Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Department of Biosystems and Technology

Crop Diversity in Scania – Geographical and Cognitive Mapping

Gröddiversitet i Skåne – Geografisk och Kognitiv Kartläggning

Shaktima López Hösel

Master´s thesis • 30 credits
Agroecology - Master's Programme
Alnarp 2019

Crop Diversity in Scania – Geographical and Cognitive Mapping

Gröddiversitet i Skåne – Geografisk och Kognitiv Kartläggning

Shaktima López Hösel

Supervisor:	Georg Carlsson, Swedish University of Agricultural Sciences, Department of Biosystems and Technology
Assistant supervisor:	Carolina Rodriguez Gonzalez, Swedish University of Agricultural Sciences, Department of Biosystems and Technology
Assistant supervisor:	Anders Larsolle, University of Agricultural Sciences, Department of Energy and Technology
Examiner:	Kristina Blennow, Swedish University of Agricultural Sciences, Department of Landscape Architecture, Planning and Management

Credits:	30 credits
Level:	Second cycle, A2E
Course title:	Master's Thesis in Agricultural Science/Agroecology
Course code:	EX0829
Programme/education:	Agroecology - Master's Programme
Course coordinating department:	Department of Biosystems and Technology

Place of publication:	Alnarp
Year of publication:	2019
Online publication:	https://stud.epsilon.slu.se

Keywords:	crop diversity, agroecology, food systems, ecosystem services, resilience, farmer's motivations, geographical information systems, self-determination theory, cognitive mapping

Swedish University of Agricultural Sciences
Faculty of Landscape Architecture, Horticulture and Crop Production Science
Department of Biosystems and Technology

Abstract

Modern agriculture is characterized by large scale and large-scale farming of a few crops, which rely heavily on external inputs. These kinds of intensive and specialized farming systems are contributing to exceeding the planetary boundaries for our ecosystems. Biodiversity in particular is under immense threat in industrial agricultural landscapes, while at the same time biodiversity itself has the ability to ensure resilience and minimize negative environmental externalities. In the face of global challenges and changes, there is a need for re-introducing biodiversity to agriculture. Crop diversity has the potential to increase the resilience of farming systems and to support vital ecosystem services, but there is little economic incentive for farmers to diversify their cropping systems. To find solutions for how crop diversity can increase, it is important to understand why cropping systems are more or less diverse to begin with. To answer this question, this study mapped the geographical distribution of farmer's crop diversity in Scania, southern Sweden, and further explored farmers' motivation for crop diversification. Geographical crop data was processed and analysed with Geographical Information Systems and Shannon's Index. Six arable farmers with high crop diversity were interviewed, and the interviews were analysed with the Self-Determination Theory of Human Motivation and Cognitive Mapping. The crop diversity analysis revealed some general regional differences, that correlated well with the five farming areas in Scania. This suggested that the variation of farmers' crop diversity could partially be explained by geographical differences. However, clusters of farms with high crop diversity were identified, which stood out from their surroundings within the same farming area. This indicates that other factors than geographical location also influence which level of crop diversity that farmers implement. The analysis of farmers' motivations suggests that economic and market aspects, as well as intrinsic motivations, such as farmers own interest and valuing of crop diversity, are factors that might explain why some farmers have more diverse cropping systems than others. The interviews also reflected how market system dynamics push farmers towards specialised production, and that the limited sales opportunities and revenue for diverse cropping systems is a barrier to crop diversification. Alternative sales mechanisms were discussed. The potential for public procurement to support local and small-scale grain legume and organic vegetable production stood out as a significant opportunity for crop diversification, based on the respondents' motivation for these crops and alternative sales strategies. If crop diversity can be increased in a way that build on farmers' intrinsic motivations, the implementation is more likely to last than if it is forced through regulations without considering farmers' motivations. Moreover, public procurement of grain legumes and vegetables has the potential to improve public health and farmer's income security, thus delivering holistic solutions that reach beyond the cropping system and ecosystem services in agricultural landscapes.

Keywords: crop diversity, agroecology, food systems, ecosystem services, resilience, farmers' motivations, self-determination theory, cognitive mapping, geographical information systems

Sammanfattning

Dagens moderna jordbruk kännetecknas av storskalig odling av få grödor, som är starkt beroende av bekämpningsmedel och konstgödsel. Dessa intensiva och specialiserade odlingssystem har negativa miljöeffekter, och bidrar därmed till att överskrida våra ekosystems planetära gränser. Biodiversitet i det industrialiserade jordbrukslandskapet är särskilt hotat, samtidigt som bevarande av biodiversitet är viktigt för förmågan att säkerställa resiliens och minimera jordbrukets negativa effekter på miljön. Mot bakgrund av de globala utmaningar och förändringar vi står inför finns det ett behov av att återinföra biodiversitet i jordbruket. Gröddiversitet har potential att öka jordbrukssystemens resiliens och samtidigt stödja centrala ekosystemtjänster. Men det finns få ekonomiska incitament för jordbrukare att öka gröddiversiteten i sina odlingssystem. För att kunna hitta lösningar på hur gröddiversiteten kan öka är det viktigt att förstå varför odlingssystem har hög eller låg gröddiversitet till att börja med. För att besvara denna fråga har den här studien kartlagt den geografiska spridningen av jordbrukares gröddiversitet i Skåne och vidare utforskat jordbrukares motivationer för att ha hög gröddiversitet. Geografiska data om grödor som odlats under ett år bearbetades och analyserades med hjälp av geografiska informationssystem och Shannon's diversitetsindex. Sex jordbrukare med hög gröddiversitet intervjuades och intervjuerna analyserades utifrån självbestämmandeteori (self-determination theory) och med hjälp av 'kognitiv kartläggning' (cognitive mapping). Gröddiversitets-analysen visade några generella regionala skillnader, som sammanföll väl med Skånes fem jordbruksområden. Det pekar på att variationen i jordbrukares gröddiversitet delvis skulle kunna förklaras av geografiska faktorer. Dock kunde kluster av gårdar med hög gröddiversitet identifieras, som stod ut från sin omgivning i samma jordbruksområde. Det indikerar att andra faktorer än geografisk plats också påverkar vilken nivå av gröddiversitet som jordbrukare praktiserar. Analysen av jordbrukares motivationer antyder att marknadsaspekter och ekonomi, samt inre motivationer såsom jordbrukares egna värderingar och intresse för gröddiversitet, är faktorer som kan förklara varför några jordbrukare har högre gröddiversitet än andra. Intervjuerna återgav också att marknadsstrukturer driver jordbrukare mot en specialiserad produktion, och att de begränsade försäljningsmöjligheterna för jordbruk med många grödor utgör ett hinder för att öka gröddiversiteten. Alternativa försäljningsstrategier diskuterades och potentialen för offentlig upphandling att stödja lokal och småskalig produktion av baljväxter och grönsaker uppmärksammades särskilt som en god möjlighet för att öka gröddiversitet, baserat på respondenternas motivationer för dessa grödor och alternativa försäljningsstrategier. Om gröddiversitet kan öka på ett sätt som bygger på jordbrukares interna motivationer är det mer troligt att förändringen består, än om implementeringen tvingas fram genom lagstiftning utan att beakta jordbrukares motivationer. Dessutom har offentlig upphandling av baljväxter och grönsaker potential att bidra till en förbättrad folkhälsa och en säkrare inkomst för jordbrukare, och medför därmed med en holistisk lösning som sträcker sig längre än odlingssystem och ekosystemtjänster i landskapet.

