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Faculty of Landscape Architecture, Horticulture and Crop Production Science

Organic Flows

– Swedish farmers' perspectives on the use of anaerobic digestates as a fertilizer. A behavioral approach on nine case-studies in Scania, Southern Sweden.

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Organiska Flöden: svenska lantbrukares perspectiv: på användning av biogödsel i jordbruket. En beteendeanalys baserad på nio fallstudier i Skåne.

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Abstract

This thesis aims to understand farmers' decision-making behavior from a socio-psychological perspective. In view of a growing need to rethink and reshape our current production systems towards their original circular nature, processing green waste into biogas offers a realistic potential and is already a growing sector in Sweden. Besides decreasing the need for and the emissions caused by non-renewable resources such as oil for industry and transportation purposes and to lower the amount of waste bound for incineration or landfill, biogas production from organic waste is of great environmental and economic value to farmers and agricultural production alike. Organic fertilizers lower the need for mineral fertilizers and manure that contribute to emissions and unsustainable resource use. The focus of this thesis is, therefore, a farmers' perspective of the use of the residues from anaerobically digested organic waste for biogas production (digestates). Behavioral studies (Theory of Planned Behavior, Ajzen 2002, 2005 & Lamarque et al., 2014) were applied to qualitatively analyze semi-structured interviews with nine primarily conventional plant production farmers in the region of Skåne, Sweden. To map this complex process of decision-making behavior regarding the use of digestates, two existing models; the Theory of Planned Behavior (Ajzen, 1991; 2005) and the 'Socio-cognitive conceptual model of ecosystems feedbacks on farmer behavior' of Pénélope LaMarque (et al., 2014) were integrated and further specified, using iterative analyzes of nine farm case studies in Skåne, Southern Sweden. The goal here was to understand how these concepts were given meaning in the light of a multitude of backgrounds; socio-economic, personal and political contexts were linked with perceptions of soil ecosystem services and the influence of geographical and climatic conditions. Attitudes were constructed by describing the digestates' expected and experienced advantages and disadvantages. The general advantage of the digestates, according to the farmers, was the positive effect on *soil health and crop quality. Subjective norms involved the influence of social peers and networks on the farmers' decisions* and were mainly understood in terms of advice and information, not necessarily as of direct influence on the personal decisions. Finally, perceived behavioral control described how barriers of digestate use were perceived. Technology played an important role in expected obstacles in order to use the digestates; spreading techniques and the risk of soil compaction due to heavy machinery were the most prominently mentioned barriers. Better cooperation

and communication between the varied stakeholders are needed. Ways of boosting the economic value and the willingness to pay for digestates can be further improved as well, once the facilities and technologies have been improved.

Foreword

Coming from an anthropological background, I understood early on in my Bachelor's program that the need to understand cultures and human behavior is an essential asset when analyzing practices that influence the way we deal with resources and nature. Researching issues in organic waste recycling is a perfect example and a challenge in both rethinking and 'recirculating' our production systems and in closing the broken ecological, societal and economic loops that each system needs to function. The Master's program in Agroecology has lifted this to a higher level; it challenged me to work and think with people from various backgrounds, and urged me to go even deeper into systems thinking and holistic analysis. However, I have also learnt that this program is still developing and that it can be a challenge in itself to thrive and grow within the institutional structures of the classical naturalistic science of agronomy. Furthermore, I personally still am unsure whether the practice of biogas production and the use of digestates fits the diverseness of the broad paradigm, science and movement of Agroecology. To agree with the renowned Agroecological scholars Miguel Altieri (1996) and Olivier de Schutter Agroecology is not merely about input substitution in agriculture. One inspiring scholar and former UN special rapporteur on the Right to Food (2008-2014) is Dr. Olivier de Schutter, who described the distinctive features of Agroecology as follows:

'Agroecology is not the same as organic agriculture. It means understanding how nature works, to replicate the complimentaries between trees, plants, animals and the natural workings of nature in order to reduce external dependencies on external inputs such as chemical fertilizer. This is a sustainable way of producing food as it preserves the ability of future generations to feed themselves. It supports the health of the soil much better, reduces dependency of fossil energies and is also a low cost way of farming' (De Schutter, 2014 in Goris, [2014], 2016).

I think his definition is very important and illustrative, as in a way, it distances itself from organic agriculture. Agroecology requires a radical shift in traditional thinking and behavioral patterns –I see a great potential here for the social sciences to fill in– and a redesign of complete production systems. I would like you to realize this while reading this paper.

The project started as part of a research internship with the media and entrepreneurial platform of Green White Space, based in Malmo, Sweden. This group gives stakeholders within the clean tech, zero waste and circular economy a stage through media productions and events, and contributes a great deal to the knowledge generation and action in this field. This thesis' name OrganicFLOWS – Organic Fertilizers from Local Organic Waste in Skåne, is the working project. I am very thankful for their support throughout the process.

Dedications and Thanks

This thesis is humbly dedicated to:

My Grandmothers, who are the real stars in dedication, resilience and resource recycling, and are the real 'climate-smart' heroes of our time, even without finishing high school. A special thought to my maternal Grandmother, who left this world during the fall of 2015 and who has been with me in spirit ever since.

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My Mothers for giving endless moral support. I have no words left to describe how grateful I am.

My Father, in loving memory, who taught me to never, ever give up. I would not have come this far without keeping him alive by repeating this mantra constantly.

My brother, who taught me to always check my facts and to stay critical.

My family, with a special note to my family in the North of Sweden, who surprisingly gave me some light and a lot of support in the darkest hours of winter.

My friends in The Netherlands, Sweden and abroad, and fellow students I have worked and lived with for two years at the SLU campus in Alnarp, Sweden. I follow my father's advice to see friends as a family, and I do not regret this decision for a split second.

Teachers of the SLU Agroecology program. Special thanks to my supervisors: Erik Hunter and Sven Erik Svennson. Others that have been very supportive and inspiring: Anna Hofny-Collins, Håkan Asp and Marco Tasin, Christina Lunner Kolstrup, Christina Ascard and Lotten Ahlqvist. A special note to Victoria Tönnberg, who has been a great mentor in the first year.

Green White Space and *The Green Exchange*, with a special word of thanks to Camille Duran and a loving thanks to my colleagues.

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And above all, the encompassing force of all life: Mother Nature.

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Chapter 1. Introduction

Global problem context: environmental consequences of mineral fertilizers and current waste management techniques

Since the 1960s, the application of mineral fertilizers has expanded in global agri- and horticulture, and have resulted in direct yield increases (Vandermeer, 2011). However, the use of mineral fertilizers poses several environmental and human health threats. Firstly, its production and use can increase Greenhouse Gas emissions (Rockström et al., 2009; Spångberg, 2014). Secondly, nitrogen flowing from the atmosphere to the biosphere creates eutrophication and affects terrestrial and aquatic ecosystems (Rockström et al. 2009; Spångberg, 2014). Thirdly, fertilizer production can increase pressure on non-renewable natural resources such as phosphate rock (Cordell, 2010; Spångberg, 2014). Due to the rising price of fossil fuels, mineral fertilizer costs can increase too (Hobbs, 2007). Finally, soil degradation and loss of soil organic matter (Alburquerque et al., 2012) can cause increased dependence of soils and agro-ecosystems on the input of mineral fertilizers for plant nutrition. This contradicts the natural resilient ability of the earth and its ecosystems to provide agriculture with 'internal resources', as had been the situation for about 9900 years (Doran et al., 1996). At the same time, the transport and incineration of waste from agriculture can be energy-intensive and cause air and water pollution and health risks for humans and other organisms (UNEP, 2013). Moreover, environmental hazards such as the emissions of nitrous oxide and methane are caused by the large scale use of manure in agriculture (Hammar et al., 2007).

Worldwide, the production of nitrogen fertilizers accounts for approximately 1% of Greenhouse Gas Emissions (GHG). In Swedish Agriculture, around 9% of agricultural emissions stems from the nitrogen fertilizer production (Ahlgren et al., 2012). However, it was estimated that N derived from the organic part of MSW has the possibility to substitute a maximum of 14% of N applied via mineral N-fertilizers on arable land, as for 23 OECD countries in 2009 (ISWA, 2015).

The nutrient and fertilizer potential of biodegradable waste has recently gained renewed interest.

The *International Solid Waste Association (ISWA)* (2015) estimated[1] that between 0.1 and 3.0 million tons of N and between 4.3 and 40.9 tons of C could be derived, if the biologically treated share (composted and anaerobically digested) organic fraction of MSW in OECD countries is increased from 66 MT per year to 124 MT per year, assuming a 70% ‘overall capacity rate’, and efficient utilization and improvement of collection schemes and technology that enhance source separation of MSW (ISWA, 2015).

Legal frameworks increasingly approach waste as not an end-product, but a resource for energy or materials production. United Nations Environmental Program (UNEP)ś waste-hierarchy pyramid functions as a dominant guideline for national waste management strategies. Waste reduction is suggested as the preferred option, followed by recovery, recycling, incineration, and disposal or landfill (UNEP, 2013). In European waste and environmental regulations, this is translated into the *Waste Framework Directive* (Directive, 2008/98/EC), which aims to add value to by-products of industrial food and energy production (Directive, 2008/98/EC in Alburquerque et al., 2012). The use of residues from biogas production by the Anaerobic Digestion of organic waste as a sustainable form of nutrient and soil management in agriculture is considered ‘an appropriate option’ at the European legislative level (Directive, 2008/98/EC in Alburquerque et al., 2012). As a follow-up of the *Circular Economy Package* (European Commision, December 2015), the Commission has proposed a revision of the *Fertilizers Regulation*[2] in March 2016 (European Commission, 2016). Its purpose is to improve inclusion of organic fertilizers from biodegradable waste in the EU’s regular fertilizer market competition by granting them –just as mineral and inorganic fertilizers– a *CE-marking* and allowing free movement in EU-trade (reference). Furthermore, *End of Waste* (EoW) Criteria specify quality and safety standards for digestates and composts (ISWA, 2015).

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[1] Estimates of nutrient values (carbon and nitrogen) of organic wastes were given, at least for food and garden waste in OECD countries, even though these estimates depend on contextual factors such as ‘regional, climatic and socio-economic factors’ and the differences in carbon and nitrogen content in households and garden waste, as well as temperature (ISWA 2015).

[2] Commission Regulation (EU) No 1257/2014 of 24 November 2014 amending Regulation (EC) No 2003/2003 of the European Parliament and of the Council relating to fertilisers for the purposes of adapting Annexes I and IV Text with EEA relevance. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014R1257 [2016-08-08]

A recent UK-based study compared the prices and nutrient values of different bio-fertilizers. For digestates, Nitrogen (N) was estimated at 4 kg/ton digestate, Phosphate (P) on 0.25 kg/ton digestate, potash (K) for 1.60 kg/ton digestate. The value was estimated at a total of 5.36 Euros, 3.80 GBP and 5.85 USD (WRAP 2015, ISWA 2015).

Despite their proven value for (soil) ecosystems (Alburquerque et al., 2012; Bernstad & La Cour Jansen, 2011; Spångberg, 2014; Arthurson, 2009; Odlare et al., 2011; Vaneeckhaute, 2013ab, Zhu et al., 2013), anaerobic digestates are still placed in the category of 'low value and high volume', compared with other bio-based products derived from biodegradable material from waste (ISWA, 2015). There is considerable interest in the use of anaerobic digestate as a fertilizer in Sweden, and it is commonly referred to as '*biogödsel*'[3] (Odhner et al., 2015). In this thesis, digestates mainly refer to this type of fertilizer.

Anaerobic Digestion refers to the decomposing of organic waste without oxygen being present. It is primarily used to produce biogas for vehicle fuel and other energy purposes. Common substrate sources include liquid manure, food waste, garden waste, sludge, post-harvest and postproduction waste. The process results in three residues besides biogas: liquid and solid digestates and composted digestates. Digestates from biogas production consist of 'partially degraded organic matter (OM), microbial biomass and inorganic compounds' (Alburquerque et al., 2012b). They can be used as a soil conditioner because of their high nutritional value and 'easily degradable carbon' (Odlare et al., 2012; Alburquerque et al., 2012b). Several studies worldwide have proven the positive effects of organic fertilization of soils with anaerobic digestates (Alburquerque et al., 2012; Bernstad & La Cour Jansen, 2011; Spångberg, 2014; Arthurson, 2009; Odlare et al., 2011; Vaneeckhaute, 2013ab, Zhu et al., 2013). Benefits of biogas digestates and composts include the improvement of: plant nutrition uptake, soil's microbial community and enzyme activity (e.g. Odlare et al., 2011; Albuquerque et al., 2012; Vaneeckhaute, 2013ab, Zhen Zhu et al., 2013), and improved soil structure (Bustamante et al, 2012) through increased soil organic carbon (Odlare et al., 2012). Renewable energy in the case of anaerobic digestates can be increased through biogas production (Albuquerque et al., 2012). Moreover, organic

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[3] www.biogodsel.se [2016-08-05]

fertilizers can reduce the demand for non-renewable resources for the production of mineral fertilizers (Stinner et al., 2008). Long-term field studies on conventional produced crop-rotated oats and spring barley in Sweden have proven that digestates will produce up to 88% of the yields that were normally reached with mineral fertilizer (Odlare et al., 2012). Some major challenges occurring with organic fertilizers can be related to the relative slower process of nutrient uptake, for example less plant-available Nitrogen compared to mineral fertilizers. However, this mostly depends on the existing organic nitrogen pool in the particular soil (Odlare et al., 2012). Another important environmental benefit of digestates is the potential to lower the number of emissions compared to manure (Hammar et al., 2007).

Local problem situation

Various county boards and environmental institutions aim to reach industries such as agricultural and horticultural production by providing incentives or setting restrictions to encourage sustainable production. The county board of Skåne has several rules that farmers have to comply with in terms of nutrient management (Lansstyrelsen Skåne, 2015). However, towards the end of March 2015, the proposed reintroduction of taxes on mineral fertilizers (*Händelsgödselskatt*) was rejected by a majority in the Swedish Parliament (Gauthier Reberg, 2015; SkU18, Sveriges Riksdagen, 2015).

Today, approximately 22,000 ha of arable Swedish cropland is fertilized with either liquid or solid residues from Anaerobic Digested organic waste, which are referred to as *biogödsel* (Avfall Sverige, 2014; Meetingpoint Urban Magma). Around 300 to 350 000 ton is produced yearly in Skåne (Odhner et al., 2015). However, the core problem this thesis aims to address is that the use of bio-fertilizers – or digestates and composts – in Swedish agriculture and horticulture is relatively small; mineral fertilizer usage is still dominant; it provides about 45% of plant-available Nitrogen in Swedish Agriculture (Spångberg, 2014). In 2012, the sales of mineral fertilizers was 680 million kg (SCB/Jordbruksverket, 2014).

However, the demand and interest in the use of such organic fertilizing methods is increasing. According to Chambers and Taylor (2013), a very strong increase in the price of mineral fertilizers has pushed this demand further up (Chambers and Taylor, 2013).

Recent studies to explore the market and use of digestates in Skåne by Odhner et al (2015) included in-depth interviews and focus groups with both organic and conventional horticulturalists and livestock farmers. Despite a 'general acceptance' and interest in certified organic fertilizers, they concluded that there was confusion about the exact meaning and use of digestates among farmers. The farmers expressed concerns on and a need for a 'utilized market' and further research on added value and economic consequences. Other concerns were related to logistics, spreading techniques and regulations, as well as concerns on supply-security (Odhner et al, 2015). The need for improved communication strategies and marketing advice was one of the outcomes of a workshop with various stakeholders on the development, communication and use of digestates from Anaerobic Digestion in Skåne. Other emerging challenges are the strong odor, difficulties in storage and spreading techniques, possible risks for plant-nutrition, soil, water and air pollution by heavy metals such as cadmium, emissions of CO_2 and ammonia (Alburquerque et al., 2012b, Spångberg et al., 2014; Arthurson, 2009; Wivstad, 2013; Odhner et al., 2015). It is argued that such problems may occur due to current criteria for efficient biogas production, which restrict the ‘residence time of the digester’ (Alburquerque et al., 2012b). When criteria mainly focus on the quality of biogas, and consider the digestate a rest product, the quality of the digestates can decline, and the 'potential fertilizer value' of the digestates is not fully acknowledged (Albuquerque et al. 2012b). The digestate market and its quality certification could be improved when the fertilizer value of the digestates is promoted and it is regarded as a soil conditioner (Wallace and Taylor, 1998), instead of mere refuse by farmers, researchers, the food-industry, waste and energy companies, environmental policy and society.

In order to reach sustainable production, changes in ‘fundamental epistemology in our culture and in our educational thinking and practice’ are needed (Sterling, 2004 in O’Brien et al. 2013). However, there is no universal package of ‘technologies, practices or policies’, and neither can these be ‘imposed’ or suggested to farmers regardless of their specific local conditions, means and attitudes (Pretty, 1996, see also O'Brien et al., 2013). Thus, to improve legislation and market-conditions, the farmers’ way of thinking needs to be understood, and several aspects from the social, cultural, economic and political systems that influence these thinking patterns need to be taken into account (Leeuwis, 2004).

It is, therefore, interesting to take studies into account in which cognitive, behavior and socio-psychological approaches have been used in explaining farmers' choices and actions in environmental farm management or conservation behavior. Arguably, applying digestates and organic manure is part of a wide and interconnected set of sustainable soil conservation practices (Rezvanfar et al., 2009). Earlier studies (e.g. Beedell & Rehman, 1999, Wilson et al., 2009, Vignola et al., 2009, Poppenborg et al., 2012; Roca, 2011) looked into farmers' choices regarding sustainable agricultural practices concerning organic production, biodiversity issues (Roca, 2011). Wilson et al. (2009) used the *Theory of Planned Behavior,* or TPB (Ajzen, 1991) to understand the farmers' decision-making in integrated weed management practices. The key principles of the Theory of Planned Behavior as first proposed by Icek Ajzen (1991), revolve around the notion that human actions and behavior can be explained according to three types of beliefs, that form three different constructs which all lead to the intention that is prior to the behavior (Ajzen, 2002): *behavioral beliefs, normative beliefs and control beliefs* . It combines qualitative and quantitative methods and analysis, although the latter has more emphasis. The model has been widely used and adapted for socio-psychological research, but increasingly, environmental behavior used the model to investigate the nature of farmers' environmental management-choices, often directed at government schemes that promote sustainable agricultural practices (e.g. Wilson et al., 2009; Vignola et al., 2009, Poppenborg and Koellner, 2012, Greaves et al. 2013). Also in Sweden, socio-behavioral concepts such as risk and attitudes have been utilized in studies aiming to understand the farmers' environmental management practices (e.g. Bratt, 2002; Lagerkvist, 2005).

