grown as an oil crop with favorable prices.

Big farms have better opportunities to support themselves, small farmers need to support their living by taking other jobs. Special crops can give farmers more possibilities to sustain their living. Most farms in Finland are family farms, it is rarely companies that own farms. Ari has given some of his farmland to his son, whom he will ask to cultivate hemp.

Market and production: When choosing a new crop, a determining factor is the price you can get for the yield and knowing someone is willing to buy the crop straight after harvest to secure profit and have easy logistics. Ari plants 25-30 kg seed/ ha. The yield is about 1000 kg of seed/ha, which he can sell for 1E/kg directly to TransFarm. This makes an average income of 1000 E/ha, which is good. Hemp is easy to sell, which makes it an easy crop to grow and combine with teaching in the school. Farmers are not in control of market prices of crops.

Socio-ecological: At OSARA farming school they teach organic farming. The agriculture school focuses on business management, so if hemp is a good crop for business, the school will start teaching how to farm it. The school mainly teach about traditional crops, as they have a higher priority in the curriculum. Hemp is a new crop, so it takes time to develop. It is comparable with other new crops emerging, such as corn and alfalfa. When teaching about

hemp farming, Ari takes the students to his farm in smaller groups. Students are not interested in growing hemp, because the machinery is inefficient and the cleaning of the combine after harvest is a lot of work. Students like oiling machines rather than cleaning them. Students need to know the crop before they can develop an interest towards it.

There has been a change in mindset in the past 10 years, today people don't think it is weird to grow hemp. Declaration stickers from the government give a warranty that hemp is a certified crop, which is legal to grow.

Technology and innovation: Newer combines do a better job harvesting, because they can cut higher, so you only get the heads with seed. When it cuts higher you get less branches stuck in the combine, which means there is less to clean. 80 cm of the stubble is left in the field after harvest, which complicates direct sowing in the spring and causes extra work. You need motivation to buy new machinery, like cultivating a lot of land.

Policy and legislation: The European Union supports the governmental payment schemes but it doesn't influence the amount of different crops. Legislation focuses on making requirements to protect nature, it includes regulations on areas that are non-cultivated and landscape parameters.

Future situation

Market and production: There will be more contract farming companies working with hemp in the future. This might result in better crop prices for farmers. To enable farmers to grow hemp, the price has to be good enough to support their living.

Technology and innovation: It would be useful to develop a combine that can harvest the whole plant. New inventions are needed to make business better.

Socio-ecology: Informing customers and making market campaigns about the health benefits of hemp can support the transition for more demand. When there is a demand and someone is willing to pay for the crop, farmers will have an interest in growing it. Farmers can also be part of the transition by giving information about new crops.

Policy and legislation: There is an external organization that makes decision about the CAP money coming from the EU. Pro-Agri is a Finnish agricultural organization, that gives information to farmers and advocates the farmers' point of view. The students can also impact the change of mindsets by telling their families about new crops.

8.4.3 Ville Saarelainen, CEO Hemka OY

Socio-ecological: Ville started as an entrepreneur, when he was 22 years old. He didn't believe in the school system and took many side jobs, but at one point he had to focus on one area. He had learned through personal research, that hemp plays an important role in history for utilities like sailing boats, but also as a trading good. That was part of the reason he chose to work with hemp.

The hemp farmers are building a cooperative.

Market and production: Hemka wants to replace man-made fibers and cotton and provide a sustainable alternative. There are 5 doctorates engaged with natural fibers working in Hemka. This is useful for the company, as they can sell their know-how.

They did this for two years, and are trying to get bigger investors for the decortication factory.

HempRefine was a company working with hemp, that had to close due to economic problems and sold all their machinery to Ukraine.

It is challenging to be an entrepreneur in a company developing a novel invention, because the investors don't trust the company to develop good technology. The investors want to see results or other investors, before they go big on it. When a new product is being developed, it starts out expensive and inaccessible, but after some time it becomes more available and new technology is developed to support the product development to be more sustainable.