Nyckelord: gröddiversitet, agroekologi, livsmedelssystem, ekosystemtjänster, resiliens, jordbrukares motivationer, självbestämmandeteori, kognitiv kartläggning, geografiska informationssystem

Foreword

In a way, I think I have always been drawn to interdisciplinarity. It might stem from my Waldorf elementary school education, where integrating natural science with arts and practical skills was fundamental to the way of teaching. I have always been interested in how things were connected. After initially starting an education in biodynamic horticulture, I wanted to learn more about the environmental and social aspects of food production. This led me to a bachelor's programme in environmental science and development studies. Being presented with a lot of 'the problems', I had a strong urge to find solutions to the current ecological crisis in society, and in foods systems in particular. When looking for a free-standing course to include in my bachelor's degree, I found the introductory course of the agroecology master's programme. With the intention of only taking this two-month long course, I packed my bags and left Stockholm for Malmö. Unknowingly, this decision marked a change of path in my life. Five years later, I find myself still in the Öresund region, although now in Denmark, finishing my master's degree from the very same master's programme.

In the agroecology master's programme, I found the holistic approach to food systems that I had been looking for in academia. I found a group of students from many different cultural and educational backgrounds and was initially filled with enthusiasm from learning in such as diverse group, and from being presented with a holistic approach to research. As the quote presented to me in my first agroecology lecture states:

> "The more we study the major problems of our time, the more we come to realize that they cannot be understood in isolation. They are systemic problems, which means that they are interconnected and interdependent" (Capra 1996)[1].

This is my conviction, and I learned - and keep on learning - from systems thinking how to look at systemic problems such as food systems in a structured way, and to apply this in research design. During the programme I have developed skills in scientific methods, and my ability to combine natural and social science approaches to explain and suggest possible opportunities for dealing with food system problems.

It has been a challenging journey. Not only due to the fact that agroecology has not yet been fully understood and appreciated in academia, but also due to the ironic sensation that the more you learn, the less you know. This has been a cause of lot of frustration, and often left me with a feeling of: 'and now what?'. Acquiring knowledge about the many aspects of a broken food system has also been frightening and discouraging, as the road towards fixing the systems seem increasingly difficult. But something that I have come to understand that gives me hope is that when we approach problems in a holistic way, we often find multifunctional solutions that deal with many aspects of the problem at once. In food systems, this means solutions that deal with economic, environmental, social, cultural and health aspects holistically. I do believe that Agroecology, as a science, practice and movement, is a tool for developing such solutions. I am leaving the programme with a greater understanding of research, and aspirations to develop my practical skills and advocacy for sustainable food system.

[1] The quote was presented by our dear guest lecturer Anna Hofny-Collins. I believe the quote is from Fritjof Capra's book *The web of life: A new scientific understanding of living systems.*

Table of contents

List of tables

List of figures

Abbreviations

CAP	Common Agricultural Policy
CSA	Community Supported Agriculture
EFA	Ecological Focus Area
ENCS	Effective Number of Crop Species
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GIS	Geographical Information Systems
LRF	The Federation of Swedish Farmers
SDT	Self-Determination Theory
SLU	Swedish University of Agricultural Sciences
SOC	Soil Organic Carbon
SOM	Soil Organic Matter
UN	United Nations

1 Introduction

This chapter presents the background to the socio-ecological consequences of modern agriculture, the state of biodiversity and the potential benefits of crop diversity in Scania, southern Sweden. A problem statement is presented, leading to the research aims, objectives and questions. Finally, a brief overview of the main points and structure of the thesis is provided as a guide for the reader.

1.1 Background

1.1.1 Socio-Ecological Consequences of Modern Agriculture

The industrialisation of agriculture catalysed by the green revolution has implicated major changes in agricultural systems worldwide. The key processes in this development have been specialisation and intensification. This means focusing on only a few crops and trying to increase productivity and profit for those. Out of thousands of edible plant species, 103 species account for 90 per cent of food crops grown globally. As few as 3 species account for 60 per cent of peoples consumption of plant based calories (Thrupp, 2000). This is a simple but yet powerful image of modern agriculture. With mechanisation and the introduction of chemical fertilizers, pesticides and high yielding varieties, big crop monocultures has to a large extent replaced the traditional small-scale practices of growing many different crops and varieties in rotation as a way to manage pests and diseases, as well as cultivating legume crops for green manure (Altieri & Nicholls, 2005). This shift has led to the erosion of not only diversity of crop species and varieties, but erosion of the overall stability of agricultural systems, which now rely heavily on external inputs (IPES-Food, 2016). Agricultural systems have thus moved from ecosystem-based to input-based; from closed nutrient cycles to open flows of nutrients through the system; from small-scale and complex towards large-scale and simplified farm systems. These processes have indeed enabled major increases in productivity, with yields for major cereals doubling between 1961 and 1991. According to FAO this helped avert a major food crisis in Asia, and resulted in a production level that could in theory provide every person with sufficient food (FAO, 1996). But with agricultural productivity now levelling off and an estimated world population of 9 billion by 2050, many researchers and policy-makers are focusing on the question of how to continuously increase productivity to be able to provide food for the future population (FAO, 2017; Foley et al., 2011; Godfray et al., 2010; The Government Office for Science, 2017).

After decades of policy and financial support leading to specialisation and industrial farming now being the dominating model for agricultural development current focus in policy and research on biotechnology is building on the same concept of uniformity, taking it even further to the level of genetics (IPES-Food, 2016). Some researchers argue that biotechnology, such as improved breeding and genetic manipulation of crops is, if not necessary (Tester & Langridge, 2010), at least part of the solution (The Government Office for Science, 2017). But other researchers object to another technological fix, since these kinds of measures has yet to solve hunger. Today, more than enough food is produced to feed the current world population, yet 815 million people are undernourished. Simultaneously, obesity is increasing globally, even in areas where undernourishment is prevalent. Out of the food produced globally for human consumption, 1.3 billion tons, corresponding to roughly one-third, is wasted or lost yearly (FAO, 2011). Moreover, industrial agriculture has resulted in negative effects on the ecosystem, such as pollution, soil degradation and erosion of biodiversity (Altieri & Nicholls, 2005; Björklund, Limburg, & Rydberg, 1999; Gliessman, 2007; IPES-Food, 2016; Pretty, 2003; Thrupp, 2000). These negative effects are limiting the ecosystems ability to provide ecosystem services – provisioning, regulating, supporting and cultural services that are vital to human survival and well-being (FAO, 2017, 2018; Rockström et al., 2009). Besides the provisioning of food, raw materials, clean water, and medicinal resources, humans rely on the ecosystem to regulate e.g. soil fertility and pollination, and to support complex ecosystem processes by providing habitat for species and maintaining genetic diversity. In addition, the ecosystem delivers vital cultural services such as nature-based recreation, aesthetic appreciation and inspiration, along with spiritual experiences (FAO, 2018). In their important work on planetary boundaries, (Rockström et al., 2009) and later (Steffen et al., 2015) have classified several ecosystem services into nine major planetary systems and modelled the boundaries for each system's safe operating space. Disturbing the planetary systems beyond these boundaries, would lead to irreversible changes that could threaten the survival of the human population (Rockström et al., 2009).