Recommendations and workshops on future communication strategies and market possibilities (Biogassyd Skåne region, 2013) and policy and stakeholders among biogas producers in Skåne (Ericcsson et al., 2013) could give an insight into the current situation and the important stakeholders, and show which new steps have to be taken.

Purpose, Research-questions and methodological framework

The aim of this thesis is to study the farmers' decision-making behavior regarding the application of liquid anaerobic digestates for fertilizer purposes in Scanian agriculture.

The broader question that will guide this thesis is: 'How can the farmers' attitudes and behavior regarding the use of anaerobic digestates for fertilizer purposes be understood from the perspective of the Theory of Planned Behavior?

Questions that arise from this aim, which will form the structure of this research, are the following:

Which attitudes do farmers have regarding the application of digestates from the Anaerobic Digestion of waste? Which factors and processes contribute to these attitudes?

What is the role of social peers and social networks in the management-decisions of these farmers? How does this affect their attitudes and intention regarding digestates?

What constraints and challenges do farmers face regarding the use of digestates?

How do these farmers relate their motivations and fertilizer-management behavior to the contexts of:

A. *Socio-economic:* technical/infrastructure, regulations; individual/personal and knowledge/media;

B. *Ecosystem-services: soil, crop quality, energy-issues;*

C. *Geography, climate, weather and seasonal conditions?*

In the discussion, these results will be held against existing literature, including some recent case studies of farmers' attitudes with regard to digestates in Skåne (Odhner; 2015). Here, I will also reflect on how the use of behavioral models such as the TPB can contribute to the development and improvement of information programs to promote anaerobic in Skåne and possibly contribute to the valuation of these fertilizer-practices.

In the long run, understanding these processes could assist the development of efficient marketing and communication strategies to promote the use of digestates in agriculture. This work could thus be useful for those companies and institutions that have to develop these strategies, as well as improve existing research related to planned behavioral analyzes of the farmer's decision-making.

The Theory of Planned Behavior will serve as the primary methodological framework and structure of the thesis. The idea is, to broaden classical rational economic decision-making concepts such as willingness to pay and opportunity costs with factors such as attitudes on risks, beliefs, values and social interactions and processes. These concepts have earlier been integrated in farmers' decision models in studies on farm management practices (e.g. Wilson et al., 2009, Vignola et al., 2009, Poppenborg et al., 2012).

This study aims to offer practical advice to firms and institutions responsible for the marketing and communication strategies of the digestates. Ideally, farmers should benefit from these strategies to be able to run their businesses in a profitable way within environmentally friendly boundaries. By centralizing the various perspectives and needs of farmers, and explaining these within their respective contexts, I aim to close the gap between the farmer's and their involvement in research and policy formation as well. Ideally, this thesis could contribute to an increase in the use of anaerobic digestates.

To provide context and background of the farming enterprises participating in this research, the Theory of Planned Behavior (Ajzen, 2005) will serve as the main framework for the analysis model. In addition, elements from the TPB-based model of Pénélope Lamarque et al (2014) will be applied. Using a TPB-based model, her research among dairy farmers in the Italian Alps investigated how the decision-making process in adopting biodiversity-enhancing management practices related to the knowledge and perception of Ecosystem Services and the feedback interplays with various other contexts (Lamarque et al., 2014) .

The research population consists of 9 different farm enterprises located in the region of Skåne, Sweden. They will be approached as case studies (see, using a multiple case study-design (Rowley, 2002). Skåne is Sweden's most densely farmed area, and is also critical with regard to the excess Nitrogen flows into the Baltic Sea, and therefore of high interest to a wide array of environmental regulation and extension services. For the fieldwork section, semi-structured interviews (Bryman, 2015) were conducted with each person representing the farm-case, be it the owner, director or manager of the farm. Prior to the fieldwork, a literature-study was conducted, which will be integrated into the frame of references (Chapter 2) and the discussion (Chapter 5). For the design of the variables and the interview-guides, steps and guidelines as proposed by Ajzen (2002) and Francis et al (2004) have been used. More adjusted to farm management behavior, Roca (2011), provided examples of questions. The interviews were analyzed qualitatively, and structured the main model by further defining sub-themes from techniques coming from Grounded Theory (Russell Bernard, 2007; Kearney et al., 1995)

In the Communication Plan for the enhancement of digestate use in Scanian agriculture (Biogas Syd & Skåne Region, 2013), the need for 'increased awareness and confidence' in the application of digestates is expressed. One of the proposed strategies involved the following: 'Gaining insight in farmers' perspective, experience and expectations with bioferitlizers through interviews with farmers who are currently using the digestates, on existing barriers and communication with other farmers and stakeholders on the supply and demand side of the digestates' (Biogas Syd & Skåne Region, 2013; Gunnarson, 2012). This has been conducted by Odhner et al (2014; 2015), of which the outcomes will be compared in the discussion section. There is also a pressing need to include those farmers that do not approve of these fertilizing practices yet. Therefore, farmers with little knowledge of and experience with the digestates were included in the research population.

Chapter 2. Frame of Reference

2.1. The Theory of Planned Behavior

The Theory of Planned Behavior (Ajzen, 1991), is derived from the Theory of Reasoned Action (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975) and aims to explain human behavior by examining three kinds of beliefs; *behavioral beliefs,* *normative* beliefs and *control beliefs*. In figure 1, a schematic description is presented (Ajzen & Fishbein, 2005) . Each of these beliefs impacts three types of norms; *attitudes towards the behavior (A), subjective norms (SN)* and *perceived behavioral control (PBC)*. These three constructs determine and form the *intention (I)* that is prior to the particular *behavior (B)* (Ajzen, 2002). The aim of applying beliefs as a measurement is to understand the 'cognitive foundation' of each construct, intention and behavior. Important to note is that the 'direct measures' of each norm are not determined by each of the beliefs. The latter are intended to provide only indirect measures of each construct. Also, only beliefs that are 'salient' or 'accessible in memory' are suited to give the explanations for why particular attitudes, subjective norms and perceived behavior control are guiding people's behavior (Ajzen, 2002).

1. *Attitude* (A) is formed by *behavioral beliefs*, which integrate the expected outcomes and evaluations of the behavior (Ajzen, 2002). Attitude of the behavior refers to an 'overall evaluation of the behavior' (Greaves et al., 2013; Francis et al 2004).
2. *Subjective Norms* (SN) refer to the perceived social pressure (Francis et al., 2004), and are influenced by normative beliefs. These beliefs involve perceptions of 'normative expectations of others', as well as the 'motivation to comply with these expectations' (Ajzen, 2002).
3. *Perceived Behavioral Control* (PBC) addresses how difficult the individual expect the behavior to be (Greaves et al., 2013). PBC is determined by control beliefs, or the equation of all beliefs related to the presence and strength of barriers or opportunities that can exist in the process towards achieving the behavior (Ajzen, 2002). Although the former variables A and SN primarily determine intention, the PBC can also impact Behavior directly, since 'many behaviors pose difficulties of execution that may limit volitional control' (Ajzen, 2002)

Finally, Actual Behavioral Control (ABC) involves 'capital, knowledge, skills, opportunities' (Roca, 2011), controls behavior directly and can impact it indirectly by influencing PBC, as it is assumed that people sometimes display a particular form of behavior as soon as the opportunity arises. The overall assumption is to expect that; the 'greater the perceived control, the stronger the person's intention' is (Ajzen, 2002). The selection of variables and the design of the interview-guides according to the TPB will be guided by recommendations of Ajzen (2002) and Francis et al. (2004).

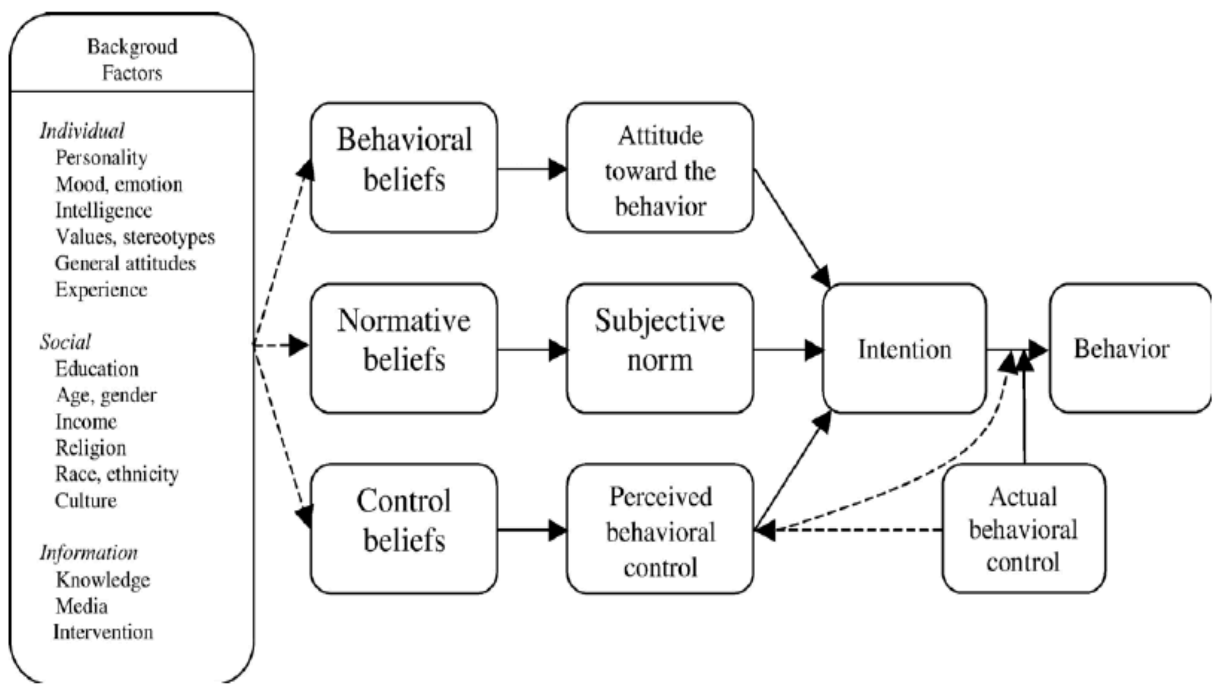

Fig 1. The Theory of Planned Behavior and reasoned action (Ajzen & Fishbein, 2005)[4]

Relevance for this study: How will the TPB be implemented in this thesis?

The goal of this thesis is to comprehend the choices an individual makes when he or she selects a certain type of fertilizer or soil conditioner (Terry and Wallace, 1998), which is identified as the *current behavior.* The goal has been specified as the context

4 Picture published in Zhang (2007)

of the application of anaerobic digestates, which is identified as the *intended behavior.* Since it is held that human beings make decisions and operate in a complex field constructed of several interconnected factors (see e.g. Long, 1992), the goal was to utilize a model that could link a multitude of contexts with the farmer's attitudes, subjective norms and perceived behavioral control, that could lead a farmer to the intention to apply anaerobic digestates as a fertilizer in their agricultural system.

Ajzen (2005) acknowledged this complex and diverse set of factors, experiences, ideas and environments that people are related to. In order to 'deepen our understanding of a behavior's determinants', these complexities were summarized into 'background factors'. These can, in some cases, impact the behavioral, normative and control beliefs that inform attitudes, subjective norms and perceived behavioral control respectively (Ajzen, 2005). According to the TPB model as shown in figure 1, there are three categories of background factors; personal, social and informationAlthough the TPB acknowledges the 'potential importance' of such factors, they were not fully integrated in the original model of planned behavior, since the relation and influence of specific background factors on the beliefs depend on the particular empirical case. Therefore, dashed arrows were used in the model (Ajzen, 2005).

2.2. The socio-cognitive conceptual model of ecosystem services feedbacks on farmer behavior and the Ecosystem-services concept

As the key subject of this research revolves around soil management behavior, it was held that a model was needed to include how or whether the influence of knowledge and discourse on soil health interact with attitudes, social norms and perceived behavior control in the course of the decision-making on anaerobic digestates. Given the increase in the use of Ecosystem Services framework in policy and research on farmers' decision-making behavior (e.g. Poppenborg & Koellner, 2013; Matthews et al., 2007; Vignola et al., 2010; LaMarque et al., 2014), the ' Socio-cognitive conceptual model of ecosystem services feedbacks on farmer behavior' (Lamarque et al., 2014) was selected to be combined with the TPB-model and to provide a broader frame of reference. Ecosystem Services (ES) is an emerging concept in policy and sustainability frameworks to define and categorize the 'benefits from ecosystems' (Assesment, 2005). As for Sweden's environmental goals this concept is rising in recognition; the Swedish Environmental Protection Agency has set the *Milestone Target* to increase the value and importance of ES, along with biodiversity before 2018, and promised to have ‘identified and systemised’ ES by 2013 (SEPA, 2016).

A common categorization comes from the Millennium Ecosystem Assessment (Assessment, 2005), hereafter referred to as ‘MA’ (Assessment, 2005). The MA combined the common definitions of Daily (1997) and Costanza (1997) as follows: ‘Ecosystem services are the benefits people obtain from ecosystems. These include provisioning, regulating and cultural services that directly affect people, and supporting services needed to maintain the other services’ (Assessment, 2005). Four categories are defined: 'provisioning services, regulating services, cultural services and supporting services'; which also covers soil health aspects such as soil formation and nutrient cycling (Assessment, 2005). In the model used in this thesis, ecosystem services focus mainly on these aspects, which bind the provisioning, regulating and cultural services. Specifications in the model are derived from the European Environment Agency (EEA)’s, Common International Classification of Ecosystem Services CICES (v4.3) categorization, which continues on the MA categories (cices.eu).

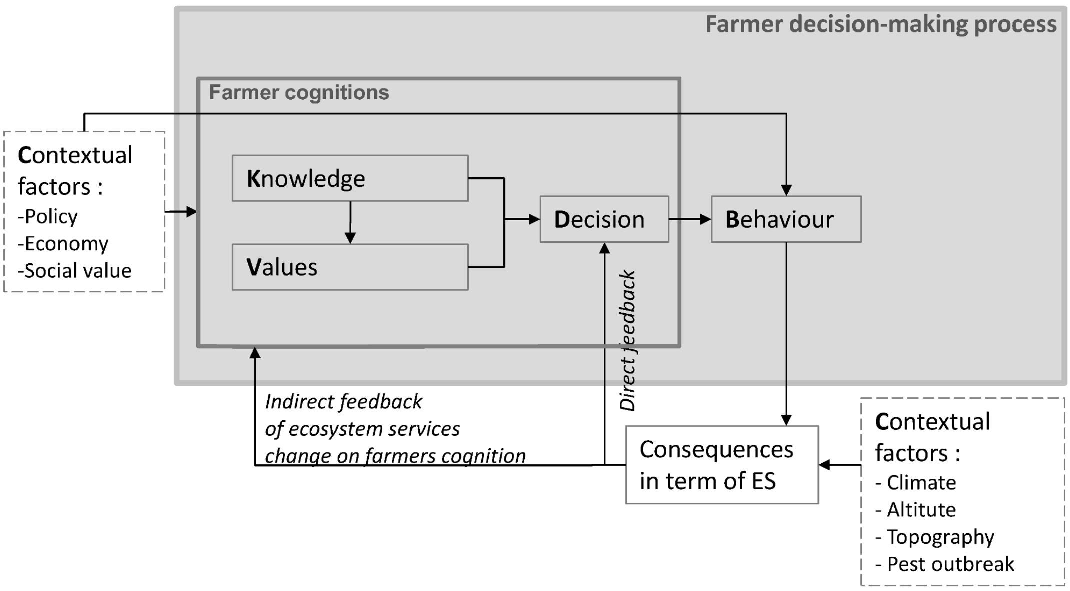

Figure 2. 'Socio-cognitive conceptual model of ecosystems feedbacks on farmer behavior' (Lamarque et al., 2014).

One study using concepts of the TPB was Philippine LaMarque et al.'s research on farmers' conservation behavior in the Italian Alps as being related to ecosystem services (Lamarque et al., 2014). Lamarque et al. (2014) have proposed a model in which knowledge, values and TPB-constructs were integrated into contexts from a wider environment, in order to visualize the interactive feedback loops at stake in farmers' decisions in land use related to Ecosystem Services, based on their research on farmers on grasslands in the Italian Alps (LaMarque et al. 2014). The key motivation for the authors to integrate the VNB and the TPB and to relate that to ES was that these models mostly ' do not explain the formation of cognitions (beliefs, values, preferences, attitudes)', and they wanted to connect such decisions to contextual factors from the socio-economic and climatic domain. It is held that environmental management-decisions are informed by the nature of people's perception of ecosystems, and to go beyond the approach of seeing human beings as mere 'utility maximizers' (Lamarque et al., 2014). In the 'Socio-cognitive conceptual model of ecosystem services feedbacks on farmers' behavior' (see figure 2) (Lamarque et al., 2014) the constructs were defined as follows: contrary to the TPB-definition, behavior is seen as directly influencing decisions, instead of defining the intention first. *Behavior* (B) is described as a 'series of actions selected among possible alternatives' (Lamarque et al., 2014). This will be an adequate definition to use in this thesis as well, since the critical aim is to explain why and how farmers choose digestates over inorganic fertilizers. The study entailed multiple and complex outcomes. Seen from the farmers' perspective, ES were integrated into a 'complex system of decision-making' (Lamarque et al., 2014).

Given the need for more knowledge on digestates in Skåne (Odhner et al., 2015), another important construct to be taken into consideration for this thesis is *knowledge*, which is related to 'farmer's knowledge' (Lamarque et al., 2014). Specifically, Anna Bratt (2002) relates this to 'local agricultural knowledge', which is defined as a 'synthesis of proficiencies based on inherited learning, i.e. indigenous knowledge as discussed by Berkes (2000), together with experience and modern science, i.e. information received from a variety of sources' (Bratt, 2002). Again, the concept of decisions is a comparable one: 'the preferred action selected among alternatives' (Lamarque et al., 2014). The often debated concept of *values* was derived from Dietz et al (2005), and will be advocated throughout the thesis. It comprises: ‘general assessments about things that are seen as desirable’ (Dietz et al., 2005).