The wood fiber industry is a huge player in the industry with billion-euro investments, having capacity to take in 40-50 thousand tons straw per year. Startup companies that work with wood-based pulp can contribute positively to effective use of side streams from the forest industry. Renewcell is an example of a Swedish company that got listed on the stock market and gained a big revenue to start their first pilot plant. The process they apply is very complex, but clean and don't use chemicals or much water. This has resulted in many investors and collaborative partners in textile industry, who see a potential in the prospects of a million-ton capacity plant in 10 years' time.

Compared to the wood-based pulp factories, Hemka is a small sized company looking for partners with the right size. This also means they don't need as big investments as companies such as Spinnova and Infinited Fiber, who have partners like Adidas, who require a very big supply of material. Moreover, Hemka has strategic partnerships in Sweden, where they benefit from the Swedish marketing skills. University of Borås has a degree in Textile Design and Fashion, where they work with innovation of textile fibers.

Policy and legislation: People working with start-ups and research and design for more sustainable industries can receive unemployment benefits from the Finnish government. Political decision can regulate the market, an example is how the legislation on using side-streams in industry, changed how companies made use of their side streams more energy efficient. Also regulating the legal status of hemp has liberalized the market. "*When someone asks, do you smoke it? I just say, yes you can smoke it, but we prefer to carbonize it."*

Agronomic practices: Hemka has contract farmers on 95% of all fiber hemp in Finland. Hemka started the harvest of the fiber hemp in the last week of May. They have contract farmers as far north as Oulu, where the sun shines 24h a day, which is very efficient growth season for the plant.

The Finnish climate doesn't allow for autumn harvest of fibers, as the season isn't long enough. The spring harvest method can save a lot of water and chemicals in the retting process, but it is close to impossible to keep the long fibers with this method. In this process, it is important to keep the traceability of biomass, even more important than having organic certification. In 2022 the harvest was hindered by wet conditions and grass growth in the late spring.

Technology and innovation: Non-woven and cottonized processes are the easiest means of refining hemp fiber, as the spring harvest prevents keeping the long fiber. There is a lot to learn about the harvest procedure, but to Ville it is not the harvesting machine that is a challenge. They can easily be modified to fit the purpose of hemp harvesting.

Future situation

Market and Production: Hemka's goal is to build 5 plants with 40 to 50 kiloton capacity amounting to 10.000 hectares/year. They have made product trials with different machines to try out different end-products. Hemka has an agreement with a flax manufacturer to overtake a development line, where they will experiment with multi-axial knitting.

Hemka wants to build their company on good analytics and traceability of biomass, where batches can be sold to different purposes and traced back to the field of origin.

To enter the market, it is necessary to create sell your idea, find customers and make strategic partnerships. The preliminary agreements with customers can prove the business feasibility, which can lead to the first small scale production line. The hardest part is marketing the idea and concept to get investors onboard. Investors want a good story, not technical details.

"It starts with the idea and concept, then comes the funding, building of the pilot plant and the last part is upscaling."

Upscaling encompasses a few years of trials with existing machines, having raw material available from farms, finding secondhand machines, which can be upgraded with proven technology and ensuring customers that are ready to take off the product. This can be challenging.

The biggest challenge for Hemka is to market their idea and concept to get investors on board. At the moment they have letter of intent for a 30 million investment. They aim at having a cashflow by the end of 2023, which will be invested in machines. When material worth 0,5 – 1 million is sold, they have proof of concept at industrial scale. The funding will be done in an A round and a B round, where the B round can be split in two. In France there are examples of companies that get 40 million euro for businesses development with hemp composites. That is big money in the hemp industry, also on a European scale.

At the moment Hemka is the only company offering contracts for hemp fiber farmers. They are happy about their place in the market.

Technology and innovation: Biotechnical applications are made to optimize the retting process and make it time and water efficient compared to current standards. Enzymatic treatments or changing the pH level of the fiber can be a part of the bio-techinical modifications that optimizes the fiber application and processing. There's a big potential in using existing technology and apply it to hemp to heighten the value and create optimized processes for the material. There are also opportunities in using the energy side streams of production to create no waste and save money in the production.

Policy and legislation: Production of biochar holds a lot of potential for hemp fiber side streams and other agricultural waste products.