1.1.2 Biodiversity Under Threat

Biodiversity is one of the planetary systems that is most threatened. Genetic diversity of species provides our planet with the capacity to persist and adapt to non-biological changes. The loss of genetic diversity has already passed what Steffen et al. (2015) define as a safe operating space for humanity. This means that the humanly induced biodiversity loss that has already occurred poses a high risk of serious negative impacts on human society. Functional diversity, i.e. the diversity of species that perform different functions in the ecosystem, may be even more sensitive to human activities than species diversity is. Although boundaries are difficult to establish, researchers suggest that the decrease in functional diversity that has taken place between pre-industrial times and today, has led to a persistent loss in ecosystem services (Scholes & Biggs, 2005; Steffen et al., 2015). Intensification and specialisation in agriculture is negatively effecting biodiversity at both a landscape and a local scale (Tscharntke, Klein, Kruess, Steffan-Dewenter, & Thies, 2005). Landscapes are simplified both spatially and temporally in terms of land use types and crops, and in terms of fragmenting and removing habitats. At a local scale, the farming system is simplified through minimizing crop rotation cycles, increasing field sizes and decreasing crop diversity including intercropping, catch crops, etc. At both levels, specialisation can disrupt ecosystem services such as crop pollination, biological pest control and resistance to plant invasions (Tscharntke et al., 2005).

Insecurities remain about what levels or types of biodiversity loss may trigger irreversible changes to the ecosystem (Steffen et al., 2015). This means that biodiversity remains a highly complex issue, with great need for precaution. Researchers and advocates for sustainable agriculture are stressing the importance of re-introducing biodiversity to agriculture, as a tool for rebuilding resilience and minimizing externalities in the face of global changes and challenges (European Coordination Via Campesina, 2014; FAO & Platform for Agrobiodiversity Research, 2011; IPES-Food, 2016)

The international community has taken a first step to secure agrobiodiversity in our global food systems through The treaty on Plant Genetic Resources for Food and Agriculture (FAO, 2009). In Sweden the treaty has been implemented through "Programmet För Odlad Mångfald" – the program for cultivated diversity. Their main goal is to bring out biological cultural heritage to life and to promote increased use of our heritage plant genetic resources, for the sake of food security, sustainable agriculture, and the maintenance of biodiversity in Sweden (Börjeson, 2009). To reach this goal, farmers would have to diversify their cropping systems. But farmers are subject to market forces, and if there are little economic incentives, few will implement higher crop diversity at their farm by their own sense of responsibility.

1.1.3 The Agricultural Region of Scania – Specialisation and Lack of Biodiversity

In many countries farms have grown bigger during the latest decades (Eurostat, 2014). Since 80% of EU farms are less than 10 hectares, smaller farms are still in majority in EU. But roughly two thirds of the total utilised agricultural area in the EU is cultivated by the 5,9% largest farms, meaning that farm land is being controlled by fewer and fewer hands (Eurostat, 2014). Land concentration is further promoted by the per hectare direct payment scheme under the CAP (Kay, 2016). Through the process of capitalisation, the benefits of receiving payments are transferred into higher rents or sales prices for farmland (Matthews, 2016). This not only reduces the benefit of the direct payments to existing farmers and raise the cost of entering the agricultural sector for young farmers (Matthews, 2016), but also encourage expansion for those with capital to invest in (more) land (Kay, 2016). As farm size increases, the productivity gains from specialisation also increase, why there is an economic incentive for larger farms to specialise compared to smaller farms, which is also the overall trend in Europe (Chavas, 2008; Eurostat, 2016). This leads to a process of continued increase in farm sizes and in turn homogenous agricultural landscapes, and the development in Sweden has followed the same trend (Statistics Sweden, 2017).

In Scania (Skåne), one of Sweden's most important agricultural regions, this alteration of the landscape has caused loss of associated biodiversity in the form of wild plants and animals (Johansson, Jonasson, Rosenqvist, & Yngwe, 2014; The County Administrative Board of Scania, 2017). Agriculture's effect on the environment is highlighted in Sweden's environmental quality objectives towards 2020. The objectives 'a non-toxic environment', 'zero eutrophication' and 'a varied agricultural landscape' are all directly associated with agricultural activities. The current states for these goals in Scania are either negative or unclear, and according to assessments none of them will be reached by 2020. This is to some extent due to continued application of mineral fertilizers and agrochemicals - 60% of Sweden's total agrochemical use is applied in Scania - as well as lack of small biotopes and structural variation in the agricultural landscape (The County Administrative Board of Scania, 2017).

Almost two decades ago, Björklund et al. (1999) performed an analysis of the ability of Swedish agricultural landscapes to perform ecosystem services under intensive input-based and specialised agricultural systems, compared to the pre-green revolution systems of low-intensity. Already then they argued that external inputs had to be reduced and that the physical complexity of agroecosystems in Sweden would need to be restored, as well as the complexity in the variety of cultivated crops (Björklund et al., 1999). While measures have been taken since then to e.g. introduce ecological focus areas (European Commission, 2017), reduce tilling (Gustafsson & Johansson, 2008), and reduce inputs of harmful agrochemicals through integrated pest management (Swedish Ministry of Rural Affairs, 2013), Swedish agroecosystems remain simplified with high dependence of external inputs. Between the years 1988 and 2015, the use of agrochemicals has actually increased with about 48 per cent, partly due to poor crop rotations and crop choices seen from a pest management point of view (Miljömål, 2016).

1.1.4 Ecosystem Services and Benefits of Crop Diversity in Scania

As agriculture in Scania follows a general global trend, the region can be used as a study area for exploring the link between resilience of agricultural systems and crop diversity. In this section, the ecosystem services status of agricultural landscapes in Scania are described in further detail, as well as the potential for crop diversity to support these ecosystem services. This literature review also illustrated the potential for crop diversity to create resilience in agriculture worldwide, since the underlying mechanisms are the same.

In 2013, researches Dänhardt et al. (2013) at Lund University produced a report on the state of, and threats to ecosystem services in agricultural landscapes in Scania, and proposed measures to support them. The report examined pollination, ecosystem services related to open waters and soil formation, nutrient retention and climate control, as well as biological control of pests, diseases and weeds. These have all been compromised during many decades by the intensification and simplification of the agricultural landscape (Dänhardt et al., 2013). Some of their main results are presented below.

Pollination

Out of all the worlds food crops 35% depend on animal pollination (Klein et al., 2007). Wild pollinators have been shown to pollinate crops more effectively than commercial honeybees (Garibaldi et al., 2013). But as a result of agricultural intensification, wild pollinators worldwide are threatened by the use of agrochemicals, and the loss of small biotopes and natural grasslands that provide nesting habitat and food sources across the season (Kremen, Williams, & Thorp, 2002). In Scania, this is especially a problem in the intensely farmed plains where species diversity and density of pollinators are lower than in the other production areas (Rundlöf, Nilsson, & Smith, 2008). To support wild pollinators in Scania, the authors Dänhardt et al. (2013) suggested increasing natural grasslands and small biotopes, creating flower strips to provide food, and increasing organic crop production, both to provide more flowering wild plants and to reduce the application of chemicals that are directly harmful to pollinators.