Various values were given to the ES, which did not always correspond to the degree of taking the ES into the decision, and it differed whether the ES were taken into account in decision-making. Concluding, values and knowledge were both needed, however, these were not always a determining factor in farmers’ decisions. For instance, as carbon storage and nitrate leaching were not part of most farmers’ knowledge systems, these variables weren’t included in the decision-making process. However, once the farmers were included in a ‘feedback-game’, and the distribution of incentives to promote the use of these ES was mentioned, farmers reconsidered taking these ES into account in their decisions. The feedback game implied that both indirect and direct feedback effects were at stake in the inclusion of ES in decisions (Lamarque et al., 2014). Mark Brady et al (2012; 2015) argue for a valuation of supporting Ecosystem Services such as soil biodiversity. The authors had developed a method for ' valuing changes in supporting soil ecosystem services' (Brady et al., 2015). As a correlation was expected between 'relative changes in soil biodiversity and the emergence of ES’, it was assumed that a further decrease of such ES will decrease the 'maximum yield and fertilizer efficiency' (Brady et al., 2015). Thus, including the value of soil natural capital in decisions is advocated (Brady et al., 2015).

2.3. Model presentation

In order to integrate the classical aspects of the TPB (Ajzen & Fishbein, 2005) with the more holistic and ES-oriented perspective of Lamarque (et al., 2014), a new model is proposed as the basis for this thesis. This will be the methodological starting point from which variables and interview-guides will be shaped. Further conceptualization and operationalization of the model's aspects will be addressed during the methodology section.

Following the example of Lamarque (et al., 2014), a combination of the basic TPB-concepts with soil-quality aspects as defined through the Ecosystem Services framework and the analysis of decision-making was chosen. The following reasons underpin this choice. Firstly, it directly assesses the supporting function of soil and nutrient recycling and how, eventually, this can be related to human well-being (Lamarque et al., 2014; Pulleman et al., 2012). Secondly, microbiological and environmental assessment-based research have proven several benefits for soil-fertility, structure, and nutrient recycling and uptake (e.g. Odlare et al., 2012, Bernstad & La Cour Jansen, 2011, Albuquerque et al., 2012, 2012b, Spångberg, 2011). Thirdly, the ES concept is a popular tool and indicator in national and European policy (e.g. Lamarque et al., 2011, Parliament 2009/2236 (INI), Naturbruksverket, 2013). Ample studies have aimed to review the possibility of valuating these services as well (Brady et al., 2015; Poppenborg et al. 2013).

The decision to use a combination of the models results from the criticism of TPB, that it focuses mainly on a primarily cognitive approach, and that contextual aspects such as political relations, policy, economy, culture and climatic conditions impact farmers decisions as well (Poppenborg et al. 2013, Lamarque et al. 2014). Furthermore, the feedback aspect of the model allows the inclusion of the farmer's

adaptation to changes in a reflexive way (Lamarque et al., 2014; see also Brady et al., 2012). Moreover, it builds on the concept of agricultural production as a 'dynamic process' shaped by 'tensions and conflicts involved in altering and questioning accepted practice' (Bratt, 2002). Brady et al (2015) argued that contextual factors matter to farmers' decisions regarding land use (Brady et al., 2012).

In a study on the AgricPolis model to examine farmers’ decision-processes regarding policy and land use, it was assumed that 'decision-making is myopic and follows adaptive expectations' (Brady et al., 2015). Overall, it was found that changes in the EU Policy impacts 'land use, mosaic, biodiversity and E.S. in extensively farmed regions'. In general, alternative practices are affected by policy frameworks. It was argued that changes in land use influence biodiversity and mosaic into a strong extent (Brady et al., 2012). As a large part of Skåne's farmland falls under both the EU-led LEADER program and the Rural Development program through Jordbruksverket, and as ES are also included in many policy instruments, it makes sense to include the influence of such policy tools on the farmers' decisions (Leader Skåne, 2015).

Returning to the main model (fig. 2), the contextual factors of knowledge, learning and education are critical in informing the farmer's decision-making behavior.

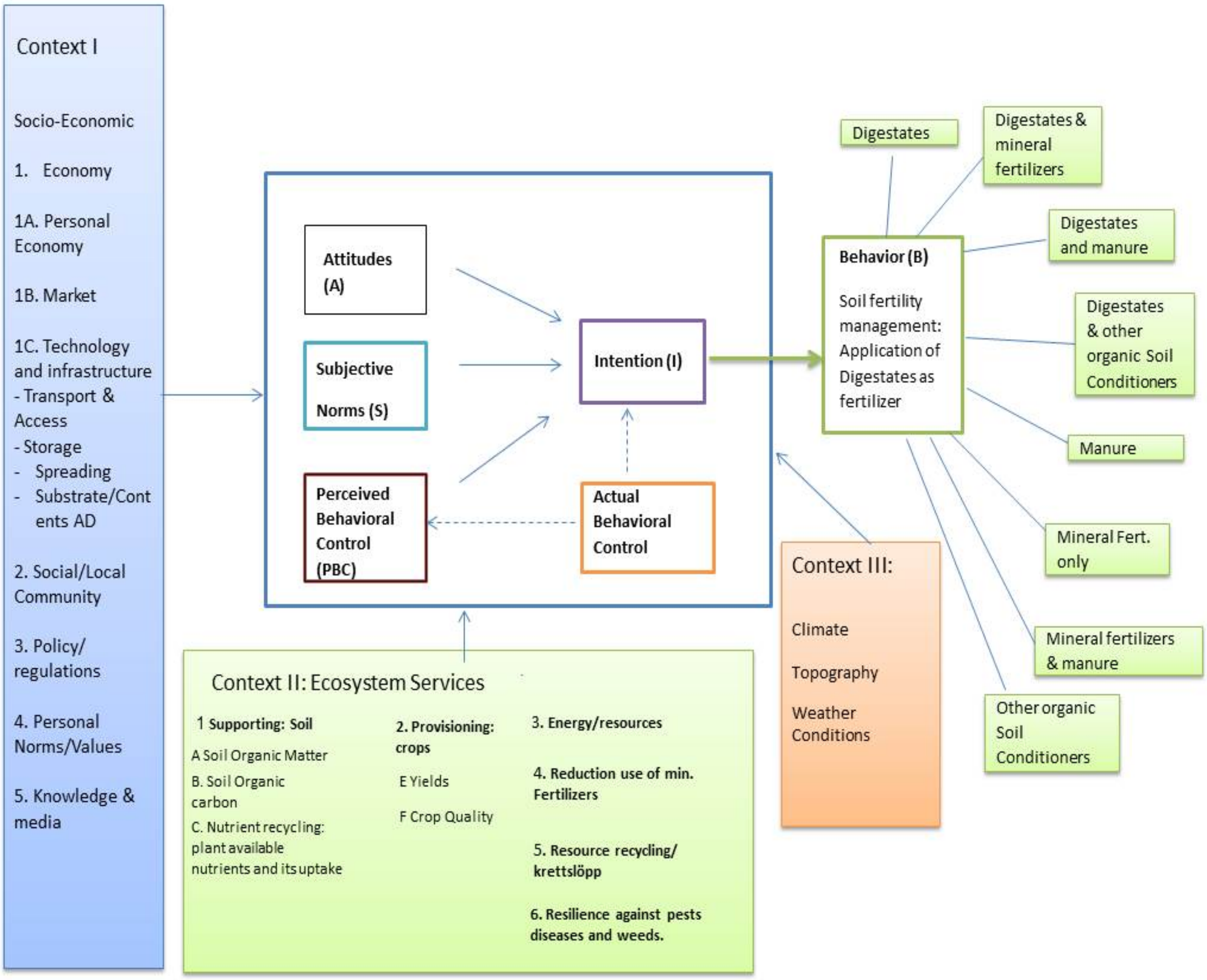

Figure 3. Theory of Planned Behavior related to contextual factors and ecosystem services, applied on the behavior of the application of digestates as a fertilizer. Adapted from Ajzen & Fishbein (2005) & LaMarque (et al., 2014).

Chapter 3. Methods and Methodology

Design

Semi-structured interviews (Russell Bernard, 2007) and further email correspondence form the basis of the empirical data. Literature research has been conducted for the review, and to broaden the knowledge base for the state of affairs of biodigestate use in Skåne, other case studies and archival reports were consulted (Odhner et al., 2015; Gunnarson, 2011). However, these conversations were not used as active parts of the data collection (Urban Magma, 2015).

Implementation

A sample of twelve farmers was selected from a list of 100 crop producing farmers in the region of Skåne [5]. Eventually, the data of nine interviews were used, due to some difficulties with the data-recording technology. Some other farmers were approached on the annual agricultural market of Borgeby Fältdagar, or recruited via my co-supervisor Sven Erik Svensson at the SLU. The semi-structured interviews started out from an interview-guide with themes and questions, based on the merged Theory of Planned behavior-model and the socio-cognitive conceptual model of ecosystem services feedbacks on farmer behaviour model (Ajzen 2005: Lamarque et al., 2014).

Examples of questions[6] are: ‘What do you think the advantages of biodigestates are? ' 'Have you ever heard of biodigestates?' 'Would you see yourself using the digestates in the next five years?’ Other more general questions aimed to grasp the farmers’ general view on decision-making; ‘Which factors do you include in making your management-decisions?’ ‘What motivates you in your work?’. With some farmers, a long discussion and narrative started, and I had to direct the conversation by probing a little bit. The farmers were approached by phone and the interviews were taking place at the farms themselves. Some of the visits were held with fellow student, Carolina Rodriguez, since both of us were interested in interviewing the same research sample, and this avoided the farmers having to be contacted and met with twice. However, we both conducted separate interviews, made agreements about the implementation and

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5 All credits for generating this list go to my fellow student Carolina Rodriguez.

6 For a complete overview of the interview guide please refer to figure A1 in the appendix p 1-8.

had the farmers consent on doing a double interview. Respondents had given their oral ethical consent, and all were given the opportunity to review their transcripts.

Analysis

Taking the basics of the above presented model as a departing point, the aim was to further define the details of the model according to the outcomes of the interviews. This entails data being analyzed on an *iterative* manner (see Charmaz, 2014); i.e. going back and forth from theory (Theory of Planned Behavior, Ajzen, 1991; 2005 and LaMarque et al., 2014) to empiricism (nine farm case studies in Skåne, Southern Sweden). Therefore, an analysis was made using a combination of strategies derived from classical qualitative methods such as *Grounded Theory* (Glaser & Strauss, 1967)*, Constructivist Grounded Theory* (Charmaz, 2007) and *Thematic Analysis* (Braun & Clarke, 2013). Throughout the analysis, the philosophy stemming from Constructivist Grounded Theory approaches was kept in mind. This entails a more reflexive interpretation of Grounded Theory, and not necessarily produces a solid theory from the data. Also, it aims to go beyond a criticism on positivist stances that Charmaz (2014) emphasizes, that being researchers, we should be aware of our influence on the data: 'Rather we are part of the world we study, the data we collect, and we *construct* our grounded theories through our past and present involvement with people, perspectives and research practices' (Charmaz, 2014). The following steps (Russell Bernard, 2007) were taken in order to analyze and make sense of the data. First, transcripts of interviews were written (Russell Bernard, 2007). The transcripts helped to identify potential analytical categories and themes (ibid.). These formed the base of the codes that categorized the data further. In figure A1 (See appendix P. 1-8) the coding schedule with the integrated interview-guide is presented. Subsequently, the data were ordered and compared according to guidelines and schedules provided by Kearney (et al., 1997; see Russell Bernard, 2007). In figure A2_1,2,3,4 (see appendix p.9-12) examples show how advantages and subjective norms were analyzed and mapped in this manner.

Subsequently, the relationships between the categories were considered. Here, the data were organized in tables (numbers, appendices, presented in the results) based on the contexts 1, 2 and 3 based on the contextual feedback of Lamarque (et al., 2014), as an extension of the TPB.

It should be noted, however, that there was a more structural and deductive aspect to the interviews, since farmers were asked to link their answers to contexts such as economy, ecosystems services and climatic conditions (Russell Bernard, 2007; Lamarque et al., 2014, Ajzen, 2005). As recommended in Grounded Theory, the model should be checked constantly against the data. This was done first on individual basis, models were filled in per individual farmer. From there, case studies were written. (Russell Bernard, 2007). The relations between these categories were thus formed further into the model. In Chapter 5, the results are presented using 'exemplars' and quotes from each interview (Russell Bernard, 2007).

Chapter 4. Results

Introduction

Considering this research's qualitative and descriptive nature, each semi-structured interview has been analyzed individually alongside the TPB-model. Each farmer's attitudes, social norms, PBC and interactions with several contexts is thus described in thick individual case study descriptions. As such, this chapter will provide a more holistic and comprehensive overview in which the various detailed data will be presented and compared. Again following the main model, this chapter will be guided by the following structure. As we read the model backwards, 4.1. will start by presenting the demographic and production system characteristics of the farmers, and comparing the farmers current behavior. 4.2. will then discuss the current behavior in applying several fertilizer techniques to their farm. In 4.3., we will review the distribution among the farmers of the *intention* regarding the use of digestates. The possible relationships between intention and behavior will be examined as well. 4.4. will focus on the *attitudes.* First, cognitive attitudes will grasp the meaning and familiarity that farmers had with the concept of anaerobic digestates - biogödsel in Swedish - will be presented and compared. Next, behavioral attitudes will be presented by mapping the advantages and disadvantages of using anaerobic digestates. The majority of the farmers did not have direct or recent experience with the utilization of the substance, so this included mainly expectations, some of which were based on their experience with manure. Paragraph 4.5. will entail a brief overview and comparison of subjective norms and social beliefs. In 4.6., an assessment of the various risks and barriers that have formed perceived behavioral control will be addressed. Here, the intention to use the digestates is evaluated, as are the perceived needs expressed by the farmers to increase their intention in using the digestates as a fertilizer in the future. Regarding the importance of finding a common understanding in defining the intended behavior (the application of anaerobic digestates in Scanian agriculture), it was decided to start off each interview by asking the respective farmers: a. how they would define '*biogödsel*' and b., whether they were familiar with the concept. As the nature of this research entails a comprehensive and qualitative systems analysis, the links with the various contexts will be outlined in the basic TPB-model. The data is summarized in figure A5 (appendix, p. 18-25).

4.1. Description of the farmers:

Nine farmers (see fig. A3, appendix p., 13-16) in the Southern Swedish province of Skåne are included in this study.

Six were conventional producers and three were mixed farmers: this entails that a part of their production system was certified organic through *KRAV*, either through two different companies or by having one field organic. All were familiar with the use of mineral fertilizers and most of them were using them at the time of the research. The acreage ranged between 100 and 900 ha. Most farms ranged between 100 and 300 ha. Most farmers were growing traditional Scanian agricultural products, for human consumption, the food industry: either Swedish or international wholesale companies. A majority was growing primarily for the Swedish market: seed and fodder, and some were growing energy crops such as rapeseed or corn. The crops included: cereals, sugar beet, peas, rape and corn. In the sample, only two farmers raised livestock. One farm raised pigs for organic pork production, of which the manure was used as a substrate for own biogas and digestate production. The other farmer raised cattle. Both of which were also familiar and experienced in using digestates as a fertilizer. One farmer was completely horticultural and produced carrots and other root vegetables for the Swedish fresh-market. All farmers had practiced crop rotation for at least five years.

The soils varied from clay to sandy lime. Soil management for some of the farmers also included the application of straw, intercropping with clover for N-fixation. The question of non-plowing was discussed as well. Even though an agro-ecological analysis would have included all aspects of soil and crop management per farmer, given the limited scope of topic and time, this was not possible.

On the socio-economic context: farmers were family farmers and male, there was one female farmer in the sample. Most of the respondents were both the owner and the manager of their family farm. Most farmers were between 50 and 65 years old. When discussing their plans for the future, many farmers did not have a clear plan for the take-over the farm after their retirement. It was not taken for granted that their children would be the next owners and this influenced the decisions of some of them. Most farmers learned how to farm from growing up on their very farm. The majority had been schooled through formal secondary education, some went to the local agricultural higher secondary school, others were schooled through higher education, mostly in the field of agriculture, economics or agricultural economics at the SLU in Uppsala. All farmers stated to be eager to continuously educate themselves and to keep themselves informed, either through agricultural newspapers, the Internet, farm groups, advisory services and conferences and year markets.

4.2. Behavior: Soil conditioner and fertilizer use

As recommended by Ajzen (2005), behavior needs to be defined prior to a TPB study. For this study, two behaviors were identified; the *current behavior* and the *intended behavior*. The *current* behavior entailed the application of soil conditioners or mineral fertilizers for agricultural purposes in the region of Skåne, with 9 practitioners of this behavior defined, being the farmers and at the same time the representatives of each case study integrated in this work. Terry and Wallace (1998) define a soil conditioner in their handbook as a ‘substance that improves the physical properties of the soil’ (Terry & Wallace, 1998). They emphasize that this could refer to both synthetic and natural substances. However, what distinguishes it from fertilizer, is that the term ‘soil conditioners’ also refers to the improvement of soil texture and the build-up of organic matter. Therefore, in this case I have opted to categorize only organic substances other than mineral fertilizers under soil conditioners.

Appendix fig. A4 (p.17), shows the current behavior: the application of mineral fertilizer and/or soil conditioners. Mostly, mineral fertilizers entailed a mix of NPK, but in some cases it was extra K, N or P only. In the table, a distinction is made between primary and secondary fertilizers, as it was a common practice to combine different fertilizers and soil conditioner. It either differed per crop, or nutrient supplies per crop supplemented each other (e.g. in the case of digestates). This distinction was made only for the totally conventional farmers, as among the other group of mixed production, it has been specified whether the fertilizers were used for the organic part or the conventional part. As for digestates, the purposes and practices varied. It was applied by two conventional farmers (farmer 7 and 10) and by one organic farmer

(farmer 6). Farmer 7 and Farmer 6 were the only farmers who were using digestates at the time of the research (July 2015). Farmer 10 used it occasionally, and received it from a nearby biogas plant that did not have sufficient storage space at that moment to store it. Farmer 7 used liquid digestates made from organic waste-residues coming from a communal biogas plant and extracted through a pipe system. He was one of the farmers that supplemented the remaining nutrient needs with mineral fertilizers after the application of digestates. Then there was farmer 6, who used both mineral and digestates. The digestates were liquid digestates based on anaerobic digested pig slurry coming from his own biogas plant. However, being a farmer with both organic and conventional production, he used mineral fertilizers for his conventional crops. Different forms of manure were used: Liquid Chicken Manure (in the table referred to as: LCh.; farmer 5), Cattle-manure (C, farmer 10) or a combination of Pig and Chicken-manure (P, Ch., farmer 4).