8.4.4 Interview with Hannamaija Fontell, Biolan

Current

Market and production: Biolan use hemp for bedding material, composters and dry toilet. Biolan's product with hemp is one of their key products, that is in high demand. They make products for hobby gardeners and professional horticulture. Current recipes constitute peat and coniferous tree bark. Hemp is useful and holds a lot of potential and can be made into a wide range of end-products.

There is a lack of supply of hemp, which has been a hindering force for Biolan. They had to import material to produce their product containing hemp. They won't develop new products,

before there is a constant supply to rely on. When quality criteria is not met, it is not profitable for Biolan to buy the raw material. Biolan has made an agreement with Aapo, that they will buy all his raw material, but they need to ensure the quality. Local supply is favorized and the demand for will be higher the coming years.

Biolan has recently expanded their market to global customers, but currently the national market is taking up all their supply. Creating value for the customers is key and having a good supply of raw material is critical.

It is difficult for private entrepreneurs on a small-scale to change the industry. HempRefine used to be the leading company on the market for hemp. They sold bedding material and hemp straw. When HempRefine bankrupted, Biolan had to find new sources for their products.

“We should aim at finding material that fits into circular economy and can provide a reliant supply, but that can be very difficult.”

Finland has precedence for marketing natural fibers, as the legislation on side streams in forest industry has induced a lot of new collaboration and investments in the natural fibers of wood. These projects have benefited from combining expertise from forest industry with expertise of clothing industry.

Agricultural practices: Upscaling the hemp production is a good idea as it can be processed with a minimum of chemicals. Biolan has known for a long time, that hemp has a big potential in agriculture. It was seven years ago they started using hemp in composting products. Biolan couldn't get the supply they needed and had troubles with keeping their product on the shelves.

Hemp doesn't compost quickly, so it keeps the material kind of loose and oxygenated. It has some of the properties of peat, so it draws a lot of water. Natural materials vary in quality due to environmental factors. Last year their expectations of the raw material from the farm was not met. The shives have to be separated properly from the fiber, so it can go to the production line without problems. The material was also too wet.

There's a big different in the quality of the fiber and the quality of the shive. It is in the interest of both farmer and customer to separate these two materials properly.

Agriculture in Finland has been in a bubble using traditional methods to reach traditional goals. Farming is done by private farmers working alone.

Environment and climate: Hemp has many good qualities for the environment, which are important seen in the light of climate change. It helps prevent erosion and nutrient washing, as it is left on the fields over winter. Furthermore, hemp uses less water and chemicals in industrial processes.

Socioecology: Theres a long history of natural fibers in Finland and Nordic countries. Collaboration across industries and knowledge exchange is essential. People working with agriculture can learn from the collaborations that have been established between forest industry and other industries to improve usage of side streams.

Consumers were affected, when HempRefine had to end their activities. There was discussion on social media platforms, that people missed the products.

People are changing their mindset towards composting due to the new European legislation on separating biowaste from normal household waste. Biolan participates in public debates in the media and discuss their strategy. *“We as a company are discussing a lot with the customers sharing information on our products and where the raw material comes from. Our role in the change process is creating awareness of the raw materials and how it can be used.* “ Discourse on sustainability of

clothing industry is established and people are guided towards making sustainable choices and thinking about life cycles of clothes.

Technology and innovation: Farmers are private people, which is not an equal partner in developing processes. If farmers have to invest in production equipment, they need to know there is a revenue.

Policy and legislation: European regulation on separation of biowaste is driving households to compost. Due to legislation, there's a high demand of composters and a good market for it in Finland. Biolan is the only company producing bedding material with hemp.

Forest industry is a big industry, which has been forces to look into side streams. Biolan started cooperating with them in 1980 to make soil products. European legislation banned companies from leaving garbage onsite. This legislation resulted in new corporations between industries. ‘Business Finland’ funded a business ecosystem project with all the big players in the forest industry and potential users of side streams. Biolan got to see their sites and all their side streams, which resulted in a new collaboration. This collaboration is valuable, as the supply is consistent. It is a win-win situation, which has been shown in many sustainability reports.

Future situation

Market and produciton

In 2040 Biolan will have no more peat in their recipes.

If the production of hemp is to be upscaled, it is essential to secure a reliant supply of no matter what end-use is intended.