Biological Control

The species diversity and abundance of natural enemies to agricultural pests has been in decline for a long time in Scania due to agricultural intensification (Dänhardt et al., 2013). The state of this ecosystem service is poor (Dänhardt et al., 2013), and risk of outbreaks in Sweden are increasing with climate change (Swedish Board of Agriculture, 2012). While chemical control can be effective in short term, they harm non-pest organisms, including beneficial organisms (see e.g. (Pisa et al., 2015)). In Scania pesticides have been found to contaminate the groundwater (Rabow, 2017). Moreover, the development of resistance to agrochemicals in pathogen and pest populations will always implicate the need to produce new products (Withgott & Brennan, 2011). Conserving or creating new habitats for natural enemies can substantially reduce the need for pesticides and also increase harvest (Östman, Ekbom, & Bengtsson, 2003). Diversifying crop rotations, as well as increasing structural variation of crops at field and farm level provides habitats for natural enemies, in addition to disturbing and limiting the population growth of pests and pathogens (Rusch, Bommarco, Jonsson, Smith, & Ekbom, 2013; Swedish Board of Agriculture, 2012).

Soil Functions

Crop diversity can also play an important role for enhancing the content of soil organic matter (SOM) and the associated soil ecosystem services. Soil microorganisms promote water regulation, counter soil compaction and provide stable nutrient availability and climate change buffering through their decomposition of SOM and binding of soil carbon (SOC) (Smith, Gross, & Robertson, 2008). But due to short crop rotations, extensive tilling, low return of organic matter and high rates of agrochemical application, soil organisms are decreasing in terms of biomass, abundance as well as diversity, which in turn leads to declining content of soil organic carbon (SOC) (Soilservice, 2012; Tsiafouli et al., 2015). Ecosystem services from soil organisms cannot be substituted fully by inorganic fertilisers, and management practices that build up SOC and SOM are necessary to secure fertility of agricultural soils (Soilservice, 2012). Increasing crop diversity can significantly improve soil ecosystem services, and some examples are introducing cover and green manure crops and increasing perennials and the use of ley (Dänhardt et al., 2013). Diversification of conventional cropping systems in Scania through introducing 1-year ley has been shown to significantly increase levels of SOC, total nitrogen, water holding capacity as well as microbial biomass in the soil (Albizua, Williams, Hedlund, & Pascual, 2015). In a Danish study, diversification through intercropping has also been found to improve nutrient uptake, and in addition produce greater yields and weed-competition (Hauggaard-Nielsen, Ambus, & Jensen, 2001).

The scientific findings above show that crop diversification serves as an important tool for the maintenance of ecosystem services in Scania. This resonates well with international experts view on sustainable food systems (FAO & Platform for Agrobiodiversity Research, 2011; IPES-Food, 2016). Besides climate change mitigation, there are other long-term benefits of crop diversity. The reduced impact from a single crop failure and price fluctuations can provide economic stability (Magdoff & van Es, 2009), and the conservation and development of plant genetic resources adapted for future conditions can greatly increase food security (Thrupp, 2000).

1.2 Problem Statement

Researchers, policy-makers, civil society and farmers alike have expressed the need to halter the negative effects of agriculture, and to adopt more sustainable practices (+130 Civil Society Organisations, 2017; European Coordination Via Campesina, 2014; Foley et al., 2011; Pe'er et al., 2017). In the face of declining areas of agricultural land, unpredictability and changes in agricultural conditions due to climate change and disruption of ecosystem functions, there is an even more pressing need for agricultural systems to rely more on the inherent ecosystem processes and functions of a natural ecosystem rather than high levels of inputs and external control. Increased crop diversity can support a range of important ecosystem services in agricultural landscapes such as pollination, biological control of pests, diseases and weeds, ecosystem services related to soil formation, nutrient retention and climate control. This can be accomplished since crop diversity reduces the need for harmful agrochemicals, promotes more natural enemies and increases soil health. Therefore, traditional ecosystem-based practices, such as crop rotation and intercropping, are once again important tools for the sustainable maintenance of our future agricultural systems, not least for pest and disease management. But the trend is moving in the opposite direction towards continued simplification and specialisation, and ecosystem services in Scania are under threat (Dänhardt et al., 2013).

Despite the so-called greening efforts of the latest reform 2014-2020 (European Commission, 2017) the European Common Agricultural Policy (CAP) has been criticised for being inefficient and inadequate in improving biodiversity and other ecosystem services in European agriculture (Leventon et al., 2017; Pe'er et al., 2017). Moreover, policies, research and the agroindustry, are built around large-scale and specialised agriculture, thereby acting as a barrier towards more holistic changes (IPES-Food, 2016).
Nevertheless, in spite of ineffective policies and lack of incentives, some farmers might adopt more diverse cropping systems than others. This could either be driven by own values and motivations, or by external drivers in their socio-economical or ecological environment. Understanding such underlying

motivations is important for implementing policies and cooperation between farmers and other stakeholders, that can lead to increased crop diversity in Swedish agricultural systems. To analyse and describe factors that contribute to either increase or decrease in crop diversity, there is moreover a need for mapping crop diversity at regional as well as national level.

1.3 Aims and Objectives

1.3.1 Aims

The aims of this study are to map farmers' crop diversity in the Swedish county Scania, and to explore if more diverse cropping systems appear to be clustered. To investigate the potential relationships between farmers' perceptions of incentives and benefits of crop diversity and their decision to implement a more or less diverse cropping system, the further aim is to explore farmers' motivations for crop diversification.

1.3.2 Objectives

In order to achieve the aims, the following objectives have been set:

i. Collect and process agricultural land and crop data to create a geo-referenced map with cropping systems of individual farmers in Scania.
ii. Assess the crop diversity of these cropping systems expressed as the number and evenness of crops grown in a year and produce a map that visually reveals geographical distribution of crop diversity in Scania.
iii. Analyse the crop diversity maps to test if farms with high crop diversity are distributed in geographically coherent clusters.
iv. Through a mix of structured and semi-structured interviews collect information about farmers' motivations for increased crop diversity.
v. Identify potential relationships between clusters (if present) of higher crop diversity and farmers' motivations and perceived constrains/opportunities for crop diversification.

1.3.3 Research Questions

The main research questions for this study is:

- Why are cropping systems more or less diverse?

The sub-questions are:

1. What does the geographical distribution of crop diversity look like at the regional level?
2. Is there a cluster pattern in the distribution of crop diversity that indicates a correlation between neighbouring farmers?
3. What are the motivations behind farmers' crop diversification?

1.3.4 Thesis Outline

This thesis is divided into six chapters. The first chapter has provided an overview of the socio-ecological challenges of modern agriculture, the current state of biodiversity, and the potential benefits of crop diversity in the study area, Scania. The problem statement and the aims and objectives have been defined, and the next chapter will state the frame of reference for the thesis. In order to approach the topic of crop diversity in a holistic way, this thesis takes its starting point in a broad theoretical framework, ranging from ecological to psychological theory. Furthermore, quantitative and qualitative data and methods of inquiry are combined in order to answer the research questions from both a social science and natural science perspective. In practice, this meant that two separate studies took place, first a crop diversity assessment, and then, and interview study with farmers. This is also reflected in the following thesis structure, where the chapters Materials and Methods, Results, Discussion and Conclusions and Recommendations are divided into two sub-sections, one outlining the quantitative study and the other outlining the quantitative study. The two different methods of inquiry helped to reach a holistic understanding of crop diversity; its geographical distribution and the motivations behind it.