4.3. The intention to use anaerobic digestates as a fertilizer: compared amongst conventional and mixed (organic/conventional) farmers.

In table 1, the farmers are divided into conventional and mixed farmers, and farmers that operate both a conventional and organic production system, either through two separate companies, or by having both organically and conventionally grown crops within one system. The possible difference in their intention to use the digestates was measured. The outcome was that of the total group, 5 farmers were positive or highly positive; that is to say: they definitely planned to use them in the future (2 farmers) or were already using the digestates at that time (3 farmers). The variable of ‘medium/slightly positive’ was applied to the farmer who stated to have a positive attitude, and that he might be interested in using the digestates in the future. He would answer the question with a ‘maybe’, for example. Often, these farmers would also mention quite a few expected barriers related to the use of the digestates. In some cases, this would be accompanied by suggestions for changes in the farming systems, that the farmer needed in order to actually apply the digestates in the future. Two farmers stated clearly *not* to have any intention to apply the digestates in the future. Both were conventional plant producing farmers from the same region, although each conducting a different soil conditioning management and having different attitudes. The ‘doubting’ farmers were conventional farmers only, as well.

Intention	Negative	Medium/Slightly Positive	Positive	Highly Positive
Conventional (N = 6)	2	2	1	1
Mixed: Organic & Conventional (N = 3)	-	-	-	3
Complete Group (N = 9)	2	2	1	4

Table 1. Intention to use digestates. Distribution per farmgroup

The relationship between a negative or doubtful intention and perceived barriers, compared with knowledge and past experience.

When introducing a new product, it is always interesting to analyze the foundation for doubts about the product. Two cases in which the farmers stated that they 'might be interested' in the digestates were the cases of farmer 1 and 3. Both farmers were plant-producers for industry and resided in the very south of Skåne, in a region relatively close to a newly started biogasplant (*Jordberga*). This is relevant, as they said this sometimes in their discourse on perceived barriers. They had in common that their discourse and knowledge of digestates were primarily based on their past experience with manure. Both farmers indicated that their definition of *biogödsel* was basically the same as manure. In the past, both farmers had worked with manure, but currently only used mineral fertilizers. They would have been interested in it, but their most prominent barrier related to investment costs, and for farmer 1 more to transport. As this farmer expected the volume of the digestate to be very large, he would expect difficulties with the transport and the costs of transport to his farm. This was also a topic for the third farmer, but less prominent in the discussion. Secondly, the barrier of *soil compaction* was an important issue for both farmers, this again related to the economic context of spreading technology, as they knew from previous experience that (a large volume of) liquid manure needs heavy machinery. Even though for both, economic investments were primary drivers of decisions on their farm, they nevertheless considered environmental issues such as soil structure (soil compaction) and resource recycling very important. Another important barrier in the social and cognitive domain for both farmers is the knowledge about digestates.

4.4. Attitudes

The main topic of conversation when measuring the attitudes focused on understanding the perceived advantages and disadvantages of digestate-application among the different farmers compared to primarily mineral fertilizers and sometimes manure. This is described in this paragraph by the outline of the most recurring themes, which will be illustrated by comparing excerpts from the case descriptions. Figures A2_1 and A2_2 (see appendix p. 9, 10) represent a flowchart of advantages and disadvantages of digestate-use.

4.4.1. Cognitive attitudes: knowledge and familiarity with digestates.

Cognitive attitudes: Knowledge and experience

The context of the importance of knowledge, experience with the farmer's perceptions, and attitudes on anaerobic digestates will be evaluated. In the tables displayed in figures A3 (Appendix, p. 13-16) and A5 (Appendix, p. 18-22), the respondents' level of education and their cognitive interpretation of digestates is presented. Earlier studies and workshops reported the lack of knowledge among farmers in Skåne on the use and contents of anaerobic digestates in agriculture (e.g. Odhner, 2015). It was difficult to find exact measurements or indicators on the evaluation of the extent of 'knowledge' or 'familiarity' with the topic of digestates. In the table (Appendix, fig. A3, p. 13-16), the knowledge and meaning of digestates is referred to as 'M' (Meaning), in the third Column, Attitudes (Appendix, fig. A3, p. 13-16). Two respondents (farmer 1 and 3) from the conventional group had 'limited knowledge' of the digestates. This was derived from questions from the farmers regarding the nutrient content, or from further explanations of the concept required by them. However, both farmers stated they were aware of the production of biogas in the region, and the possibility to utilize the digestate as a fertilizer. During their comments about the market in digestates, they referred to *Jordberga,* a local biogas production plant that was known to use sugar beet (residues) as a substrate in exchange for digestate. In the table (Appendix, fig. A3, p. 13-16), this is referred to as 'market', referring to (some) knowledge about the market and stakeholder network of biogas (-digestates) in the region. However, a majority (7 out of 10) of the farmers turned out to have medium knowledge or were very knowledgeable about the digestates. Of these farmers, five had medium to strong experience with digestates. The two farmers (6 and 7) that have strong experience with the digestates are the farmers that have been using digestates for many years. One of these two farmers (farmer 6) has his own biogas plant, from which he also utilizes the digestates as a fertilizer. Both farmers had perceived positive attitudes towards the digestates. Regarding the farmers with average knowledge about the digestates (farmers 4 and 5), one farmer (farmer 4) came forward as 'very knowledgeable' on the digestates during the conversation, but had medium experience (he worked with/became familiar with biogas in a previous position), had a positive attitude towards them and the intention to use the digestates in the future. Farmer 5, however, had limited experience with the digestate, a low intention to use them, but was, however, positive about the digestates and during the conversation proved to have medium knowledge about the digestates. The table also shows that a majority of the respondents associated digestates with the residual product of biogas. Sometimes, biogödsel was understood as organic fertilizer, which might as well be organic manure. The attitudes about the nature of the substrate were diverse, however. Some farmers were confused about the adjective of 'bio', as they were aware that the organic substrate was not always grown organically.

4.4.2. Advantages and disadvantages of digestates versus mineral fertilizers

Perceived advantages on digestate use in agriculture

Both mixed and conventional farmers perceived the improvement of Ecosystem Services in the sense of improving soil fertility, nutrient recycling and enhancement of crop quality as the most prominent advantage of digestates.

Soil quality and soil fertility was seen as an important asset of the farm system. Nutrient uptake, a healthy soil and crop quality were, according to the majority of farmers, interrelated. Some related this directly to 'improving being beneficial for their economy'. The following quotes illustrate this:

Farmer 6

'Now, it sinks down to the soil, it sucks up from the soil faster.. and the effect on the plants is quicker. I mean, the plants are considerably greener after a few days.'

Farmer 7

His attitudes are, overall, very positive about the effects of digestates, in several contexts. The first advantage mentioned is related to crop quality, 'plants tend to like it'. It improves the crop quality and it also makes available nutrients more quickly available for plants. Another advantage is related to costs, even though this farmer does pay for the digestate, it is still half the price compared to mineral fertilizers. Also, the farmer has experienced benefits regarding soil quality: he mentioned the benefits from micro-organisms, since he does not have any problems, while referring to other farmers; 'other people might have problems with missing this little micro or other… I don't..'. In his words, micronutrients (present in digestates) 'add life to the soil'. Also, the importance of adding carbon to the soil was mentioned; 'in the long run, I must at least stay on the level of carbon'.

This interrelatedness of improved soil organic matter and the overall improvement and resilience of the farm-system was expressed by farmers who used manure as well. Such as the following farmer, who did not have the intention to use the digestates in the future, even while being positive about digestates.

Farmer 5

The farmer saw similarities between digestates and manure; 'I think that biogas godsel has the same... (effect) it's the same thing... you put some life to the soil.' Currently, the farmer did not have any intention to use the digestates in the near future, as he seemed very content with the effects of his manure mixture of pig and chicken manure, in combination with eggshells. As a first advantage, the farmer mentioned the beneficial effect on the soil quality in terms of soil-organic matter. This increase in soil-organic matter due to the application of manure was linked by the farmer to economic benefits; as he explained it, emphasizing the importance of a long-term perspective and the possibility of some form of resistance to weather conditions. Moreover, when asking for any other specific advantages of the manure, the farmer's answers made clear that it is not anything in particular that forms his positive attitude; but that it is rather about the complete picture; ' I can't put any finger on any special things... it is total'. The manure had also positive implications for the technical context; the plowing and cultivation of the land were enhanced. Also, the crop quality had improved. So all three contexts are integrated in this important advantage

Another important advantage that connected the benefits for soil health to economy and benefits for the local community was the aspect of local production and krettslöpp or circularity:

Farmer 6

‘I mean, in the first place it (other organic fertilizers, MH) is way more expensive, the other thing is, I find it stupid to buy some pellets made of meat-meal or blood-meal from a slaughterhouse in Norway, instead of using the product of the neighboring farm. I mean, the manure is here. I mean, we have the manure here, we process it in the biogas plant, we have the residues coming out...’

Furthermore, some positive attitudes were mentioned in the context of economy and technology, but mainly by the farmers who were working with the digestates at the time of the interview (farmer 6 and 7).

Perceived disadvantages on digestate use in agriculture Since the research also contained the element of investigating risks and barriers, the perceived disadvantages were often understood as risks or barriers. Of course, this also depends on the experience of the farmer. As there were three farmers who used the digestates at the time of the research, the choice was made to mention only those farmers who actually experienced these disadvantages in their work with the digestates (5,6,7) in this section. The further negative attitudes towards digestates will be discussed in the section on Perceived Behavioral Control, where perceived barriers are discussed and compared with notions of control over decisions.

In the domain of ecosystem services, soil compaction due to the heavy machinery was perceived as the most prominent disadvantage. It was mentioned by both farmers who had experience with digestates or with manure, and there was a common sense that liquid manure needs spreading machinery of such weight that the soil can compact, as do liquid digestates. This problem will be further reflected upon in the discussion.

Farmer 6

‘It's so big volumes. We produce like eeh.. 25,000 m3 a year, which has to be brought into the fields, by heavy machinery, I mean, these big tanks weighing 20, 30 tons, it means soil compaction.’ Other disadvantages were also related to the technical, economic and infrastructural section and will be discussed in the PBC section.

Perceived advantages on mineral fertilizers in agriculture

The reasons farmers used mineral fertilizers mostly reflected efficiency, and were described as being more ‘easy’ and controllable to apply, often in comparison to liquid manure: e.g. being able to calculate the nutrient-needs precisely and to be allowed to spread the fertilizers all year round, which would require less storage space than manure, for example. It was compared with the ‘unpredictability’ of manure, and placed in the context of fluctuating weather conditions and regulations.

Farmer 10

‘If we get any N supply from the organic fertilizers.. we are not sure about that... and we could....it could come in a bad timing... now we are applying 70 kg of N to the potatoes.... now to last time.... (every) 7 weeks.. but if we get all of a sudden a good supply from the organic fert., through mineralization.. than we have misjudged the supply... and that is the hard part with org. fertilizers. ‘

Perceived disadvantages on mineral fertilizers

When discussing the disadvantages of mineral fertilizers, the negative effect on the environment and soil ecosystem services was acknowledged. Some farmers did mention as an advantage of using digestates, that it would lower their need for mineral fertilizers. However, positive attitudes often did not necessarily lead to the intention of completely replacing mineral fertilizers (or manure) with anaerobic digestates.

Farmer 4

Negative attitudes towards the mineral fertilizer were related to environmental impact: the farm manager sees the use of mineral fertilizers as a problem for the future (sustainability) and connects it to environmental issues such as the scarcity of resources and fossil fuels (oil): ‘it will be a problem in the future. It is not endless. And, and… and you use a lot of oil when you produce. So I know where you want to come with your questions’. Also, a comparison with manure was made: ‘you don’t have the other good things that are inside manure’.

4.5.Subjective Norms and Social Beliefs: description and comparison

In figure A6 (appendix p., 23) all subjective norms are summarized. In the flowchart presented in fig. A2_3 (appendix, p.11) the relation to intention is combined with quote descriptions for the category/context of 'information, advice, education and learning' .

As for social *descriptive* norms, the answers were varied throughout the cases. Most farmers would discuss farm management issues with their social peers, of which family and neighboring farmers were the only categories mentioned by more than one farmer.

Farmer 1

(..) In terms of social descriptive norms, family members are the mostimportant people that farmer 1 takes into account when making decisions on his farm. He perceives them to fully trust him in his decisions. ‘They know, if I do it, I do it for their best’. As it is a family farm going back various generations, the farm/history and traditions are also important in making decisions for large changes on the farm.(..)

Farmer 3

(..) Family members and extension services, information-fairs (such as the large fair of Borgeby Fältdagar) and his customers (Food industry companies such as Lantmännen) are important in informing his decisions (..)

However, only two farmers (3 and 4) stated that these discussions would also directly influence their decisions. In that sense, a pure injunctive norm was only found at one farm-case.

Farmer 7

When taking decisions nowadays on his farm, he describes his own family, 'my wife and kids' as being important. Although they aren't very involved in the daily farm activities and management, he explains that he 'behave(s) as if they were'. However, the factors of economic costs and benefits, and environmental aspects and future plans are prioritized. As for further social injunctive norms he emphasizes the importance of making his own decisions, as his answer was ' it doesn't really matter' what the influences of others are on his decisions, his social network is more important to gather information, 'it is very important to make decisions yourself'. In that context, one could conclude that the personal injunctive and self-efficacy are strong in this farmer.

Many farmers did, however, note the importance of gathering and exchanging information with social peers throughout several categories, both non-formal (family, friends, neighboring farmers, colleagues, local community) and formal relations (consumers, extension services, indirect colleagues, customers/industry). This was varied as well. Most farmers (9 out of 9; as 1 farmer was missing from the dataset in this case) stated to have mostly conversations that would give them solely information, about which they would make their decisions themselves. Here, media was the most important provider of information. Only two farmers stated to include social actors in their decisions, of which one had a family-member (daughter) working as an extension service. Therefore, both professional and non-professional relationships overlapped in this case.

Farmer 2

He determines his choice of information and extension service on the reputation and the trustworthiness of that person or organization. However, the final decisions he prefers to make personally. Social injunctive: he does not mention that there is any particular pressure from any (close) social peers. However, when he gets advice, this is examined according to his perceived feasibility and the reputation of the advice-giver. Also, measurability and validity are further important aspects on assessing information to use for decision-making.

The factor of *comparison* was also important to about three farmers. The comparison would mainly be from neighboring farmers.

Three farmers (two organic/mixed and one conventional) found the topic of moral responsibility towards others (family, consumers, education/research, employees and the local community) important considerations in their social norms influencing their decisions.

Farmer 8

When discussing social injunctive norms, the farm manager mostly related this to the expectations and communication/cooperation with institutions and networks. For example, she feels she should comply with the pressure and expectations of her customers. Both in the economical expectations that she shouldn’t be ‘too small' and that she feels she should comply with these norms to keep up with the competition. Another expectation from customers is the hygienic and food safety factor, in relation to objections on the use of sludge, for example. Moreover, the local municipality expects the farm to comply with environmental regulations that desire certain technical and infrastructural investments on the farm. (…) A further aspect of maintaining the relationship with society and the local community is that farmer 8 is involved in a scholarship program for students from a nearby college. She has been attending events in which she had been speaking with younger entrepreneurs and found that very inspiring. Regarding environmental management, she would also like to be a role model. (…)Another aspect within social beliefs is the sense of responsibility, she emphasizes being a farm manager of an enterprise run by 50 employees, this concerns the need to keep the enterprise economically fit, but also to be able to invest in infrastructure and machinery that does not affect the health and working conditions of her employees. Thus, she strives in her management for values that go beyond mere economic gain.

Another farmer reflected consciously on the moral implications of his behavior on others:

Farmer 7

A little later, (referring to his overall farm management?) he expresses within conative or behavioral attitudes a link to the context of moral responsibility: 'I want to do the right thing. I don't want to behave bad'. When asked how he would explain that emotionally, he answer it is all about having a general feeling of 'doing the right thing'

Farmer 6

The farmer's aim is to leave the farm in an improved state compared to the moment he started managing it. 'I don't want to leave the farm in a worse shape than I got it: when I give it to somebody else, my daughter, or anybody who wants to continue after me, it should be in a better condition if possible than before....' This is again related to the often emerging concept of finding 'pride' in his management and feeling of responsibility towards future generations. Since the answer refers to actions and behaviors, I would label it as a conative or behavioral attitude. 'To be a proud farmer you should leave your farm in a better shape than you got it in. It is not my farm, it is a gift that I pass on to my children' (...) 'Something you treat, and handle all your life, it's not your property... it's in your hands during your lifetime, and you must give it onwards to somebody else... '

Continuing on the aspect of moral responsibility and compliance, the pressure of consumers and regulations was also related to the representation in the media:

Farmer 4

As for subjective norms and social beliefs, the relation to the contexts of society and media were linked to the relation with consumers.

The farm manager considers consumers as the most important people in his decision-making. In his explanation he referred to feeling a strong responsibility in the way the farm is represented; 'As a farmer, you are always hung out in the media, for doing something wrong'. In his perception, the media can sometimes present a more negative image than it is in reality. He is concerned about this as a farmer. This can happen in the context of sludge-application, which will later be further explained in terms of perceived behavioral control. Here, he connects it to the context of responsibility within the society; as recycling and separation is needed on the household level in order to improve the safety and quality of sludge.

4.5. Perceived Behavioral Control: What constraints and challenges do farmers face regarding the use of digestates?

In this thesis, *Perceived Behavioral Control* refers to the perceived barriers or risks and perceived matter of control that farmers had, of which the latter is referred to as *self-efficacy* by Ajzen (2005). For conventional farmers, most barriers were to be found in the lack of sufficient budget for investments in improved required technology. Other barriers related to energy and resources, and to regulations. In figure A2_4, an overview of these perceived barriers is summarized in the flowchart (Appendix, p.12). Among the three mixed production systems, the majority of barriers were also found in the economic domain. The difference here was personal economy and access; distribution and transport were less of a topic when discussing barriers. However, the topic of substrate was a problem at two out of three organic mixed production systems. The farmer that mentioned the problem of soil compaction (due to heavy spreading machinery) did see it as a serious disadvantage, but not as a barrier to continue using digestates.

The conventional farmers' perception was that, in order to start using digestates, it is necessary to have improved technology. Spreading and storage were most mentioned required technological improvements. This was an emergent topic for both groups, even though soil compaction due to heavy machinery seemed to be less of a concern to the mixed farmers.

Most of the barriers perceived by the conventional farmers were related to an expression of *low efficacy* over the degree of control and influence over an event.