It is a challenge to upscale the production of hemp, so it can be used on industrial scale. Biolan imports material to cover their current need for hemp shives. They will continue to buy shives from Aapo if he upscales the production. They prefer to have a local collaboration, where they contribute to a positive development in local farm businesses. However, they do not see themselves investing in developing the value chain at farm level.

Biolan wants a partner with continuous supply that can also do sustainable farming.

A hindering force for hemp entering the market is establishing a business with a clear goal on what purpose and product they want to produce. Furthermore, entrepreneurs entering the market need to have a good network.

Technology and innovation: The fibers should be the leading need in the innovation of production line, and side streams should be additional perks.

Innovation in the value chain is necessary to make a clean product and enhance the quality of the raw material. The production has to be upscaled from traditional small scale to something more streamlined with proper equipment. The quality of the raw material has to be the same, even with the weather affecting the crop.

Socioecology

Consumer mindset is changing towards sustainable choices. Natural fibers of all kinds are gaining interest in the public and can make high quality textiles that last for many years. New solutions are needed to shift towards sustainable pathways and replace plastics and usage of peat. Business as usual is not desirable anymore, the current situation is calling for change.

University studies may enable change. Making change takes time and requires different solutions. Events like pandemic can change the market mechanisms, and factors such as price can affect the whole market and consumer choices.

Agricultural practices

Networks of farmers are necessary to create change. This can be difficult to create, but with momentum and good examples it can happen. The change can also be made on a local scale that promotes circular economy. At farm level it would mean growing hemp to be self-sufficient with bedding material, while improving the soil quality. It could be a viable and profitable

initiative for farmers, as they would have less costs of material and also gain an income by selling out the fiber.

There should be a network of farmers or a company in between the farmer and the manufacturer. Making change could be supported by building a network of farmers and innovating equipment for harvesting procedures.

Policy and legislation

Legislation is a mechanism that can motivate industries to work together. Textile and forest industries have been able to collaborate because they are both big industries.

European policies should regulate the global market trends of outsourcing production to outside Europe, as it has weakened supply chains, and there is a need to get industries back to Europe.

8.4.5 Interview with Ulrika Dahlberg and Lars Fridefors, Novia University of Applied Sciences

Current situation

Socio-ecological

Novia University has created a 15 ECTS course on natural fibers. They hope to influence regional development work in the region of Raseborg and Osterbotnia. They wish to expand their reach towards international students and offer a variety of courses on different natural fibers. Most students finish their bachelor program at Novia, but it has been a challenge to find students who can fully commit to a course lasting 1,5 years. Courses are also open to public through the Open University of Applied Science, if they pay. Ulrika, project leader of the natural fiber program and Lars, teacher of crop rotation, believe that hemp should be used more, and that there is an economic and environmental potential in using both the plant itself and the by-products of hemp.

The module brings together many different groups in society - advisors, companies, entrepreneurs, farmers, researchers. Gathering them can facilitate knowledge exchange and improve collaboration. Novia recently created a reference group for natural fibers, where different experts expressed interest in taking part in meetings and knowledge sharing. Experts from different fields are interested in collaborating, and this has been facilitated by the program.

Agricultural practices/ Environment and climate

Hemp production is versatile, it can create diversity on farms and more circular farm systems. Novia is focused on both preserving traditional knowledge and also innovation and technology. Agricultural production is not only about food, but also about fiber and material production and can have an impact on sustainable development in industries. Cultivating hemp brings diversity both to the environment and to farming. Hemp production can also benefit the wetlands by reducing peat extraction. However, there are many challenges with cultivating hemp, and it is easier to choose other crops.

Technology and innovation/ Market and production

There are technological challenges about harvesting hemp. It could indicate that there is not enough market demand of hemp at the moment. Hemp is not a popular choice of material these days, and as a forgotten fiber, it is challenging to market. Many buyers and perhaps even sellers do not know where their product comes from and how it has been produced.

One of the challenges now is that hemp varies in quality from farm to farm. There is a need from buyers to have the same quality for the raw material, which is not possible at the moment with European production, therefore buyers prefer to buy in large quantities from Asia.

Future situation

Agricultural practices: Growing and processing hemp can increase the local economy. It is more sustainable to produce natural fibers than synthetic ones. One of the first steps is to get farmers to cultivate these crops. A key aspect of producing fibers in Finland is transparency and being clear about them being produced sustainably. It is a challenge to finance the production of these crops.