2 Frame of Reference

Agriculture is a complex socio-ecological system. People are the central driving force of agriculture and understanding why farmers manage their land the way they do, is as important as understanding how their management strategies affects the ecosystem. Integrating natural and social sciences is therefore needed to perform a systemic analysis that studies both crop diversity and farmers' motivation for diversification. This chapter provides the theories and concepts that form the basis for this study. Firstly, the overarching concept of agroecology is described, which establishes the importance of systemic analysis in agricultural research. Resilience theory is thereafter explained as the principle underpinning the benefits of crop diversification. Finally, self-determination theory is presented as the guiding theory for analysing farmers' internal and external motivations for their cropping system, and for crop diversification.

2.1 Agroecology

Agroecology includes various approaches to deal with the sustainability challenges in our global food system. Although agroecology was first developed as a scientific discipline in between the 1930's and 1960's, it has since evolved to also include a set of agricultural practices as well as a social movement (Wezel et al., 2009). The three branches of agroecology are interconnected through peoples shared goals to transform the food system, and through re-enforcing each other through learning and cooperation across the different fields of work. Guided by both ecological principles and principles of equity, agroecology today encompasses the study, design and management of agricultural systems - and food systems as a whole - that conserves natural resources while also being productive, economically viable, culturally sensitive and socially just (Francis et al., 2003). Through incorporating both the ecological, economic and social dimensions, agroecology embodies the concept of sustainable development (World Commission on Environment and Development, 1987) within the field of food systems.

As an agricultural practice, agroecology is contrasted to industrial agriculture, and the socio-ecological problems it has resulted in. The design and management of agricultural systems (agroecosystems) takes its starting-point in understanding ecological processes. Beneficial ecosystem processes are incorporated into the design, mimicking the structure and function of natural ecosystem, such as high species diversity, biologically active soil, natural pest control, and low resource losses thanks to high soil cover and nutrient cycling. Such a design can create a production with less dependence on inputs, while improving the productive capacity (Altieri & Nicholls, 2005). Altieri and Nicholls (2005) defines the basic ecological principles that guide such agroecological design as 1) optimising recycling of biomass and nutrient flow, 2) enhancing organic matter and biotic activity in the soil, 3) minimising resource losses through increased soil cover, water harvesting and establishment of microclimates, 4) creating genetic and species diversity in both time and space, and 5) supporting ecosystem services by enhancing beneficial processes by crops and other organisms in the agroecosystem. These principles are applied differently at different locations, adjusting to the local ecosystem.

Besides the practical measures at farm level, many researchers, farmers and social activists alike mean that agroecology also involves social, cultural and political aspect throughout the entire food system (Altieri & Toledo, 2011; Coordination Nationale des Organisations Paysannes du Mali et al., 2015; Francis et al., 2003; Gliessman, 2007). The food sovereignty movement, including La Via Campesina and other peasant organisations are especially strong advocates for agroecology (European Coordination Via Campesina, 2014). With food sovereignty they mean that people do not just have a right to sufficient food, but also to healthy and culturally appropriate food that is produced sustainably. Moreover, food sovereignty means that food producers have the right to control their land and other natural resources, and that the interests of food producers, consumers and future generations should shape food policies, not the demands of markets and corporations. For the food sovereignty movement, agroecology has become a tool for achieving these goals, and to reshape the food system (Coordination Nationale des Organisations Paysannes du Mali et al., 2015). Many scholars share the food sovereignty movement's views on the need for a substantially different food policy, and on the need to put control back to farmers and consumers (Altieri & Nicholls, 2005; Altieri & Toledo, 2011; Gliessman, 2007; Rosset, 2008, 2011). The vital role of people in agriculture has been increasingly emphasized by agroecologists in academia through trans-disciplinary research (Francis et al., 2003; Méndez, Bacon, & Cohen, 2013), and by involving farmers, consumers and communities in participatory and action oriented research (Altieri & Toledo, 2011; Méndez et al., 2013). Such research processes value different types of knowledge, both scientific and local, experience-based knowledge held by farmers (Méndez et al., 2013).

Finally, a concept that over time has become central in agroecology is re-establishing a more direct connection between those who grow the food and those who consume (Altieri & Nicholls, 2005; Gliessman, 2007). Shortening food supply chains releases financial resources to farmers for sustainable practices and reduces transport and energy consumption for storage. Localizing food systems can also support a shift towards healthy and seasonal diets, crop and species diversity at the farm and landscape level, along with generating income for the local community, thus contributing to both ecological, social and economic sustainability (Gliessman, 2007). Based on agroecology, it is highly motivated for this study to take an interdisciplinary approach, taking the topic of crop diversification, a practice supported by ecological theory, and using ideas and methods and both natural and social science to explore crop diversity in Scania, as well as identifying drivers and farmers motivation for crop diversification. Below, the benefits of crop diversity is described with ecological concepts from resilience theory, after which self-determination theory is presented, and it is explained how the theory can contribute to the understanding of farmers crop diversification.

2.2 Resilience Theory

Resilience theory was for the first time described by (Holling, 1973) as a way to describe the dynamics of our ecological systems and their capacity to absorb change. The theory has been an important foundation for the development of sustainably science, as well as many other fields, and have had a great impact on policies regarding sustainable development (Folke 2016). Based on Carpenter *et al.* (2001) and Folke *et al.* (2002), a general definition of resilience in socio-ecological systems can be divided into three general properties: 1) the ability to absorb disturbances, 2) the capacity of self-regulation, and 3) adaptive capacity. These properties are further described below.

2.2.1 Ability to Absorb Disturbances

Central to resilience theory is the understanding that ecological and social-ecological systems are dynamic. One of the three major properties of resilience, a systems ability to absorb disturbances while still maintaining its structure and function (Carpenter et al., 2001). As Gunderson (2000) argues, humans induce disturbances to ecosystems to the degree that that they can't be absorbed, and the systems thus change into a new, undesired state and function. This is e.g. done by interfering with species population at a local level, or by contributing to global climate change through the burning of fossil fuels.

2.2.2 Capacity of Self-Organization

The second feature of resilience is the system's capacity to organize itself (Carpenter et al., 2001). The various interactions that take place between species and process within a defined ecosystem create large-scale and complex patterns, such as climate regulation, landscape formation, nutrient cycling etc. The emergent large-scale properties feed back to the systems components, and re-enforce their interaction (Kauffman 1993; Levin 1999, see Folke et al. 2002). The emergent properties of these complex interactions are some type of order and behaviour of the ecosystem, in other words self-organisation (Gunderson, 2000). This can be contrasted with organization that is forced by external factors. Agriculture is an example of such external organisation, although to varying degrees depending on the farming methods. The concept of self-organisation is also central to agroecology, which argues that the higher similarity of an agroecosystem to the local natural ecosystem, the higher its sustainability (Gliessman, 2007). In other words, the more human intervention and external organisation of an ecosystem, the lesser the degree of self-organisation, which makes the system more vulnerable.