Low efficacy is the term in which perception of control over a situation was experienced (see Ajzen, 2005). Low efficacy related to a decision could entail the question whether it was a decision or event that would involve control: overall, the conventional farmers felt that they had little control over the circumstances that could avoid or overcome a barrier.

Another point of concern, also among mixed farmers, was found in terms of contamination and phytotoxicity of the digestate, in terms of heavy metals. This is to be traced back to separation issues and substrate safety. However, some of the farmers that mentioned this could also have been associating digestates with sludge. However, it seemed that the perception of the economic risk of transport and spreading technology was more important.

The other area in which the least control over decisions was perceived, was linked to *regulations and policy.* This was an emergent topic among a majority of the conventional farmers and half of the mixed farmers, mainly for farmers who had experience with the use of manure. Regarding manure, for example; two conventional farmers (farmer 3 and 5) who had previous or current experience with manure, mentioned as a possible barrier the restricted spreading times and the control/compliance on nutrient balances by agricultural and environmental institutions such as *Greppa Näringen.*

Farmer 3

'Because you are not allowed to use as much as P as you want. Every year you have to make a calculation on how much P you add, and how much P you are taking away… you are not going to increase. You are not allowed to increase the P in the soil. It's about the balance. And the … (Greppa Näringen, MH) they check it up… so they control us. '

Farmer 5

Farmer 5's main perceived barriers are in the field of regulations, as these mainly concern that the regulations regarding the amount of and the spreading times for manure are pretty strict. Here, he also compares it within his social/ professional network; 'When I speak with colleagues in Denmark, they buy it 2 weeks before they need it. And they don't say they have any problem with distribution (of manure, MH)... in Sweden they say 'we can't distribute everything... this month when.... you need... so I don't.... I think it is... eeh... it's historical! It's historical! That we do this...'(Farmer 5). This barrier is related to the disadvantage of manure needing storage, as you cannot determine yourself when you apply the manure. This is up to the regulations. He has a confused attitude about it; 'I don't understand it'. As for intention and needs, the farmer does not plan to use the digestates, as he has 'enough' organic manure to spread. Further, he would desire that the manure could be delivered and spread for free in the future.

On the impact of regulations one of the farmers (1) said:

'It's very important, because I want to do, and make a good quality. It's very important.'

Furthermore, it is important to have transparency and possibilities for farmers seen from a certification perspective. One farmer, for example, had a strong intention to use the digestates, but felt that it was not possible within the boundaries of KRAV. Also, land access and ownership play an important role.

Farmer 8

'We... we are very interested. We really need it. this growing with KRAV, it doesn't give us a lot of options to... and it restricts our possibilities to change land. In DK for example... they can rent a farmer 100 ha for 5 years. They can have the transition for 2 years. Than they can... grow carrots 3 years... than they leave it! they take a new farm. We can't do it.'

Chapter 5. Discussion and Analysis

This chapter will first compare the results discussed above in the light of similar studies on farmers' attitudes regarding digestate application and environmental management choices. Afterwards, recommendations for policy and further research will be made, to conclude with a short summary of the results.

Figure 4 represents the model that was formed before and during the analysis of 9 semi-structured interviews with Scanian farmers on their choices regarding digestate-use in agriculture. The central square represents the classical Theory of Planned Behavior (Ajzen, 2005), whereas the surrounding contexts were based on both Ajzen (2005) and Lamarque (2014), and included specifications inspired by the results of the data-collection. These specifications or sub-themes represented the key negotiations which illustrated attitudes, subjective norms and perceived behavioral control respectively. In the analysis below, these subthemes are connected to the various building blocks of the TPB, with the emphasis on Attitudes, Subjective Norms and Perceived Behavioral Control. On the right side of the center, two behavior categories (B1 and B2) are displayed. B1 represents the current behavior of soil fertility management for each farmer. The larger the block, the more farmers in the case studies used these techniques. Here, B2, or the use of digestate application, is related to intention. As the 'very positive' block is the largest, it indicates that a majority of the farm-sample had positive attitudes towards the digestate use and a positive intention, too. One improvement of this analysis or for further research is, that we need to find ways to better understand the dispositions and negotiations that lead farmers to actively keep leaning towards practices they themselves consider disadvantageous for ecosystem services.

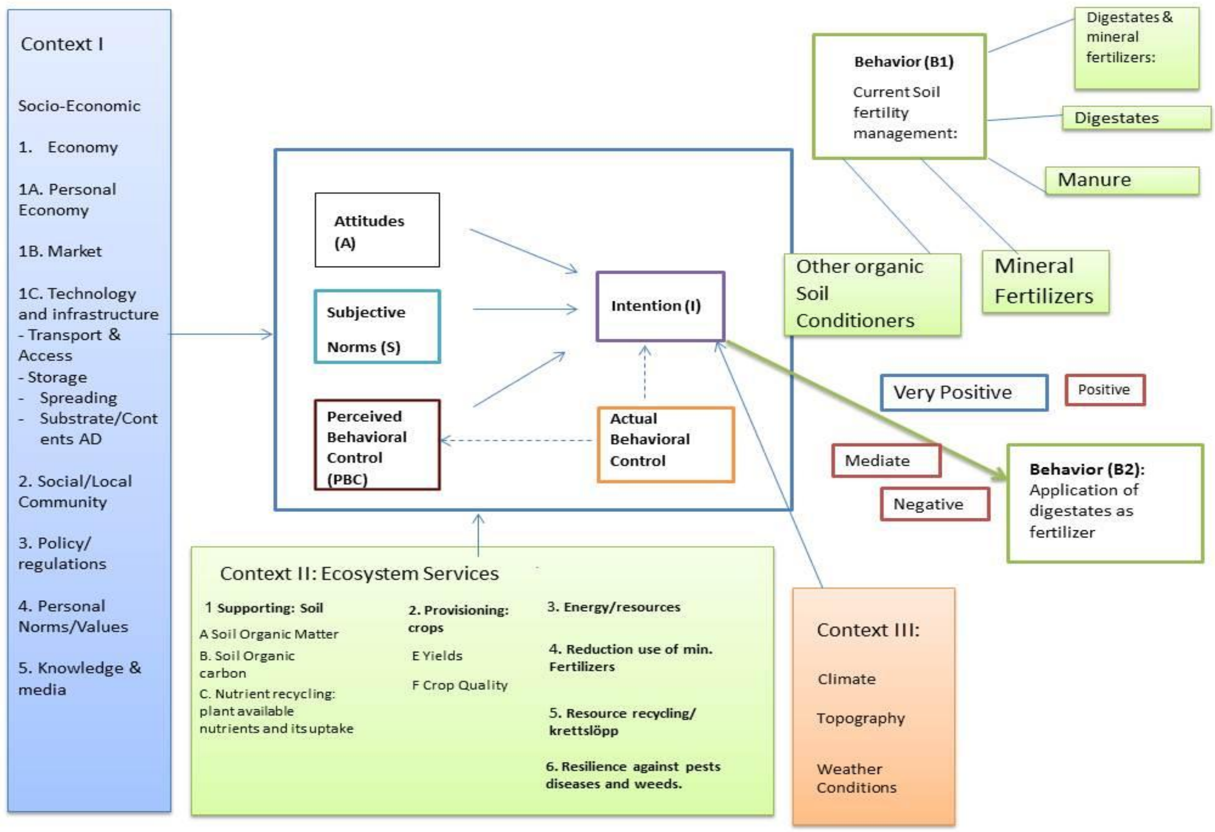

Figure 4. Final Model: Scanian farmers' intention to use anaerobic digestates in agriculture.

I Analysis according to the model and literature

5.1. Attitudes: Which attitudes do farmers have related to the application of residues from the Anaerobic Digestion of organic waste? Which factors and processes contribute to these attitudes?

Meaning and knowledge of digestates: Cognitive attitudes

First, cognitive attitudes towards and knowledge of digestates were measured. There was a mixed outcome of cognitive attitudes among both groups of farmers on familiarity, knowledge and experience with digestates. A majority of the farmers was moderate to very familiar with the digestates. About 1/3 of the conventional farmers and about half of the mixed farmers were ‘very knowledgeable/familiar’. The limited knowledge occurred mostly among conventional farmers. However, those with limited knowledge did know about biogas plants having biogas residues available. Questions and doubts were asked about nutrient content, regulations regarding hygiene. Similar to Odhner (et al., 2015), the farmers in this thesis recognized digestates as a residual product of biogas production, although some farmers did define it as being similar to liquid manure or sludge.

Similar results were shown by shown Odhner (et al., 2014; 2015), among Scanian and Halland’s farmers’ perceptions on digestates. One of their main outcomes was the strong ‘unclarity’ on what biodigestates are, and on the utilization of it in terms of regulations, time planning and crop types (Odhner et al., 2015). Odhner’s respondents did distinguish it from mineral fertilizers and sludge, but saw it as a similar product to organic fertilizer.

This was also the case with the perceptions of the farmers of this thesis. In two cases, it was at first understood as liquid manure. Even though the majority of the farmers did recognize the concept of biogödsel as the residue of biogas production, often assumptions about regulations regarding spreading amounts and timings, substrate, and hygiene/food safety were related to sludge (*rötslam*) or to manure (*flytgödsel*).

Perceived Advantages of digestates

In general, farmers had positive attitudes towards digestates, which were mainly expressed in terms of soil ecosystem services as a general improvement of soil quality. This is again confirmed by Odhner (et al., 2014; 2015), who had also shown that there were overall positive attitudes on the digestates: awareness and knowledge on positive effect for soil fertility were shown. Similar to results in this thesis, farmers did also relate the digestates to the transformation to sustainable agriculture and improvement of closing loops (*krettslöpp*). Regarding the substrate and contents of the digestates, the groups in Odhner’s study did note the need for certification (ibid.).

On the Swedish level, Avfall Sverige has been facilitating this form of compliance towards biogas producers by means of the SPCR 120 certificate (Avfall Sverige, 2013; Bramstorp, 2014). The values maintained here are however not legal requirements as for Swedish Environmental law as for now, but rather 'approximate values' or *riktvardar* (Bramstorp, 2014).

Many national companies and branche organisations in the foodindustry do require from growers to use only digestates that are SPCR 120 marked however. SPCR 120 maintains for example for Cadmium (Cd) a maximum of 1 mg/kg TS of Cd. within digestate, and a maximum of 0.75 g/ha in a 7 year period to apply on the soil according to both SPCR 120 (Bramstorp, 2014; Avfall Sverige, 2013; Sveriges tekniska forskningsinstitut, 2013). The Swedish Environmental Protection Agency Naturvårdsverket published a plan to lower Cd. Content in both biogödsel, composts, sludge and mineral fertilizers in the period between 2015 untill 2030. For cadmium in digestate this will be from 40 mg cd/kg plant via 35 mg Cd/kg P in 2023 untill 25 mg Cd/kg P in 2030 (Bramstorp, 2014). Currently, regarding the application of mineral fertilizers there is 100 mg Cd/kg per plant allowed, and it is investigated whether it can be brought down until 46 mg/kg P (Bramstorp, 2014). For organic cultivation, KRAV allows digestate to be used as a fertilizer under certain conditions, the digestates are allowed only when the substrate contains at least 5 percent of organic production and is limited untill 'plant-based products from the food industry, plant-remains and manure' (Bramstorp, 2014). There are also strict requirements on contents from animal produce (ibid.).

Relationship between knowledge of and positive attitudes towards soil ecosystem services and the motivation to adopt management practices that can enhance them

The majority of the farmers had a positive intention to use the digestates. Also, there were overall positive attitudes and an acknowledging of the benefits that digestates and manure can have on soil fertility and crop quality. However, the relationship between considering the (soil) ES as ‘advantageous aspect of digestates’ and it being the reason for the positive intention still needs to be shown. In Odhner’s study, the farmers also related digestates to being beneficial for soil health and quality. However, even though this was seen as an ‘extra value’, there had not been a ‘willingness to pay’ directly for this (Odhner et al., 2015).

This reflects other studies that have seen a discrepancy between cognitive and affective attitudes that show knowledge and approval of ecosystem services, biodiversity or conservation practices (e.g. Bratt, 2002; Vignola et al., 2010), and other factors that eventually are more determinant for the decision being made (e.g. Bratt, 2002; Vignola et al., 2010). In Anna Bratt's study on Swedish farmers' management practices in order to decrease nutrient leaching (2002), various values were given to the Ecosystem Services, although these values were not always taken into account in the decision-making. Through a decision-model based on belief, knowledge and risk perception (Bayard and Jolly, 2007 in Vignola et al., 2010) it was found that Costa-Rican dairy and horticulture farmers engaged in conservation practices were more affected by cognitive variables, whilst socio-economic and institutional aspects were finally decisive for the actual implementation of the practices (Vignola et al., 2010).

Regarding cognitive understanding and knowledge ofout ecosystems, Lamarque (et al., 2014) found that farmers were familiar with and had knowledge of ecosystem services, 'even without calling them 'ecosystem services' (Lamarque et al., 2014). The latter was also reflected in this thesis population, as topics and soil organic matter were put into the context of fertilizer choice, however, not one farmer referred independently to the concept of ecosystem services. Also when this concept was explained by the interviewer, not everyone was familiar with or knew about the concept, although some did. The ES that were assessed in this thesis, nitrate leaching and carbon storage, were less known by the farmers in Lamarque's study and 'required more explanation' (Lamarque et al., 2014).

Furthermore, Wilson et al. (2009) found a division in knowledge and perceptions between Ohio grain and wheat farmers and weed scientists on the topic of *Integrated WeedManagement*. Most profound differences were due to the integration of experience and education and local knowledge on the farmer's side. Here, we see the relevance of 'mapping' differences in knowledge, perceptions and learning for the improvement of communication systems and policy aimed at generating a change in farmers' behavior. For instance, it was concluded that farmers' related causes of weed-spreading to environmental events, and not explained it through specific terms as the scientists did (Wilson et al., 2009).

Anna Bratt (2002) relates farmers' knowledge to 'local agricultural knowledge' which is defined as a 'synthesis of proficiencies based on inherited learning, i.e. indigenous knowledge as discussed by Berkes (2000), together with experience and modern science, i.e. information received from a variety of sources' (Bratt, 2002). Again, the concept of decisions is a comparable one: 'the preferred action selected among alternatives' (Lamarque et al., 2014). It comprehends: 'general assessments about things that are seen as desirable' (Dietz et al., 2005). Concluding from LaMarque's study, values and knowledge were both needed, however these were not always a determining factor in farmers' decisions. For instance, as carbon storage and nitrate leaching were not part of most farmers' knowledge systems, these variables weren't included in the decision-making process. However, once the farmers were included in a 'feedback-game', and it was suggested to distribute incentives for the use of these ES, farmers reconsidered taking these ES into account in their decisions. The feedback game implied that both indirect and direct feedback effects were at stake regarding the inclusion of ES in decisions (Lamarque et al., 2014).

5.2. Subjective Norms: What is the role of social peers and social networks in the management decisions of these farmers? How does this affect their attitudes and intention regarding digestates?

Although this thesis has not directly reviewed the impact of knowledge on the decisions that the ten case-farmers made regarding the use of digestates, the research did find that

the farmers have various channels and ways of learning and gathering information. Regardless of varied formal education levels, all farmers were knowledgeable on aspects of soil ecosystem services. Most farmers stated they were continuously learning and valued the Internet, newspapers, extension services and conferences or fairs with either direct or indirect colleagues as important sources of information, and to follow trends in market and technology. A majority of the farmers perceived social peers such as family, neighbors and colleagues to be valuable in exchanging information regarding their management behavior, either in the way of discussion knowledge, such as management techniques, prices, and experiences within their management systems, or by comparison. However, although such actors and interactions did influence farmers knowledge and (cognitive) attitudes, it did not always necessarily result in a direct influence on their decisions. Most farmers valued their own perception of knowledge, risk perception and estimated results by outweighing the various results of their decisions themselves, thus seeing themselves independently capable of making these decisions. Nevertheless, a majority of the farmers were running a family farm, so they did take the (economic) wellbeing of their family into account when making decisions. Intergenerational effects of their decisions were also at stake. Many farmers expressed a feeling of responsibility towards future generations, whether these be the new owners of their farm by direct descent (which was for some farmers still unsure), other new owners of the land, or further generations that are affected by their farming practices through a wider environment and context. Farmers were also influenced by management practices and possible expectations of their (grand)parents.

Relationship between subjective norms and intention

It is difficult to conclude whether there was a strong link between subjective norms and intention among the farmers in this thesis. Intention and decisions were not directly influenced by social peers and colleagues, but did contribute to farmers' normative beliefs. Furthermore, compliance and responsibility, which were influencing decisions, were felt rather stronger regarding the local community, consumers, clients and policy/regulations on different levels. However, the role of extension services was taken in some cases seriously and had more direct influence on digestates. Other studies (Roca, 2011; Armitage & Conner, 1998; Fielding et al., 2008; White et al., 2009) did not find a strong significant relationship between subjective norms and intentions to change farm management behavior. However, in Roca's study group, norms did matter in some cases. Also, social identity or group norms did not significantly influence intentions, corresponding to other studies (Norman et al., 2005), which Roca related to the fact that group norms were measuring perceived behavior, while in studies in which group norms measured perceived behavioral control and attitudes, a significant relation was found (Fielding et al., 2008; White et al., 2009).

The farmers in this research showed that subjective norms were often understood in terms of learning and gathering new information through example extension services, or via professional networks and events such as fairs or conferences. In Sweden and abroad, there is an increasing number of initiatives and research and policy groups that explore communication and awareness on the use of digestates.

Intertwined with the cognitive and socio-psychological approach, the importance of knowledge and education in policy programs aimed at reaching a change in behavior is proposed (Beedell and Rehman 2000, 1999; Vignola et al., 2010; De Snoo et al., 2013; Hansson, 2008). In a critical review of the EU's incentive based Agri-Environmental Schemes (AES's). De Snoo (et al.:2013) advocate a more social and cognitive approach in changing farmers' behavior. Two main approaches were discussed: the rural sociologist 'farming styles'- paradigm (Van der Ploeg, 1994) and the Theory of Planned Behavior (Ajzen, 1991). To achieve changes in people's behavior towards environmental practices, it is argued that both farmers' personal and social norms should be included in research and communication. One of the arguments against AEs was the short-term nature of the programs, as it was doubted whether the farmers would continue the desired behavior after the payment of incentives (De Snoo et al., 2013). Critical in reaching a farmer's change of behavior in the long term, is to include the social norms that exist in farmers 'peer groups' (De Snoo et al., 2013; Fielding et al., 2005; Prider & Karpinnen, 2010; Pretty, 2003). This is also reflected in the social identity theory (Tajfel & Turner's, 1979); in case of a salient social identity, people's behavior corresponds with the group norms of the particular social group (Roca, 2011). Therefore, group norms corresponded significantly to decreased fertilization practices and delayed mowing in the studies of Roca (2011).