Policy and legislation: Hemp production is included in a global sustainability agenda. Politics in Europe and globally generally support hemp production, but there are also many challenges. The companies need support from external stakeholders, such as the EU, national government and unions.

Market and production: One of the challenges might be that individual companies will not necessarily be supported to start working with hemp. If new products are developed with hemp, perhaps it would speed up the production of hemp at farm level. Horse-owners are also interested in hemp production, as they can use it as bedding material instead of peat, which has many regulations. Development in the production line of hemp is necessary, since the raw material from the farm is not the highest demand.

It's difficult to say what the exact steps to increase hemp production are, but perhaps developing the industry here in Finland is a good step. It would be a good idea to have collaborations between Nordic and/or Baltic countries for all the steps of hemp production.

Socio-ecological

Movements such as the Fibershed movement can generate change towards more local and circular production. The public opinion of citizens matters in how popular the product is and can impact market prices by higher demand. It happened with sheep wool during the pandemic, setting a good example of the potential of public opinion changing demand patterns.

Establishing this program and making more awareness in the agriculture school can affect some of the supply chain and thus increase quality of production. Knowledge exchange, networking, collaboration and innovation are important parts of developing the supply chain. Networks of producers and processors, as well as researchers play an important role. People who have been enrolled in the program come back with successful initiatives, integrating them into different institutions.

8.4.6 Interview with Satu Pura, TransFarm

Current situation

Market and production: TransFarm is a contract farming company that buys and retails caraway and hemp from farm to producers. Transfarm was established in 1990 as an export company for caraway seeds. Hemp growing started in 2006 in co-operation with Dr James C. Callaway, who is the breeder of the FINOLA variety. Hemp sales separated into two streams; hemp for certified planting seeds and hemp for food grade. In 2006 TransFarm started business with developing hemp for seeds production, and later in 2020 they expanded their portfolio and established a sales company called FoodFarm.

TransFarm exports planting seeds to 30 countries, mainly inside Europe, but also outside. They are the main distributor of FINOLA variety in Europe, where 25% of production is for certified planting seeds and 75% for food grade seed.

TransFarm chose to expand their business with food grade hemp because they saw a growing market and had a chance to widen their crop selection to reduce risk. It was easy to establish the food grade market, because they already had experience with Finola variety and factory facilities. The market for plant-based protein was developing and hemp is an excellent choice for that. This led to an upscaling of the hemp food grade production.

Finola has dominated the certified planting seed market in Northern Europe since it was established in 1990's. The variety development of food grade hemp is rapidly growing, and now the market for Finola as planting seed is going down, which is a challenge for TransFarm in their marketing strategies of certified planting seeds.

TransFarm processes all food grade oilseed hemp into end-products such as whole seeds, roasted seeds, hemp proteins, hemp seed oils, but not CBD products. Hemp is a good product for plant-based protein and healthy oil, which is trending in the market. Market development and possibilities look good for food grade hemp seed.

Policy and legislation: Change of legislation in the 90's induced the development of Finola variety, which became a more familiar variety in Europe and expanded market in Unites States. TransFarm made prototypes of biomass collection for CBD products, but closed the R&D due to current legislation.

The production of hemp is controlled by the food safety authority in Finland. FIMEA (Finnish Medicine Agency) controls the market for CBD, which is very regulated by legislation. The environmental regulations are decided by CAP policies and is administrated through the Ministry of Agriculture.

Agricultural practices: Seed production of Finola is only farmed with conventional methods. For food grade hemp they have organic farmers, contract producers and conventional farmers. Approximately 2/3 conventional and 1/3 organic production. The normal field size of hemp is between 10-15 hectares and normal farm size is 50 ha. Crop rotation is mandatory based on EU regulation. The biomass is left on the field after harvest in autumn. Most farmers in Finland have cereal and don't have bailing machines.

Future situation

Market and production: TransFarm will stay as a strong player on certified seed market, and work on variety development. For food grade, they want to expand activities and expand contract area 3 times what it is now and expand both global and national market for food grade hemp. TransFarm is open for collaborations, if new companies who work on industrial scale enters the market and can offtake the fiber from their contract farmers. The easiest solution would be for the farmers to sell their biomass from the field to a fiber company directly. The main problem is how to organize logistics, as Finland is a big country with long distances.