2.2.3 Adaptive Capacity

Finally, the third feature of resilience is the "the degree to which the system can build and increase the capacity for learning and adaptation" (Carpenter et al. 2001, p. 766). Again, it reflects that systems are dynamic and undergo continuous re-organisation, and the adaptive capacity of a system explains its behavioural response to disturbances. Systems with high adaptive capacity have the ability to re-organise themselves, without significant decline of essential functions, such as primary production and hydrological cycles in ecological systems, or social relations and economic prosperity in social systems (Folke et al., 2002). When diversity exists at every level, the system's ability to adapt to change and disturbance is high. The same concept can be applied to agroecosystems, where it is referred to as agrobiodiversity. In the following section, the concept of diversity is the described from the perspective of crop diversity in agroecosystems.

2.3 Resilience in Agriculture Through Crop Diversity

Agriculture is often a way of managing natural resource to produce high yields in a short-term, which often involves focusing productivity to a reduced number of species, creating less diversity in both space and time. This produces less beneficial functions, and there is less response diversity to uphold the functions during disturbances, be they biophysical, economic or social events (Peterson, Allen, & Holling, 1998). The capacity of the agroecosystems to produce goods and services thus becomes more vulnerable to disturbances and environmental, social or political change. When agroecosystems on the other hand are planned to include a diversity of species (both crops and non-crop plants), they can provide a diverse set of functions as well as responses to disturbances, and thus sustain the productive capacity for the future (Folke et al., 2002). When the concept of diversity is applied to agroecosystem, it can be expressed at three levels: genetic diversity within a crop, species diversity within a field or farm, or structural diversity within a landscape (Lin, 2011).

Just as diversity is the foundation for adaptive capacity in natural ecosystems, diversity in agroecosystems enhances beneficial ecosystem processes and provides options under various disturbances. Crop diversity is thus essential for sustaining resilient agroecosystem, than can continue to provide the vital services of food, fodder and fuel production, now and in the future (Altieri, 1999; Lin, 2011). In section 1.1.2, different examples of disturbance in agroecosystem were described, along-side the beneficial ecosystem processes provided by crop diversity. From a theoretical perspective, these processes can be divided into two groups: functional diversity and response diversity. The next sections will explain the theoretical understanding of functional and response diversity, after which some of the ecosystem services provided by crop diversity will be presented with examples and categorized under these two of types processes.

2.3.1 Functional Diversity

In any given ecosystem there are a range of different organisms, which each holds one or several specific function, such as pollination, predation, nitrogen fixation, soil generation etc. Different species can occupy the same function in the system, either at the same or at different temporal and spatial scales. These species can be categorised as a functional group for that given system (Peterson et al., 1998). Having both a diversity of functional groups, as well as a diversity of species within that group, is needed to sustain the adaptive capacity of a system. When diversity in a functional group is low, the loss of just one species might lead to loss of function, if there is no other species left to perform it (Folke et al. 2002). For agroecosystems, this means that the function needs to be externally maintained, e.g. by substituting natural predation on a pest with pesticides. Cultivating a small number or crops thus limits the ecological functions that can be provided by the agroecosystem, while a greater combination of crop species through intercropping and crop rotation holds the possibility to deliver more ecosystem functions. Some examples of ecosystem services that are obtained from functional diversity in diversified cropping systems are presented in table 1.

Table 1. *Ecosystem services emerging from functional diversity in the cropping system.*

Ecosystem service	Crop diversity measure	Example of reference
Weed suppression, yield increase	Intercropping of two or more crops in the same field	Hauggaard-Nielsen *et al.* (2001)
Yield increase	Varied crop rotation, cover crops	Smith *et al.* (2008)
Pest control through natural enemies	Increasing the length of cropping sequence and the diversity of crops, in combination with management that conserves or restores semi-natural habitats.	Rusch *et al.* (2013)

2.3.2 Response Diversity

Although species that occupy the same function can be grouped together, most species perform more than one function in a given ecosystem and belong to several groups. This means that there is overlapping of functions between groups. Moreover, species that share the same function usually respond differently to changes in their environment, which is called response diversity. The higher the response diversity in an agroecosystem, the better is it to cope with disturbances, while still maintaining its functions. This means that a species that seem redundant from a productivity perspective can prove to be essential when disturbances emerge. One example is that different grass species respond differently to changes in rainfall patterns or grazing pressure (Folke et al., 2002). A few other examples are presented in table 2.

Table 2. Ecosystem services emerging from response diversity in the cropping system.

Ecosystem service	Crop diversity measure	Example of references
Food sovereignty and nutritional security	Growing a diverse set of crops	Bachmann, Cruzada, and Wright (2009)
Increased soil microbial biomass, improved soil structure and fertility	Including ley in crop rotation	Albizua, Williams, Hedlund, & Pascual (2015)
Disease control	Crop rotation	Peters *et al.* (2003)
Climate variation buffering	Intercropping	Tengö and Belfrage (2004)

2.4 Self-Determination Theory of Human Motivation

While understanding how crop diversity supports ecosystem services is important for improving sustainability in agroecosystems, it is just as important to understand why farmers adopt such practices, and what drivers and barriers they perceive themselves. Motivation serves as a useful concept to explore these questions, since the consequence of motivation is production (Ryan & Deci, 2000), in this case the production of crop diversification and hence ecosystem services. Through trying to listen to farmers and understand their motivations, there might be insightful knowledge to be gained for further research and policy aimed at farmers' adoption of crop diversification. Self-determination theory (SDT) is a theory that deal with human motivation and is therefore chosen for the overall analysis of farmers' motivations for their cropping systems and crop diversification. SDT has been developed over many years and is the principal theory of human motivation within the field of social psychology. The theory is suitable for identifying farmers' own values and internal motivations, as well as their external drivers, and how these affect their motivation for crop diversification.

Ryan and Deci (2000) describes how social environments have the potential to both foster and undermine positive human potential, such as motivation and personal growth. Self-determination theory relates to people's innate psychological needs, defined as: 1) the need for competence, 2) the need for relatedness, and 3) the need for autonomy. When people feel competent in performing and action, and feel supported and connect with their social environment, they become more motivated and perform their tasks with greater interest and enjoyment. The same has been shown for people who experience sense of autonomy, in other words self-control over their actions. Based on these findings, SDT has further examined the environmental factors that either fulfil or hinder these needs, and describes the relationship between behaviour, people's motivation and the level of regulation on their actions from their social environment. Ryan and Deci (2000) groups these into different categories on a scale of perceived autonomy, ranging between non-self-determined to self-determined behaviour. A simplified diagram of the categories is shown in figure 1. The most self-determined is the intrinsic motivation. According to psychological theory something that is inherent in all humans and can be defined as showing a spontaneous interest even in the absence of specific rewards.