In the end, all this revolves around how one defines and positions agency, structure and social actors. Within sociology, development studies and a broader scope of social sciences, the structure agency debate has been a central point of discussion (see Long, 1992). Long defines 'agency' as the individual's 'capacity to process social experience and to devise ways of coping with life, even under the most extreme forms of coercion' (Long, 1992). Departing from Giddens' vision on agency, Long notes that actors can be perfectly 'knowledgeable' and 'capable' (ibid.), while living and acting within the boundaries of information, ambiguities and 'physical normative or politico-economic constraints' (Giddens 1984 in Long 1992). In the further description, some similarities were seen with the key constructs of the TPB (Ajzen, 2005). According to Long (1992) and Giddens (1984), problem-solving and learning for intervention within the 'flow of social events' is crucial, while it is held that if observations are continuously made on somebody's personal acts (Giddens 1984 in Long 1992) - similar to Ajzen's description and emphasis on evaluative aspect of attitudes and normative beliefs (Ajzen 2005) - the response of others on their own behavior (Giddens 1984 in Long 1992), social beliefs and subjective norms (Ajzen, 2005) is monitored and finally, 'contingent circumstances' are overseen. This can refer to the PBC (Ajzen, 2005).

5.3. Perceived Behavioral Control: What constraints and challenges do farmers face regarding the use of digestates?

Among both groups of farmers in this thesis, control beliefs related to the socio-economic context influenced the perceived barriers: a lack of budget for investments in storage facilities and spreading techniques. This was similar to Odhner (et al., 2015), who added to this the perceived difficulties with access and distribution. Main barriers in the study of Odhner (et al., 2015), were also related to the technical/economic context, as the farmers reported difficulties in access, together with lacking or absent storage facilities which could disrupt the intention to use the digestates.

Back to the results of my thesis: a negative effect from the socio-economic context on (soil) ecosystem-services of soil structure was the perceived risk of Soil Compaction. This risk was mentioned when asking about disadvantages and when discussing barriers that could refrain the farmers from using it. Among both conventional and mixed farmers, it was the most prominent disadvantage and risk of digestates, although it was a bit less emergent issue among the mixed farmers. The perceived risk factor/cause was the heavy machinery that is also used for spreading liquid manure. Generally, this was related to knowledge (either through experience or common knowledge) on manure spreading technology. Therefore, it is important to note here that liquid digestates and liquid manure were discussed. Self-efficacy was lowest here among the conventional farmers. Soil compaction as a possible risk was also mentioned in Odhner (et al. 2015).

Soil compaction is described as 'the physical consolidation of the soil by an applied force'(Wolkowski and Lowery, 2008) and is also acknowledged by the EU as a pressing problem in agriculture, due to the use of heavy agricultural equipment (Wageningen University, 2016). It has a severe impact on soil structure, can limit the absorption of water and air, and can diminish porosity. A possible impact and result of compaction is a decrease in yields, as root penetration can be limited due to compaction (Wolkowski and Lowery, 2008). Soil compaction can also enhance erosion, diminish soil biodiversity and cause greenhouse gases to increase (Wageningen University, 2014). Wet soil can increase compaction, and therefore the timing of spreading should be regulated. However, many farmers, in the barriers section, mentioned the strict regulation and spreading timing as another drawback during manure management.

Thus, it is important for both technology, research and policy to reflect this in solutions. For example, to support the investment and research in spreading technology that would be lighter than the traditional tractors for liquid manure spreading. Also, the adaptation to weather conditions is very important to take into account.

However, as increased Soil Organic Matter can improve soil structure, by forming strong 'aggregates' or bounded soil particles (Wolkowski and Lowery, 2008), it is important to take into account both the effects of conventional fertilizing methods such as mineral fertilizers (and conventional manure) on SOM, and whether enough SOM can be created for the soil to recover and handle the heavy machinery, and therefore increase the resilience to deal with devastating effects of soil compaction.

The other area in which least control over decisions was perceived, was connected to *regulations and policy*. This was an emergent topic among a majority of the conventional farmers and half of the mixed farmers. The following section will, therefore, discuss this matter.

II Recommendations, shortcomings and concluding remarks

5.4. Needs and improvements desired: how cancurrent policy and communication strategies be enhanced in order to improve the current bio-digestate landscape?

Investment in and access to technological infrastructure

Firstly, spreading-technology should be improved in such a way that the perceived impact of soil compaction can be decreased. Following up on the discussion above, a combination of both access and investment in the form of subsidies for lighter machinery should be promoted. The fact that soil with a lower amount of soil organic matter is more susceptible to technological impact such as compaction, shows the need for an increased implementation of strategies that rethink soil management, and do not focus on mere input substitution (Altieri et al, 1996). Techniques such as integrated soil management, of which digestates can be a part in combination with a diversity of crops and if possible with animal production, can create more environmental and economic resilience (Altieri, et al 1996; Gliessman, 2007) However, a common criticism or question regarding agro-ecological farming is the doubt whether it is also possible on a larger scale. However, some technological solutions are available; spreading the digestate by integrating tubes or *matarslang* in the machinery can lower soil compaction (Odhner, 2015). In addition, when the fertilization is integrated with plowing (*nedmyllningsaggregat*), the release of ammonia can be decreased significantly (Odhner, 2015).

Economic barriers:

Furthermore, as most farmers did state economic investments (in technology) as one of the key barriers in the use of digestates, it makes sense to compare the economic picture of mineral versus digestates, as has been done in the study of Odhner et al. (2015). At a plant production farm of around 500 ha, it was calculated that the farmer would save around 710.000 SEK per year on mineral fertilizers, whereas the key costs of biodigestates center on the costs for soil compaction and proliferation, and were estimated at 450.000 SEK. The surplus a farmer would gain, therefore, was estimated at around 21 SEK per m^3 (ibid). If the digestate would be delivered for free to the farmer, there would be an estimated gain of 750.000 SEK (ibid.).

Energy use of transport and distribution of digestates (i.e. delivery and spreading) was mentioned by some farmers as a perceived barrier or disadvantage of the digestates and could lead to a negative environmental impact when looking at, for example, source separation as a strategy to lower the environmental impact of waste handling compared to incineration. It is acknowledged that the source separation of waste can, in fact, enhance transport. However, the Global Warming Potential (GWP) is still significantly lower during source separation than incineration (Bernstad & La Cour Jansen, 2011).

Substrate: source separation, certification and acceptance by the industry and consumers

A concern for substrate safety was expressed. The SPCR 120 aims to regulate the contents of the digestates and focuses in particular on the metal and the nutrient content of the substance. All biogas producers need to comply with these rules (see e.g. Bramstorp, 2014; Odhner, 2015)**.** The recycling of food waste has been added to the Producer Responsibility Ordinance (SFS, 1994ab in Bernstad & La Cour Janssen, 2010, Bernstad & La Cour Janssen, 2010). In Malmo in 2010, food waste and dry recyclables were able to lower the amount of this waste to be incinerated by 33%. The researchers predicted that the effects for the environment of an 'optimized source separation behavior' would be the following: the amount of waste going to incineration can be decreased by a total of about 80%. In addition, at least as twice as much of the subsequent environmental impact can be prevented. In order to reach this, Bernstad & La Cour Janssen (2011) suggested to focus on enhancing source separation at the household level, and on the recovery process on the industrial level. Noteworthy is his comment, that even though source separation is enhanced, it is sometimes directed more towards those substances that do not have such a large environmental impact (Bernstad & La Cour Janssen, 2011)

Regulatory Framework and improving communication in an open source and participatory way.

As mentioned previously, farmers may perceive the regulations on spreading, storage and the time of spreading as a barrier. The 'organic' content of the substrate raised questions for some farmers as well. Apart from economic resilience, the farmers felt a responsibility and compliance towards both consumers and the local community, to provide safe food while taking care of the environment. Contrary to what some farmers perceived, the use of SPCR 120 certified digestates is, in fact, allowed by stakeholders within the food industry, and to a certain extent by KRAV, the organic certification scheme of Sweden (Bramstorp, 2014). Earlier studies on the biogas chain and organic waste handling in Southern Sweden have showed the complex network of stakeholders that are related to biogas production, which transcends many different production sectors (Hammar, et al., 2007; Odhner, 2015; Gunnarson, 2012, Ericsson, Arthurson 2009, Spangberg, 2010; Bernstad & La Cour Janssen, Corvellec Bramryd, Lantz et al 2007). However, experts in the field generally advise to improvethe communication between the various stakeholders, and thus reflect this in the regulations as well (Ericsson et al., 2013). As for policy frameworks, institution and investment, the production of substrate is influenced by the agricultural policy and the policy for waste management (such as the organic waste ban of land filling.) Moreover, the 2006-2010 tax on incineration had pushed it further. Important stakeholders include KLIMP and the rural development program (Ericsson et al, 2013).

Over the past years, workshops and working groups have been organized by groups such as Biogas Syd and the Swedish University of Agricultural Sciences, in which representatives of various sectors involved took part. The farmers' organization LRF is also actively engaged in rethinking strategies to improve and increase the use of digestates. However, such meetings could be improved by adding *participatory learning* aspects (see e.g. Eksvärd, 2010) that work towards engaging the participants in more active learning, without following traditional hierarchical structures.

As mentioned in the introduction of this thesis, it is currently discussed on an European Legislative Level whether and how digestates can be included in the revision of the *Fertilizer Regulation 2003/2003* (see Commission Regulation (EU) No. 1257/2014, European Commission, 2016a ; ISWA 2015) and to be acknowledged through End of Waste[7] criteria (EoW) (Waste Framework Directive 2008/98/EC; Council Directive 2008/98/EC; ISWA 2015; ESPP 2016).
However, to label digestate as non-waste should not mean that the products will be included in the scope of REACH regulations as applied on chemicals (Wilken et al., 2013; ESPP, 2016). The proposed revision includes an 'optional harmonisation' and

[7] The 'criteria specify when certain waste ceases to be waste and obtains a status of a product (or a secondary raw material)' (European Commission, 2016b; Council Directive 2008/98/EC). The criteria apply to waste products that have been recycled or recovered as per Waste Framework Directive's articles 6 (1) and (2) (ibid.). Up till now, the criteria are established for non organic waste materials.

- 'The substance or object is commonly used for specific purposes' ((European Commission, 2016b)
- 'There is an existing market or demand for the substace or object' (ibid.)
- 'The use is lawful (substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products' (ibid.)
- 'The use will not lead to overall adverse environmental or human health impacts' ((European Commission, 2016b)

can create more opportunities for digestates and other organic fertilizers to be included in the European Market. Also, it can enable improved innovation and research on fertilizers produced from organic waste, improve quality, safety and nutrient labels by regulating these and to a connect current diversity of complex network of various regulations, definitions and directives (ESPP, 2016).

As the farmers of this research sample have shown, education and information exchange is valued as important to increase awareness on the topic of digestates, especially among colleagues. The Internet can be a great source for these information exchanges, on a more equally accessible manner. Responding to this growing need of knowledge exchange and collaboration within the movements and discourses of zero-waste, clean tech and circular economy that have gained more recognition in the past years, podcasts such *as The Green Exchange* (2016) could play a crucial role (The Green Exchange, 2016).

5.5. Further recommendations & Shortcomings

Shortcomings, recommendations for further research and collaborations

Many TPB-studies are designed for quantitative research, and as a result, there are some shortcomings in the significance of the relationship of the constructs and the intention. However, this paper could be considered of an investigative and explorative nature. Regarding the now small and new market for digestates used for this purpose, it could be a recommendation to expand this field by conducting larger behavioral based studies, from a quantitative point of view, without losing the chance to grasp the uniqueness and dynamical and specific context of each case. Classically, Ajzen (2005) advises to first do a pilot study among a small number of respondents to define the emerging themes and from there, to proceed to gather a larger and broader account of information by designing questionnaires to reach a larger number of people and in doing so, get a better overview of the total market potential and challenges. Therefore, the outcome of this study could possibly serve as the start of a quantitative and behavioral analysis of the market for digestates and the model presented here could be used as a framework for analysis.

One very important area that this thesis has not touched upon to any great extent, because the focus is more on smaller case studies and individual's cognitions, is the wider political and economic scope and context. A single farmer is not isolated in his decisions from a wider and complex web of regulations, which is influenced by the fast developments of both macro economy and (multi) lateral decisions that affect both price and environmental regulations, which in turn impact municipal and regional regulations for farming and land use. The power of the market for mineral fertilizers should also be investigated further. How can these regulations be adapted to better suit needs and workings of local environmental and social ecosystems? How can academics and policy reflect more on the daily negotiations of a farmer and his way of affecting the land and ecosystems on aquatic, terrestrial and air level, using natural and common resources that can impact further generations of life in different ways?

An analysis with a greater depth should be made, including discussions with stakeholders in the energy and fertilizer industry, as well as the food-producing companies. Several agendas and interests are at stake, and instead of conflicting with common goods for environmental, social and economic health , ways should be found in which these can cooperate and grow into circular systems of exchange and production.

This thesis has given insight in the complexity of factors at stake in the decision-making on environmentally friendly and enhancing management practices in agriculture; in this case, the exploration of the willingness and motivation to use anaerobic digestates as a fertilizer. Being schooled within soft system's thinking, I have learned that neither research, policy or practice can address only one (decision-making) factor and context in an isolated matter. Earlier research has shown that an interdisciplinary approach is needed. Even though the relationship between one aspect of a person's cognition, beliefs, social norms and risk perceptions does not always lead directly to the intended behavior, whether this intention stems from the actor himself (in this case, the farm manager), his direct social, economic or natural environment, or from interventionist approaches resulting from research or national, regional, European or international policy and regulatory schemes.

5.6. **Concluding remarks according to the three constructs of the Theory of Planned Behavior**

Attitudes

For *both groups*, the major *context* in which positive attitudes were assigned to the digestates was in the field of ecosystem services, as it was held that they would be improving soil organic matter and nutrient recycling. In both the economic context (primarily technology) as in soil ecosystem services, disadvantages were mentioned. Two primary conclusions were drawn; firstly, both conventional and organic farmers in Scania have a positive attitude towards the digestates. Secondly, this was expressed through advantages in context 2: *soil health and crop quality.*

Subjective Norms Social beliefs and subjective norms were mostly understood in terms of advice and information, not necessary as directly influencing personal decisions. Here, farmers showed a high level of personal injunctive norms and self-efficacy, which shows a high degree of certainty of one's own decisions.

Perceived Behavior Control

The most mentioned barriers of digestate use are in the field of technology: i.e. spreading techniques and the risk of soil compaction due to heavy machinery. Also, transport, access and regulations, and unclarity about the freedom of choice and behavior were mentioned here. A better cooperation and communication of the various stakeholders is needed, as are ways of boosting the economic value and willingness to pay for digestates once facilities and technologies have been improved. Farmers often have a multitude of responsibilities, social and economic, and are entwined in a web of demands stemming from regulations, consumers, and contracts with the food industry.

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Abbreviations

A- Attitudes

ABC – Actual Behavioral Control

B - Behavior

C - Carbon

C.E. – Certified European

CO_2 – Carbon Dioxide

ES – Ecosystem services

EoW – End of Waste criteria (Waste Framework Directive 2008/98/EC)

ISWA- International Solid Waste Association (ISWA, 2015)

I – Intention

K – Potassium

KRAV – Founded in 1985 as 'Kontrollforeningen for Alternativ Odling', and Sweden's certification body for organically (*ekologisk* in Swedish) grown food. The KRAV label follows the EU- regulations for organic production[8].

MSW – Municipal Solid Waste

N – Nitrogen

OECD – The Organisation for Economic Co-Operation and Economic Development (OECD, 2016)

P – Phosporus

TPB – Theory of Planned Behaviour (Ajzen, 1991)

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8 https://sv.wikipedia.org/wiki/Krav [2016-07-08]

Appendix

Fig. A1. Coding Manual with integrated interviewguide (version October 2015)

Concept	Questions: Intv. Guide, during intv. Or filtered from data Variables	Code	Measurements/Examples in data/ values and extra sub codes
I.Background factors ***1.*** **About your farming business** **2. About you as a farmer/ farm-manager** **3. General introductory on biofertilizers**	1A Name of the farm? 1B Size 1C Into bussiness since (year) 1D Are you part of a cooperative? Which one? 1E Are you a member of a farmers organisation? 1F Are you engaged in any form of financial support or subsidies? 1G Productiontype: Conventional, organic or mixed 1H Productionsystem, crop rotation: what are you producing? 1I To whom are you delivering? 1J Is your bussiness a family farm? If not, what else? 1K Soil Type 2A.What is your age? 2B.(Knowledge/ experience) How have you learnt to farm? (Kolb – learning styles?) 2C Gender? 3A. **Which fertilizer practices*** do you currently practice? (Since when?, what is the dominant form) 3B. **Have you ever heard of digestates and biofertilizers**? How? What do you think they are?	1A F_NAME 1B F_SIZE 1C F_START_(year) 1D F_BUSS_COOP 1E F_BUSS_ORG 1F F_SUPPORT 1G F_PROD_org/conv 1H_ PROD_SYS_CR/F_PROD_SYS_OUT 1I F_CLIENT 1J F_BUSS_FAM 1K f_SOILTYPE 2A_AGE 2B_ED/2B_EX 2C_SEX 3A_FERT 3B_COGAT_DIG	YES/NO between 45 and 65 Formal education*/ working on own family-farm, farm elsewhere/other work/media: internet, newspaper, mag./social learning ED: formal education EX: experience. Adv: advisory services M/F 3A_FERT_DMAN_NPK See * in box 4 for examples Yes/no, manure, residues from biogasprod In case of combi of diff. Kinds: proportions in % 3A_FERT_PROP_[FERT TYPES &%]_ Crop type: 3A_FERT_CROP_[cropnames] Attitudes (see 4) were mentioned here in the answers.