Industry for fiber hemp may develop in the future. There's a potential for fiber hemp, and the current market for food grade hemp doesn't close off the market for fiber hemp. The biggest

change in the supply chain will be more companies working with hemp. Some will become strong, but the most part will drop out. There are many possibilities for fiber hemp as well. It could be possible to harvest fiber hemp from oilseed crops, even though the yield won't be as high.

TransFarm find it easy to make investments to upscale the production. "*We see it as a strength to be EU based. In the Nordic countries we are proud of the traceability of end-products. Also in our company, we have transparency in the production line from field to production. We have recently expanded the FSSC22000 quality certification to hemp."* For TransFarm, the easiest product to expand with would be CBD products, as they already have equipment to collect biomass for CBD.

Policy and legislation: For CBD production legislation is the biggest challenge, and they don't have much influence on this. The only other option to expand market for CBD is to take production outside of Finland. In ten years there will be more clear legislation and the market will be more established.

Agricultural practices: The fiber crop is difficult to manage, and is lacking an easy and cost-efficient procedure to be used. The machinery for hemp harvest is expensive and logistics are difficult to figure out. It is a good idea to utilize the whole crop, but the economic incentives are not there.

It would be easy for TransFarm to expand their activities with hemp, as industrial investments are easy to make for a company their size. They don't have interest in investing in harvesting equipment however, as the Finnish farming culture leaves that responsibility to farmers. It would be logistically complicated to invest in harvest equipment as distances are big and farming activities happen locally at the farm. TransFarm believes that their place in the value chain is important as it creates precedence for other companies to enter the market with hemp.

Socio-eological

TransFarm is the leading company in Finland, informing public about the many health benefits and usages of hemp. TransFarm want to work on a European level to have their voice heard in the European Parliament, and be able to affect legislation and lobby for the benefit of hemp.

"We want to educate the farmers that work with us as well as the food industry to become more familiar with hemp products. Hemp is a new crop for farmers, so we want to develop a best-farming-practice on how to manage hemp, especially harvest is one of the most crucial activities."

By offering competitive prices to farmers, they realize it is a good deal to grow hemp. We want to expand the production area, so we don't have to import from other countries.

8.4.7 Mari Rahkola, SUOMINEN

Current situation

Market and production: Suominen is a stock listed company with a CEO and a board, who will make decisions based on detailed information and comprehensive data. When transitioning into biodegradable materials, it is important to maintain the same quality of the initial product. They have partners in both directions in the value chain and are partnering with novel fiber suppliers. Baby wipes is the biggest end-use product from Suominen. Having clear goals and values in the value chain can contribute to more trust among stakeholders.

For example, Bast Fibre Technologies Inc. has a list of the certifications they have acquired through an application procedure, which is helpful for their customers such as Suominen to know that they live up to their sustainability measures. Another example of a useful certification is the SWAN label.

Currently all hemp for Suominen's development work is imported from other countries, and it is not an active strategy for the company to work towards more local collaboration or generating new technology in this part of the supply chain. However, if a local company can supply the same material with the quality measures required, they are open for collaboration.

The hemp products that Suominen produces are not fully commercialized yet and are in the development phase, where they introduce product samples to potential customers. This means the product cannot be too expensive. Viscose is cheaper than hemp, but hopefully the commercial production will make more quantities available at cheaper prices. The local hemp needs to be at comparable prices with international prices of fiber hemp.

Agricultural practices: There could be a challenge in the availability of hemp, as it is in high demand in many industries. As it is an agricultural crop, it is more unstable supply than manmade fibers.

Technology and innovation: The hygiene requirement for the end products is very high, and there cannot be any microbial growth, which could be hard to obtain with hemp fiber. It is not possible to take the raw material straight from the farm. There is a need for a decorticating industry, that understands the requirements of the industry's needs. If the requirements are not met, it entails a great risk for the company.

Environment and climate: Sustainability is at the core of Suominen’s strategy, referring for example to raw materials, energy consumption and people. One of their targets in their sustainability strategy is to launch new products with sustainable fibers. Research and Design is done with conscious thought of raw materials.