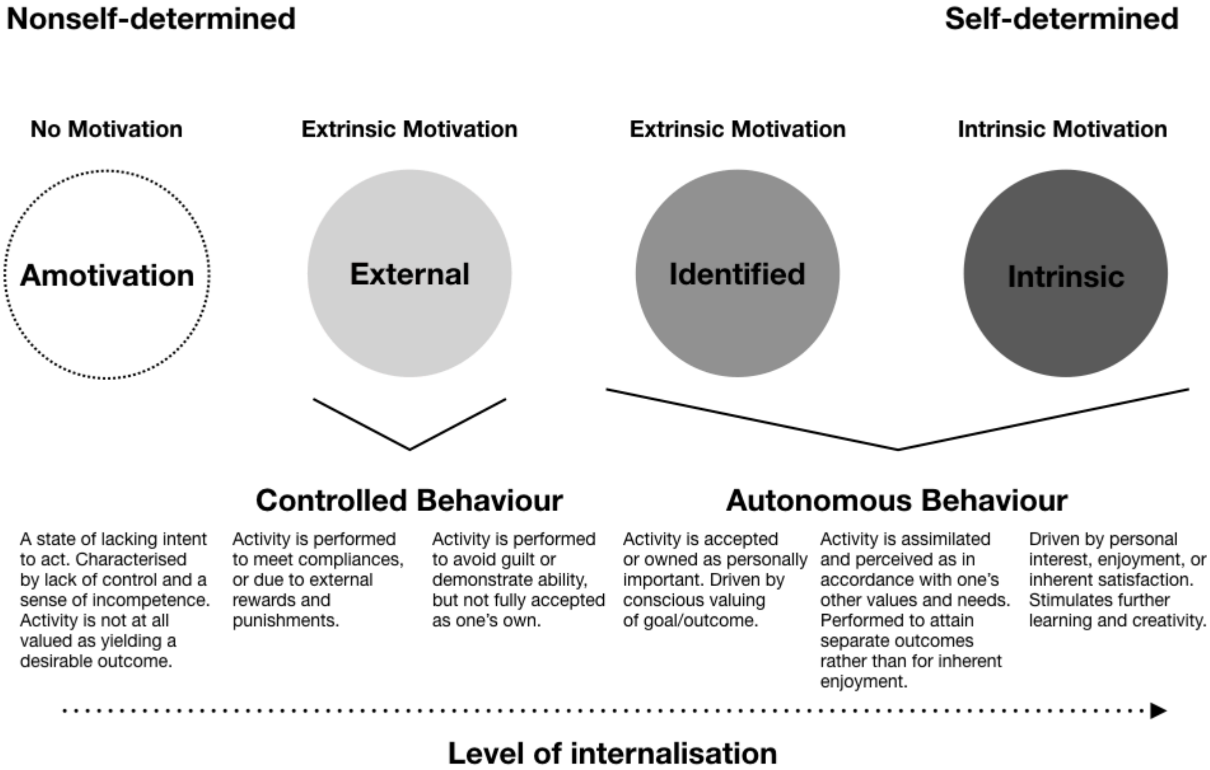

Figure 1. The Self-Determination continuum: The figure shows three main types of motivations and their level of internalisation with the individual. The figure also shows the type of behaviour that is induced by the different motivation types. Based on Ryan and Deci (2000) and the adaptation of SDT used by Garini et al. (2017).

Intrinsic motivation is awakened and will flourish in individuals if the circumstances are facilitating (Ryan & Deci, 2000). In contrast, the non-self-determined state is when an activity is not valued, when it is not expected to generate a desired outcome or when the person doesn't feel competent to perform it, people lose their intention to act an become unmotivated. In between these two opposites lies extrinsically motivated behaviour, which is characterised by individuals feeling controlled and alienated from the activities demanded by them. Activities can e.g. be performed only to meet external compliances and to benefit from external rewards, or to achieve internal rewards by demonstration ability to others. If the individual accepts the activity, internalise it and finds it to generate a valuable outcome, this type of extrinsic motivation is called identified, and with an even higher degree of internalisation, the individual might even find the activity to comply with personal values and needs (Ryan & Deci, 2000). The theory has previously been used to e.g. explore influence from policies and drivers of adoption of agroecological practices amongst winegrowers in Italy with satisfying results (Garini et al., 2017). In this study, the theory will be used to explore why some farmers choose to diversify their cropping systems, through identifying what type of motivation that influence these actions, and what factors in their social environment as farmers are fostering or hindering their motivation for crop diversification.

3 Materials and Methods

This chapter first describes the study area that the analysis is based on, in terms of some brief national farm statistics and policy framework, as well as general agricultural land use trends in Scania. Thereafter, the chapter presents the materials that were used, and explains how they were prepared and analysed, first for the quantitative data used for studying crop diversity, and then for the qualitative data used to explore farmers' motivation for crop diversification. The validity and reliability of materials and methods are also discussed in this chapter.

3.1 Study Area

3.1.1 Agriculture in Sweden

The total amount of agricultural land in Sweden is approximately 3 085 364 hectares and covers about 8 per cent of Sweden (Statistics Sweden, 2013, 2014). Agricultural primary production accounts for only 1,2 per cent of the labour force in Sweden, and in 2016 the number of workers in Swedish agriculture were 171 400 (Swedish Board of Agriculture, 2016a, 2017b). There are about 63 000 farms in Sweden today, compared to more than twice as many in the 1970's, while production levels have not decreased (Swedish Board of Agriculture, 2017b). Whilst the number of farms is decreasing, farms are growing larger and larger. In 1990, the average Swedish farm size was 29,5 ha, and today it is 41 ha (Statistics Sweden, 2017).

In terms if economic value the production of animal products, is about equally big as the production of cereals, ley and other arable crops, although the used arable land is almost six time as big as the land used for pasture (Statistics Sweden, 2017). The total amount of arable land and its use for different (selected) crops are listed in table 3. The Common Agricultural Policy (CAP) of the European Union is the most important regulatory framework for Swedish Agriculture. Its three key objectives are: viable food production, sustainable management of natural resources and climate action and balanced territorial development. To support these, the latest reform 2014-2020 had the reform objectives of enhanced competitiveness, improved sustainability and greater effectiveness (European Commission, 2013a).

Table 3. Arable land in Sweden by crop, 1 000 hectares*. Source: (Statistics Sweden, 2015, 2017).*

Arable land, crop (1 000 ha)	1990	2014	2016
Total arable land	2 845	2 597	2 580
Wheat	350	455	451
Rye	73	27	17
Barley	…	335	327
Oats	388	165	181
Mixed grain	33 (incl. triticale)	14	13
Triticale	…	38	31
Potatoes	36	24	24
Sugar beet	50	34	31
Leys, other fodder	918	1 172	1 107
Oilseed	…	103	101
Other crops	…	97	128
Fallow, untilled arable land	193	132	169

The structure of the CAP is in the form of two pillars: pillar 1 for direct payments per hectare, that accounts for about 70% of the CAP budget, and pillar 2 for rural development, that accounts for roughly 20% of the CAP budget (European Commission, 2013b). Under the CAP 2014-2020, there is a possibility to transfer up to 15% of the budget between the two pillars, which Sweden has chosen not to do (Swedish Board of Agriculture, 2016b). The second pillar of the CAP is partially funded by the member states, and while they have to comply with a set of EU priorities, it is the member states themselves that shape their own rural development program (European Commission, 2016). In Sweden, the rural development program offers: environmental investment support, environmental compensation, compensation for organic production, compensation for areas with natural constraints, animal welfare payments and support for business investments, joint projects and local joint development projects.