II. Attitudes: **Behavioral Beliefs** **2 types** - **General** **On an object** - **Behavioral** **On an action/ behavior** **3 Structures, ABC** - **Affective Attitudes (AF. AT.)** - **Behavioral /Conative Attitudes (CON.AT.)** - **Cognitive Attitudes (COG.AT.)** **5.Attitudes towards past and future experiences**	4A1* What do you see as the **advantages** of applying digestates** as fertilizer this season and the next 5 years? 4A2* What do you see as the **disadvantages** of applying digestates as fertilizers this season and the next 5 years? **4A3* What else comes to your mind when you think about** applying digestates as fertilizers this season and the next 5 years? *Same questions were asked for mineral fert (_MIN). (4B_MIN), manure*** (4C), other org. fert. (4Da: compost (_COM), 4Db: fungi (_FUNG), 4Dc: sludge (_SLUD), 4Dd. Human waste (_HW), 4De. Algae (_ALG), 4Df. Bonemeal (_BON) or other org. fertilizers (_FERTorgMISC)), Other soil nutrient management (4Ea. Crop rotation (_CROPROT), 4Eb. Intercropping (_INTERC), 4Ec. Green manure (_GM), 4Ed. Cover crops (_COVER), 4Ef. Leaving/ down plowing crop residues (_CROPRES), 4Eg. No plowing (_NOPLOW), 4Eh. Soil coverage with Straw, hay or other mulch (_STRAW) *digestates (DIG) - liquid; substrate from manure (DMAN), foodscraps households (DFOH), foodscraps industry (DFOIN) sludge (DSL) ***manure from cow (MCOW), chicken (MCHI), pig (MPIG) or other livestock (MO) - How is it acquired: Often it is in exchange with other farmers; (_EXCH) and the min. fertilizers are bought: (_bought). Biogas producers are self-sufficient: (_SELFsuf)	4A1_PROfert or CONfert 4A2_ATfert 4A3_AT GAFAT BAFAT GCONAT BCONAT GCOGAT	Soil-Quality (ES_SQ), Crop-quality (ES_CR) Nutrient Recycling (ES_NR), Easy to handle (_easy), Nutr Uptake (ES_NU)., Quicker and visible results (Results), Economical benefits: EC_POS_price Infrastructure/transport: INFRA_PRO: I.E. pipeline Clean (CLEAN) Disadvantages: Unpredictable, soil compaction (machinery), Infrastructure/transport: INFRA_CON transport-costs, transport-energy, heavy metals, regulations, Economical not feasible (e.g. transport or equipment costs), discussion on substrate origins – conventional or organic (_nonconv/substrate). spreading times. Energy/resource scarcity _ES_ENERGY/RES Soil BAFAT: 'I am satisfied with' COGAT ín my knowledge..''

III. Subjective Norms: Social Beliefs - **Descriptive Norms (SUB DN)** - **Social Injunctive Norms (SUBSIN)** - **Personal Injunctive Norms (SUBPERS)**	*5a. **Past experiences*** In case you have been applying biofertilizers before: How has your **experience** been with it? *5b. **Future*** I would **excpect** this technique to be very *DescrIptive* 6a. **Which people** are important for **you in making decisions on your farm**, and how important would you consider them? 6b. **Which** people* are important for you in making the **decision to buy biofertilizers?** 6c. Can you **describe their role in these decisions?** 6d. I value the opinion of these people (neighbours, coworkers, businesspartners (of the farm), clients (the food industry companies), authorities, family, customers (both the food industry and the consumer), the general public, myself the most when it comes to making decisions on buying or applying biofertilizers (descriptive subj. norms) *Social Injunctive Norms* 6e. **In which sense do these people* motivate you, or not motivate** you to buy these? (social injunctive norms) 6f. My ….. * (e.g. family members)- expect me to use biofertilizers (social injunctive norms) *6g. when do you value a good advise?* *Personal Injunctive Norms (not asked as direct question, but filtered from data)* 6g. '**I do (not) feel a moral obligation/ responsibility' to apply digestates'**	5a atPAST 5b atFUT Codes attitudes *see 4 SUBDN_farmdec SUBDN_fertdec SUBDN_dec_role SUBDN_dec_motiv/press SELFef	ADV & dec. factors: Crop performance importance of own decisions (- cross check with SELFef) 6a, 6b, 6d. *various social and institutional Actors were mentioned: My familymembers (FAM), my neighbours (NEI), my coworkers/employees (CO), other farmers, through organisations, study/friend contacts (FAR), clients (CL), authorities (AU), extension services (ES), food industry (FI), energy industry (EI), consumers (CON), society (SOC), adiviors (ad), research?univ (uni), companies (corp), internet, newspaper (media) 6c. involved: taking decisions together/advisory role but no decisions/inspiration only/no involvement at all 6d e.g. 'when you have confidence with'

IV.Perceived Behavioral Control (PBC): Control Beliefs	7A. Can you explain me what kind of barriers you expect when using the biofertilizers* 7b. Can you explain me which barriers you have experienced when using the biofert.? 7c. How would you rank these barriers in importance/ Which barriers do you consider as most important To filter from data:e you facing any barriers at the moment? 7d. 'How much **control** and confidence do think you have over your decisions' on the application of digestates or other fertilizers (adapted from White et al., 2009) Optional 7d. Self identity: was not included in a question, but integrated within the farmers' answers. 7e. 'If I wanted to apply biofertilizers, it would be easy/not easy (difficult) for me because…' (adapted from White et al., 2009) *if mentioned, other fertility management practice also applies	7aPBC_fut_barriers 7bPBC_past_barriers 7cPBC_present_barriers 7cPBC_fut_barriers_ (I), 7cPBC_past_barriers_(I), 7cPBC_present_barriers_(I) 7dPBC_perscontrol_dig_SELFef 7ePBC_SELFid	**Examples of barriers** Economically not feasible or profitable (ECMIN) General economic issues (ECON) Machinery/equipment (MACH) Transport/ Infrastructure (INFRA Regulations (REG) Geographical location (often interlinked with transport/ infrastructural issues (geo) 7d. Self-efficacy (SELFef): 'confidence in one's own ability to carry out a behaviour'. (Armitage & Conner, 2001). 7e. Self-identity: 'the salient part of an actor's self which relates to a particular behavior'. (Conner & Armitage, 1998) Often, respondents connect this to an issue within impact & contextual factors, such as energy (ER) Til. Ex (SELFef) 'I am not sure if have enough knowledge (about biofertilizer, to reply it, MH)) 'I dont know if I have the right equiipment'. 'Maybe you need a different mindset' (SELFid) 'I am too conventional for thatt I think' … 'I see myself as an entrepreneur' 'I consider my management/ farm practices/ fertilizer management as

			'good' – 'ok', 'bad'
V. Impact on/from contextual factors (IMP) **Attitudes (see 4) were mentioned here in the answers.**	**Context I and III Interaction/ feedback, see the schedule.** *8a. Please explain* ***how*** *do you think that the fertilizers are related to the following areas* (see contextual factors)* *8b. Which of these areas do you consider* ***most important****?* *Optional Questions OR factors to filter from data and what is their impact on?* 8c. KNOWLEDGE: What do you know about these aspects and interactions? (COGAT) 8d. PBC: Which of these areas do you think will be most at risk/ affected when you start using the fert.? (PBC) 8e. SUBJECTIVE NORMS: Which of the areas is most important for your social environment (see section 2). What do you think that they know of these areas? (SUBDN)	8a_IMP, 8a_IMP_STR, 8a_IMP_Q, with added any of the codes from contextual factors* 8b _IMP_I *Contextual Factors - 1.Social Economic Domain: Economy (PE, personal economy) and General Economy (E) Policy/regulations (P), Social (S): krettslopp thinking included: e.g. _krettslopp _consumer relation. Local prod.: _LOCAL 2.Environmental Domain (ENV): Climate and weather (C) , topography (T), energy (ER)(resource scarcity) and emissions to air, land or water (EEA;EEL,EEW) 3.SOIL ECOSYSTEM SERVICES (SES) (soil) I Regulation and Maintenance: Soil: A. Soil Organic Matter (IMP_soil_SOM) B. Soil Org. Carbon/SOC (IMP_soil_SOC) C. Nutrient Recycling and N-fixation (IMP_soil_NR) II Soil Struct (& SOIL FORMATION	Measurements: IMP: -Strength (STR): This shows how *strong* the respondent the impact considers. Strong(1), Medium (2), Weak (3) -Quality (Q): This shows how the respondent perceives impact on the *quality* of the area. Very positive (1) –positive (2)–medium (3)- negative (4)- very negative (5) -Importance (I): This shows how the respondent perceives importance of the impact the behavior can have: Most important (1) – important (2) – neutral (3) – not important (4) E.g. when the answer is something similar to: *'I know that the application of liquid biogödsel can cause compaction of the soil because of heavy machinery. This is bad for the soil structure, so this would be a barrier for me in buying the fertilizers'* – it is a cognitive attitude towards an impact that is graded as 'negative' for the soil structure. It is an expected barrier (PBC) for his intention to buy the fertilizers. **The answer will be than coded as follows: COGAT_CONdig_IMP_soil_str_Q4_PBC_int**

Intention	9a. I would use digestates in the next 5 years as a fertilizer-management 9b. I would need the following to be able to use the digestates Throughout the converrsation, farmers mention about their decisions/ dec. making processes INT_dec	IMP_soil_str): general. Compaction: IMP_soil_str_comp 9a_Int_pos/neg 9b_Int_needs	Strong ('definitely')- positive ('Yes I would') - medium ('maybe')- neutral ('I don't know')-negative ('I would not do it')-very neg. ('I would absolutely not do it') e.g. _Pos or _Neg (Ajzen, 2001 advices to use favorable or unfavorable attitudes) Often related to the (metal and/or nutrient) contents of the digestates and related to certification -KNOWLEDGE -SEPARATION TECHNIQUES -CERTFICATION -INFRASTRUCTURE AND TECHNOLOGY: TRANSPORT, SPREADING

ATTITUDES	Final categories/ last notes: many farmers had an opinion about organic farming and sustainability in general, and this I have connected to both the attitude section and the PBC section as well. Attitudes/ personal motivations in farming in general	_OrgProd _Sust eg: PBC_ _farm_motivations	

Fig. A2_1: Flowchart: Attitudes towards Digestate Application: Advantages. N=number of answers. C=Conventional farmers. M: Farmers with a Mixed (Organic and Conventional) production system

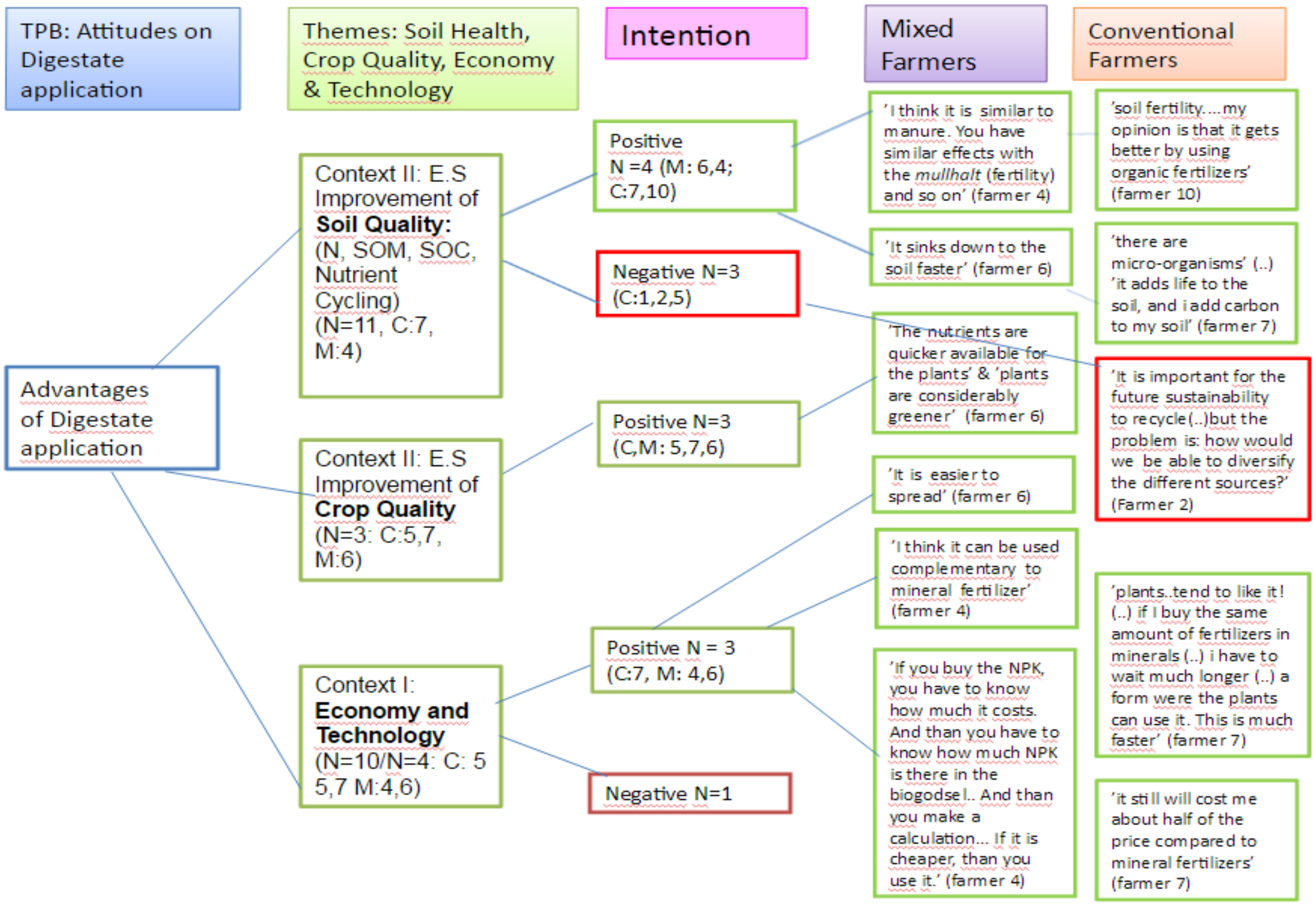
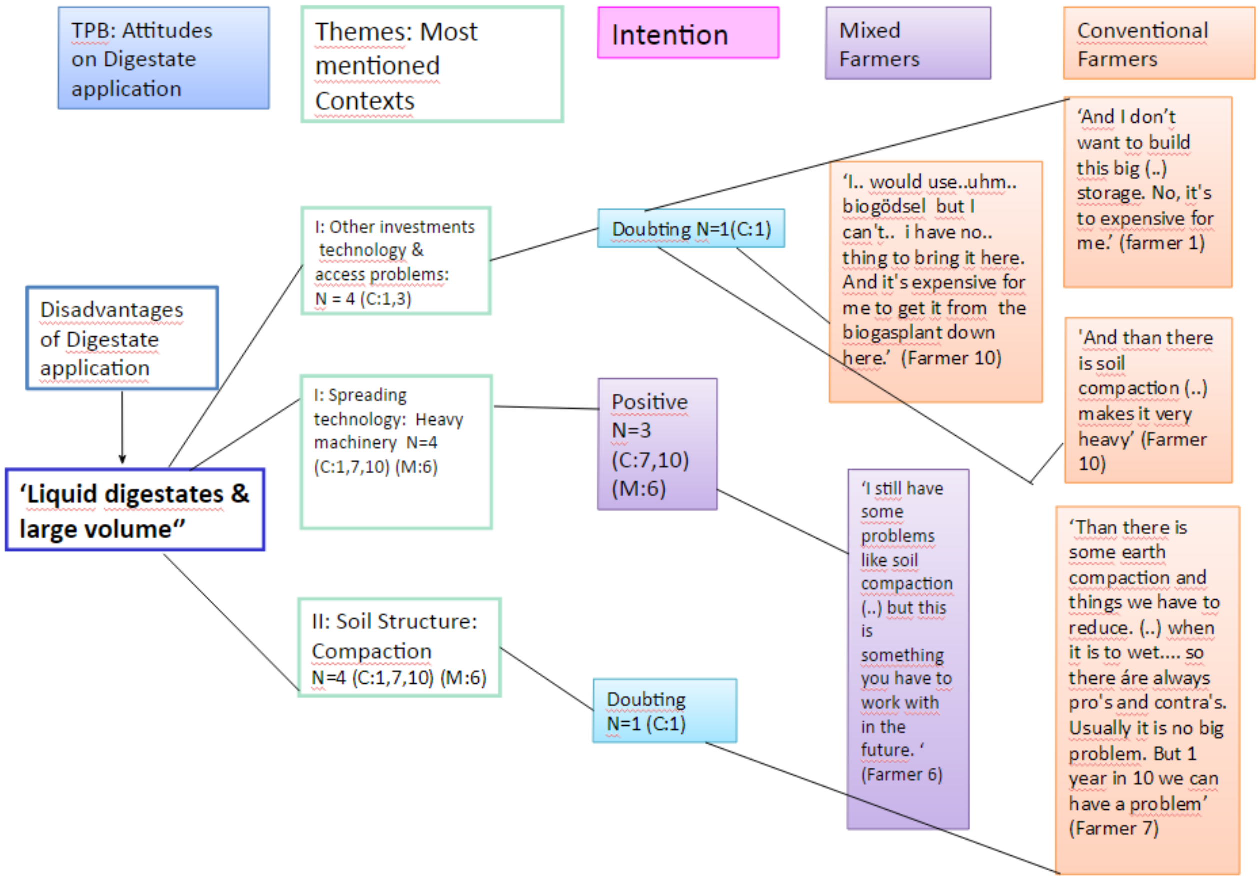


Fig. A2_2: Flowcharts: Attitudes towards Digestate Application: disadvantages. N=number of answers. C=Conventional farmers. M: Farmers with a Mixed (Organic and Conventional) production system