The energy and water consumption for producing natural fibers is important. Also, the social dimension of the production is important. Labels such as OEKO-TEX sets a sustainability standard for manufacturing and production of different kind of textiles.

Socio-ecological (Knowledge transfer): Suominen hosted a Seminar on Sustainability and New Fibers the beginning of 2023, where customers meet producers and get a better understanding of the material. For example Bast Fibre Techologies Inc. participated.

Policy and legislation: Some years ago the European Commission decided to implement the SUPD, Single Use Plastic Directive, which means that certain single-use products need to be marked with a Single-use plastic label. It affected the customers, and now there is a demand also for products without plastic. The SUPD has pushed the industry to act, and now there is also talk about new legislation against deforestation. There are also lobby organizations, which affect conditions for nonwovens, such as EDANA (non-wovens member association) and European Disposable Association.

Future situation

Agricultural practices: A driver for the change towards more hemp production in Finland, would be making farming activities more profitable and have the machinery required for hemp farming.

"I think it is difficult to say what is going to lead the change, but I think it starts at the farm level. The farmer needs to make the first decision about entering into hemp farming. And this decision is impacted by the availability of machines and the price you can get for the crop. "

The farmer needs to know if he/ she will send it to another European country to be processed, or if there are opportunities for processing in Finland. It is important to clean the fiber properly before sending it to a manufacturer, as it can contain many impurities.

Farmers are funding their own activities, so it would be hard for one single farmer to invest in a big refining factory. It could be a network of farmers that established something together. To establish a refining factory, you need to do pre-engineering and studies about the costs and incomes. So the key question is who would buy the raw material from the farmers.

Market and production: It is necessary to map the market demand and make a business plan if you want to build a refining factory. This includes finding out who are the customers, which

could include for example textile industry, construction, or any other industry that needs the product.

The business case evaluation of the hemp refining factory should include pre-engineering calculations on transportation and how viable the business is. Part of the viability calculations include the expected costs compared to the price you can get for the end-product and if it is viable to produce the material. Starting at the farm level to check availability of fibers, then a market analysis to map the demand; what are the existing industries that you will compete or collaborate with, who are the customers that will take off your product.

To make this study, it requires preliminary resources. It could either be funded by stocks or existing players, that need the material. It should be considered if they already have a place in the market and if they have free capacity to invest in the business.

"It is a big homework, which also requires funding to get started. It could be from a third party and help from people who have done this kind of study before."

It would be necessary for Suominen to understand how a hemp refining factory would benefit their purpose and if the material would live up to their quality measures, before they will invest time and money. If the quality and price is comparable with current international standards, Suominen could take up buying hemp from a local supplier.

Technology and innovation: A key question is what actor is between the farmer and the customer. Who is cleaning the fiber and where is it located? It could be a joint consortium, including machine suppliers, farmers and stakeholders that together create a validated demand for the factory. The government could also play a role, which would change the approach towards funding. In either case, the most essential thing is to map the market need and it should be made for the specific location that you expect to have a market in, for example Finland or the Nordic countries. It is also an option to buy up an old textile factory, where there is already some machinery, which can be modified to fit the purpose of the new industry. There should be someone who has a good idea for the market need and is able to sell the idea. Business Finland is an incubator, that funds a lot of business ideas and projects.

Logistics of transporting cottonized hemp fiber may be challenging.

Socio-ecological: The European mindset about hemp is liberal and opens up the market for more trade. In some places hemp is still regarded as a drug, which can hinder companies from choosing this material because they want to keep a good reputation.

There are certain certification labels, that verify the production standards of fiber, for example the FSC and PEFC for forest industry, that validate the production means throughout the value chain. Part of Suominen non-wovens have the FSC-certification, which means they only use wood-based fibers that live up to the environmental requirements set by the certification organization. The FSC is not applicable for hemp since it is not forestry. In cotton industry there is a certification called GOTS (Global Organic Textile Standard), that regulates the use of GMO varieties and the use of pesticides and chemicals. There isn't a certification label that is applicable for hemp at the moment. It's maybe because it's a novel material, the production has to start first and then there will be a demand for the certification.

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