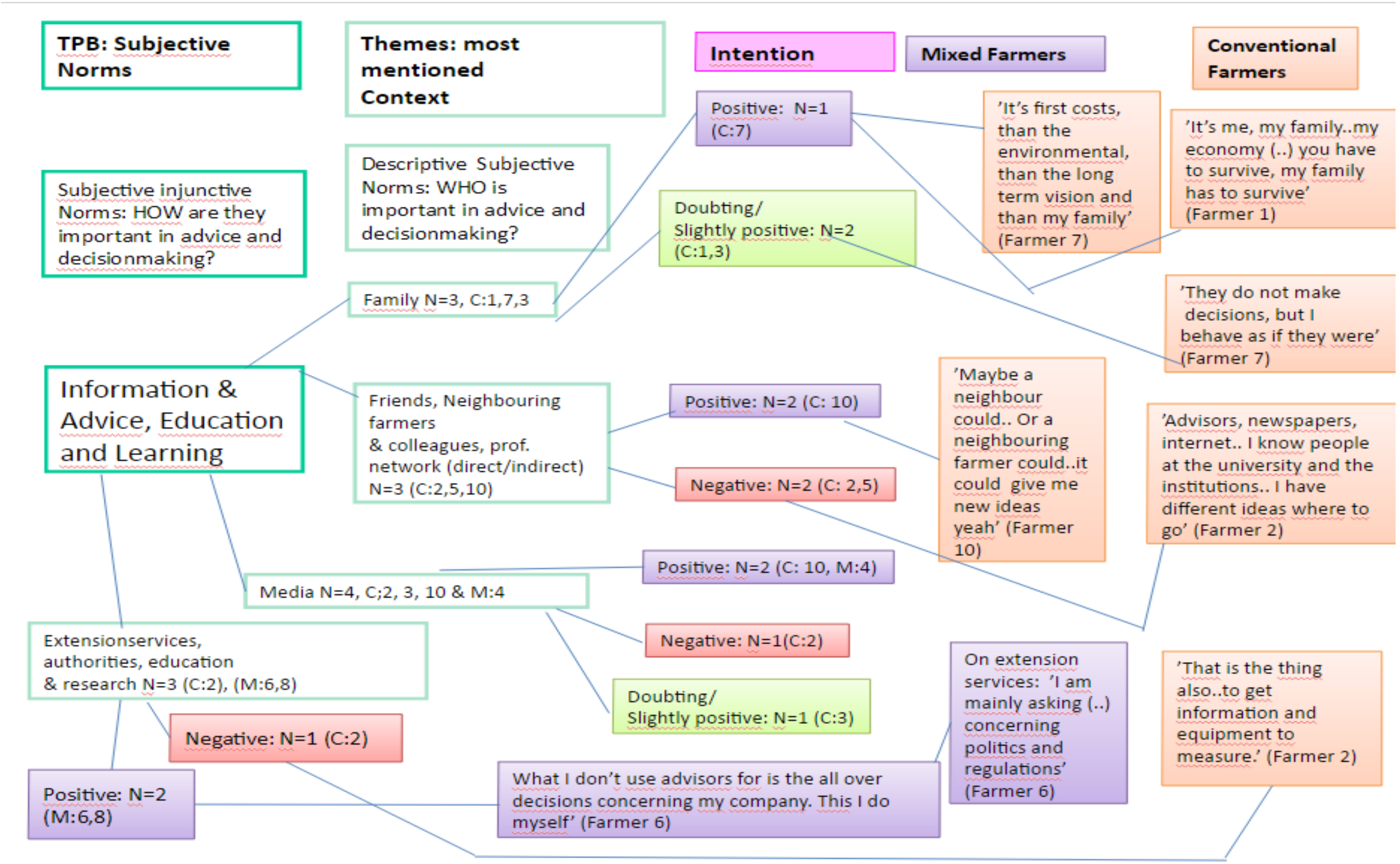


Fig. A2_3: Flowcharts: Subjective Norms towards Digestate Application: Information & Advice, Education and Learning. N=number of answers. C=Conventional farmers. M: Farmers with a Mixed (Organic and Conventional) production system

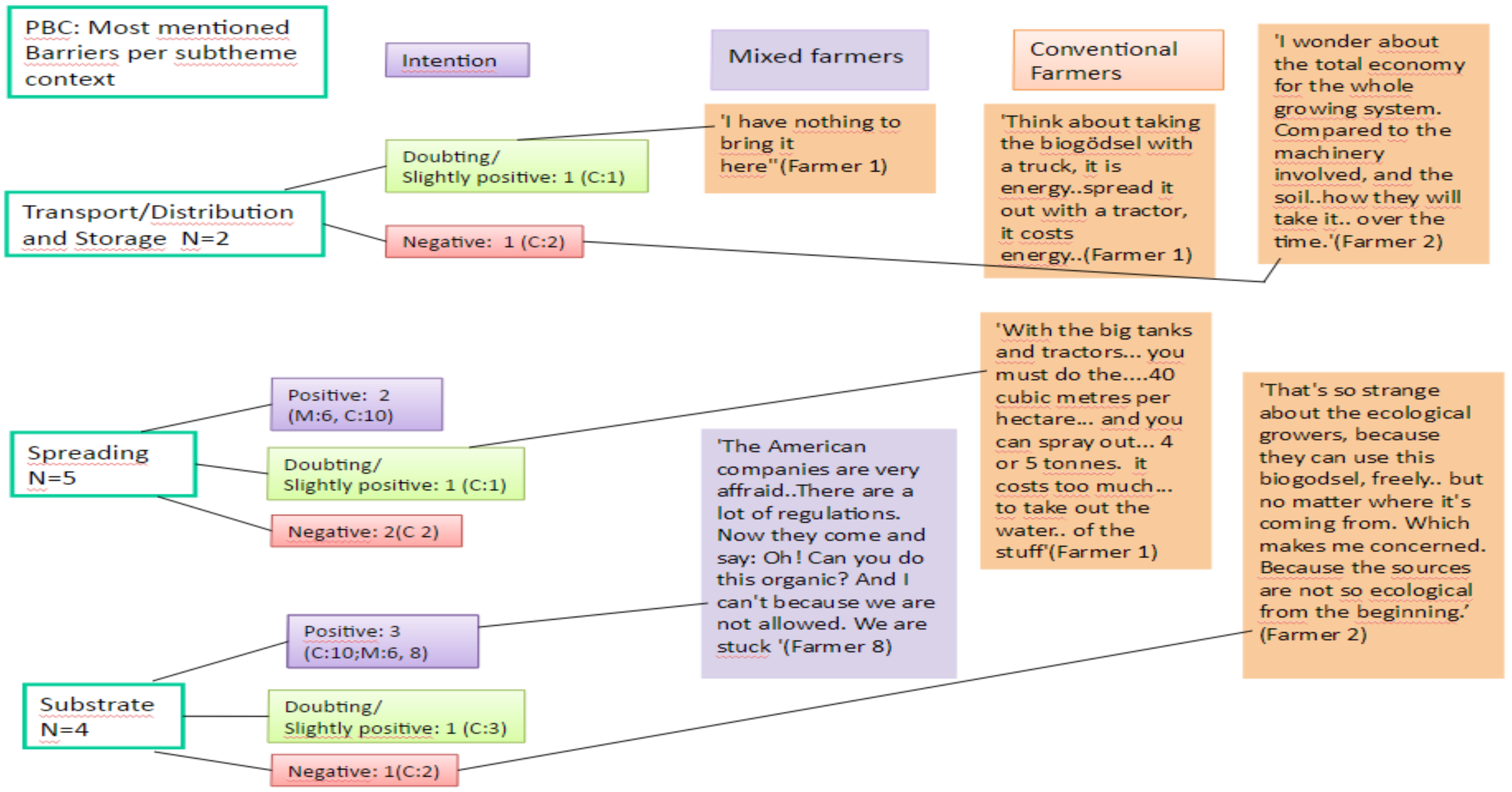


Fig. A2_4: Flowcharts: Perceived Behavioral Control Digestate Application: Most mentioned barriers; transport, spreading and substrate

Fig. A3. Demographic and Production-system Information of the nine respondents: Farmers in Skåne, Southern Sweden.

Conventional	**Birthyear**	**Education**	**Acreage**	**Crops**	**Soil**
1	N.d.	Experiential: On family farm Formal: Naturbruksgymnasiet	120 ha	Sugarbeet, malt barley, rapeseed, corn (for biogas prod.) peas (food industry)	N.d.
2	1955	Formal: Agricultural Engineering, SLU Experiential: On farm, food companies	170 ha (own) 130 ha (cooperation)	Potatoes, peas, wheat, rapeseed	N.d.
3	1958	Experiential: On family farm Formal: Naturbruksgymnasiet	100ha	Barley, sugarbeet, rapeseed and winterwheat (food industry), bed and breakfast, workshops, honey production	N.d.
5	1958	Experiential: On family farm Formal: statutory primary school	185ha	Winterwheat, sugarbeet, barley, rapeseed, rotated with clover	Clay

7	N.d.	Formal: Economy, SLU Experiential: Learnt farming on farms outside family farm	330ha	Sugarbeet, winterwheat, oats, barley	Clay: 80% Lighter soil: 20%
10	1977	Formal Technical Agronomist & Civil Ingenior (SLU, Univ. Uppsala)	n.d.	Livestock (160 cattle; vealproduction and some dairy production), cereals, carrots, potatoes	Varies between clay and sandy soil

Fig. A3. Demographic and Production-system Information of the nine respondents: Farmers in Skåne, Southern Sweden.

Mixed: Organic and conventional					
4	1956	Experiential: 25 years exp. as farm manager, no family farm Social learning: involved in farmers groups advice from university	900 ha: 800: conventional 100 organic	Conventional: rye, rape, triticale, cereals, sugarbeet, barley/oats & wintercrops salix for biomas Organic: potatoes, carrots, chickenfeed, wheat, barley	N.d.
6	1953	Experiential: On family farm, farms abroad Formal: Agronomy, SLU	600-650 ha	Feed for own pigs Organic pig production (20.00 p/y) Conv. Pig production Biogas	N.d.

Fig. A3. Demographic and Production-system Information of the nine respondents: Farmers in Skåne, Southern Sweden.

8	1952	Formal: Physiotherapy Experiential: On farm	500 ha	Carrots, Rootvegetables (foodindustry)	Intermediate fertile claysand (*sandig matlig mullhalt lerig sand*)

Fig. A3. Demographic and Production-system Information of the nine respondents: Farmers in Skåne, Southern Sweden.

Fig. A4. Behavior: Current Soil Conditioner Management

Conventional	**Min Fertilizers**	**Manure**	**Digestates**	**Other organic fertilizers**
Farmer 1	X (primary)			
Farmer 2	X (primary)			X (secondary)
Farmer 3	X (primary)			
Farmer 5	X (secondary)	X (secondary, LCh)		X (primary)
Farmer 7	X (secondary)		X (primary, LO)	
Farmer 10	X (secondary)	X (secondary, CM)	X (secondary, LO)	
Total Conv. (N=6)	Primary: 3 Sec.: 3	Sec.: 2	Primary: 1 Sec.: 1	Primary: 1 Sec.: 1
Conv. & Organic (Mixed)				
Farmer 4	X (conv. pr)	X (org.pr.: PM., Ch)		
Farmer 6			X (primary, LP)	
Farmer 8	X (conv. pr)			X (org. pr.: PS)
Total Mixed (N=3)	2	1	1	1
TOTAL (N=9)	8	3	3	3

Farm-number and system	**Current Soil Management Behavior**	**Attitudes**	**Subjective Norms**	**PBC**	**Intention to use digestates**
Conventional					
1	Mineral Fertilizers	M N.d. II (E.S.) + Improve Soil Quality II (Socio/Econ-) -High Investments: -Storage -Spreading -Transport	Important people/institutions in decision-making Family Extension Services	High Investments in technology and infrastructure -Storage -Spreading -Transport	Slightly Positive

2	Mineral fertilizers	M Biogas residues, but questionable attitude on the the organic substrate I - Substrate: -Organic origin is doubtful -Hygienity risk due to possible contaminants II + E.S.: Soil, Crops, Energy: Nutrient Recycling can be improved	Important people/institutions in decision-making Extension Services Values info for decisions: - reputation - trustworthiness - perceived feasibility -measurability Social Injunctive: No pressure from peers Personal Injunctive 2. High Self efficacy 3. Confidence in himself in decision making	I: Personal Values -Perceives that his 'way of thinking' is 'too conventional' Economy: - Distribution - Investments/ (personal?) economy - Machinery	Negative. Needs: - Change of cognitive attitudes on organic production (Farmers' words: 'I have to change my way of thinking'. 'I am too conventional' (for the use of digestates, MH) - New machinery

3	Mineral Fertilizers	I - Market: Not perceived as very large Knowledge: Needs more knowledge on content and use	Social Injunctive Important people/institutions in decision-making - Family & -Extension Services: daughter is a consultant with a lagre extension service: knowledge-sharing -Information-fairs: knowledge-sharing -Customers in the food industry: production, profit -Consumers: distant relationship, but important in decisionmaking Learning and knowledge through: 4. extension services 5. information fairs	I: - Economy: not profitable to grow sugarbeets for nearby biogasplant in exchange for biogas residues - I + III: seasons and regulations - Spreading times of digestates to be restricted -	Slightly positive: Needs: - More knowledge on nutritional contents of digestate - Technological support Context influencing decisions: - E.S.: A 'good soil' is the most important impact factor

5	Organic fertilizers Manure Eggshells Supplemented by mineral fertilizers	M: Restproduct of biogas production On Manure II +Soil Quality: SOM +Crop Quality improved I +Economic beneficial on long term (because ES improved) +Enhances plowing and land maintenance III Weather resistance - Technology: Heavy Machinery	Social Injunctive Advice/decisions -Extension Services Comparison -neighbouring farmers Social Descriptive Info/advice -neighbouring farmers and colleagues -friends	Barriers I Transport	Negative: Current fertilizer technique is sufficient, Positive attitudes

7	Digestates Supplemented Mineral fertilizers	**I** + **Economic:** Lower costs than mineral fertilizers: 'half the price' + **Transport/Infrastructure**: Easy access due to pipeline + **Personal/Moral Values**: ' I want to do the right thing, I don't want to behave bad' II + **Crop Quality: Improved** **Crops, Soil, Energy:** Plant Available Nutrients are quicker available/ + **Nutrient uptake is improved** +**Soil Organic Matter**: Increases SOM, Activates Micronutrients Soil Organic Carbon: level of SOC is improved Technology: Heavy Machinery. -II Soil Compaction - III Hilly Landscape enhancing the drawbacks of using heavy machinery	Social Injunctive: Advice/Decisions -Family: 'behaves as if they were' (involved in the day to day activities on farm, MH red.) Info/advice Social Network Personal Injunctive: High Self-Efficacy: 'It is very important to make decisions yourself' Influence of others on decisions: 'it does not really matter'	Barriers (to expand digestate use) I - Costs - Regulations: Nutrient Levels - Technique	Positive ' I don't do organic production, but i definetly try to behave in a sustainable way'

10	Manure: cowmanure NPK supplementary Digestates: Liquid digestates from municipal biogas plant occiassionally	N.d.	Social Descriptive: Info/Advice & comparision: - Neighbouring farmers and colleagues - Media Personal Injunctive: No direct impact on his decisions in the first place	I Technology: - Storage - Economy: - application costs II - Heavy machinery can cause soil compaction - Soil & crop quality/ food safety: - Risk of Cd accumulation due to heavy metals Low self efficicacy	Positive Needs: - Should be free of any costs - ' the companies need to convince me that this is safe sound and economic'

Farm-number and system: Mixed 4	**Current Soil Management Behavior** NPK Manure Straw	**Attitudes** Cognitive attitudes: M: residues of biogas production, manure substrate and sugarbeet substrate. Familiarity: intermediate knowledge digestates, had heard from it from others and through earlier work Conative attitudes/ advantages/disadvantages + Can decrease use of min. fertilizers +Spreading: homogene substance	**Subjective Norms** Social Injunctive Info/decisions - Consumers, strong feeling of responsibility Info/advice - Media: perceived as powerful for reputation. here: low self efficacy: ' as a farmer you are always hanged out in the media' Moral responsibility - Consumers	**PBC** Barriers (sludge) -I Technology/substrate: better separation techniques: risk of contamination by e.g. medication in human substances No direct influence on intention: ' I understand, but for me it is not a big issue. I have respect for the people when talking about this, but at the same time (...) we must find ways to take care of the good things in the sludge. and separate the bad things of it' (farmer 4).	**Intention to use digestates** Positive Will maybe use it in the future in a different function Needs: -Better spearation techniques (i.e. of sludge)

6	Liquid Pig Manure Digestate	I Economy/ opportunity costs: **Lower costs than other organic fertilizers** Spreading: Digestates **are 'easy to spread'** **Example of local production/kretsslöpp thinking**. Personal Values/ Identity: **Describes himself as an entrepreneur.** II Crop Quality: Improved due to Quick nutrient uptake Soil Quality: Quick nutrient uptake III Example of local production/'kretsslöpp' thinking/ circular economy I Technology: Heavy Machinery is needed for large volume of digestates II. Soil Compaction	Social Descriptive: Info/advice - Extension services Comparison -Neighbouring farmers & colleagues Social injunctive: Moral responsibility - Local community - Education - Employees	Barriers I -Technology: Heavy machinery II - Heavy machinery, soil compaction Attitudes on barriers: - One should have a flexible attitude Self-efficiacy: -Very high: I: substrate: control over substrate in biogas plant in perceived as very strong, as he owns it High degree of confidence in decisionmaking: 'I know that my decisions are right for me'	Very Positive Scientific proof is key in decisions

8	Conv.: K, NPK Organic: Lyckebo organic (potato starch) Biofer	M: 'only organics' I,II,III Can **improve krettslöpp/circular economy** Regulations: Not sure whether it is allowed by organic certification/KRAV and customers Hygienity/heavy metals: Doubts about the presence of heavy metals/ cleanliness of the product Economic needs are given priority	Social Descriptive: Info/advice - Extension services Social injunctive: Moral responsibility - Local community - Education - Employees	Barriers I -Regulatory Framework: Perception that application is not allowed by -Customer (Food Industry demands) -Certification: KRAV related/ associated to the resturcted use of sludge -Technology/ Machinery - Acreage seems to be a problem	Very interested Needs: - More legal and contractual freedom in decisions

Fig. A5. TPB: all concepts summarized per context. I, II, III refer to contextual factors: I = Economy, technology,social, political, personal, information. II: ecosystem services and soil health. III: Geographic and Climatic Conditions. M: refers to meaning and definition of the digestates. Figure is displayed on page 17 - 25

	Info/ Advice (indirect)	Advice/ Decisions (direct)	Contract and compli-ance (regula-tion included)	Compa-rison	Competi-tion	Moral Responsibility	Environmental Responsibility/ Compliance
Family	1, 7	3				6	
Consumers		4				3	
Neighbouring Farmers and colleagues*	5, 10			5,6, 10			
Local Community			8			6, 8	10
Friends	5			5			
Customers/Industry	2		3, 8		8		
Extension Services	6	3					
Authorities/Institutions	8		8				8
Indirect colleagues/prof network	2	3					
Education & Research	2	3				6, 8	8
Employees			8			6, 8	
Media (internet, newspapers)	2, 4, 10	3					

Fig. A6.  Subjective Norms and social beliefs organized per context. Descriptive norms are represented in the rows, the subjective injunctive norms in the columns.