A new policy instrument directed to the provision of environmental public goods was implemented with the latest CAP reform to achieve improved sustainability. This instrument is the Green Direct Payment, also referred to as the greening (European Commission, 2013a). The greening reform included three new requirements for direct payments of the first pillar: Ecological Focus Areas (EFAs), Permanent Grasslands and Crop diversification – cultivation of minimum three crops (European Commission, 2017). The EFA requirement, that require farmers with more than 15 ha to set aside part of their land for nitrogen-fixing crops, fallow, short rotation coppice (willow), catch crops (under-sown grass), or non-cultivated field margins (Swedish Board of Agriculture, 2019a), was in 2016 evaluated by the Swedish Board of Agriculture (2016b) as the most environmentally beneficial greening requirement. The crop diversification requirement on the other hand was evaluated as highly ineffective and lead to almost no environmental benefits in Sweden. Since the majority of farmers affected by the requirement already cultivated at least three crops, the measure only lead to crop diversification for five per cent of farmers, and about 0,5 per cent of arable land (Swedish Board of Agriculture, 2016b).

3.1.2 Agriculture in Scania

Scania has historically been called 'the breadbasket of Sweden', and the county still provides 40 per cent of Sweden's total harvest of the most common cereal and oil crops, as well as potato and sugar beet. Arable land and pastures cover roughly half of the area of Scania and some of the best quality soils in terms of production capacity are located here (The County Administrative Board of Scania, 2016). The primary land uses in Scania are shown in figure 3. The agricultural labour force in Scania is declining, and small and medium-sized farm operations are becoming fewer, with an average farm size of 53,6 ha (Statistics Sweden, 2017). That is about five times bigger today than they were 70 years ago, and the trend of specialized crop production by fewer and larger farms dominating agriculture is expected to persist (Johansson et al., 2014). While there is not necessarily a causal link between farm size and crop diversity, the productivity gains from specialisation increases with farm size (Chavas, 2008). There is therefore a risk that that the trend towards larger farm has a negative effect on crop diversity and the associated ecosystem services. Although the continued application of mineral fertilizers and agrochemicals, and the simplification of the agricultural landscape (The County Administrative Board of Scania, 2017) are big contributors to the degeneration of ecosystem service, the decline of arable land in favour of urbanisation and infrastructure development is further contributing to landscape homogenisation (The County Administrative Board of Scania, 2016). Nevertheless, specialisation is focused on different crops in different areas, and regional differences in crop production can be described using five main farming areas: the 'Mixed farming area' (Blandbygden), the 'Middle area' (Mellanbygden) the 'Forested area' (Skogsbygden), the 'Plains, mixed farming' (Slättbygd, blandad växtodling), and the 'Plains, specialised farming area' (Slättbygden, specialiserad växtodling). These are show in figure 2.

In general, intensive arable crop production dominates the plains, while in the Forested area most land is not suitable for such production. Milk and beef production are instead the major farm activities, and the cropping systems are instead dedicated almost entirely to ley, with some additional fodder crops, to support milk and beef production. About half Mixed farming area have the same characteristics, while it also contains some areas where the cropping systems are more focused on cereal crops, as well as pig production. In the Plains with specialised farming most of the arable land is used to grow crops such as sugar beets, vegetables, oilseed and cereals. In the Plains with mixed farming about half of the labour input is dedicated to animal production, while the other in crop production as well as horticulture. The Middle area has a very mixed farm profile. Both milk and pig production are substantial, and ley crops cover about a third of the area. But there is also a significant production of both cereals and other arable crops. The overall trend in Scania is that the specialisation in the different farming areas is growing stronger (Johansson et al., 2014).

3.2 Quantitative Data - Cropping Systems in Scania

3.2.1 Limitations

Due to the time constrains associated with a master thesis and the data treatment being time consuming, the study will be based on data from one year. Although one year does not provide complete information about all crops in the crop rotation, the crops present in one year does provide an indication of whether the cropping system has a high number of crops or not. The year 2014 is it the most recent year for which there is contact information to farmers that can be linked to the geographical data and crop data, why this year is chosen for the analysis.

The fields and crops that are included in the analysis are furthermore limited to those that farmers have applied agricultural subsidies for during the time period analysed, since there is no geographical data on agricultural fields for which farmers have not applied for subsidies. Moreover, only crops that can be considered to be included in a crop rotation with annual crops are chosen for analysis. Other more permanent crops, such as leys for pasture, fruits and bioenergy tree crops are considered as a separate sub-system, and although perennials and pastures play an important role for ecosystem services, these would be better evaluated for in a different type of study, and not assessed with annual crops for crop diversity. See the full list of excluded crops in table 5.

3.2.2 Data Collection and Preparation

Datasets that were used in this study are provided for free by the Swedish board of agriculture and Lantmäteriet. Crop data was obtained from Dawa Statistik, block and parcel were obtained via the SLU GIS database and land use data was collected with the Geodata Extraction Tool (GET) download service at http://maps.slu.se/get.

Table 4. *Datasets used in this study.*

Dataset	Source	Data type	Description	Use
Parceldata 2014	SLU GIS database	Vector	Farm parcels in Sweden	Map presenting distribution of crops in Scania
Blockdata 2015	SLU GIS database	Vector	Farm blocks in Sweden	Map presenting distribution of farm-based crop diversity index in Scania
SAM data 2014	Swedish Board of Agriculture, Dawa Statistik. Provided by the Rural Analysis Division.	Excel table	Crops grown in Scania or by a farmer living in Scania.	Calculating crop diversity index for farmers with one or more parcels in Scania
Översiktskartan 2017	GET download service	Vector	Land use and administrative borders	Maps present land use and farming areas in Scania

Two of the main datasets Parceldata (skiftesdata in Swedish) and Blockdata contain geographical information that can be processed and presented with Geographical Information Systems (GIS). Parcels mark the area for one single crop, grown by one farmer. This classification of farmland primarily serve an administrative purpose, when farmers report what crops they plan to grow in each of their parcels in their SAM-application – the yearly applications for farm subsidies from the Swedish board of Agriculture (Swedish Board of Agriculture, 2018c). The parcel dataset is a vector data file containing all the agricultural parcels in Sweden, their area and location, as well as what farm block they are located in. Farm blocks are another administrative classification that divides farmland by natural boundaries such as roads, lakes, forests and stone walls. A block consist of one or more parcels that all are cultivated by the same farmer (Swedish Board of Agriculture, 2018c). The Blockdata vector file for 2015 has the best geographical match with the Parcel data reported for 2014, why this year was chosen.

The primary dataset for the crop diversity index calculation is a table including all parcels in Scania, as well as parcels outside of Scania that are managed by a farmer living in Scania. The table is also a product of the SAM-application 2014 and includes the farmers' user IDs assigned by the Swedish Board of Agriculture, the ID of all their respective farm blocks, the crop codes and area (ha) reported for each farm parcel. This table (hereafter called SAM data 2014) was joined with the dataset Parcel data 2014 for presenting the distribution of crops classes in Scania, and with the dataset Block data, for presenting the distribution of crop diversity indices in Scania.

Table 5. *Eight parcel classes were excluded from analysis.*

Parcel classes excluded from analysis	Comment
Pastures (not arable land)	
Zone of protection	Field edges
Adjusted zone of protection	Within fields
Fruit production	Classified as permanent crop
Nursery with production of permanent crops	Classified as permanent crop
Hybrid aspen (energy tree crop)	Energy crop classified as permanent
Willow (energy tree crop)	Energy crop classified as permanent
Other berry production	Classified as permanent crop

All datasets were prepared using the software environment ArcGIS 10.5/6. The SAM data 2014 included 143 253 parcels and 54 crop classes (out of 84 possible, presented in Appendix 3) defined by the Swedish Board of Agriculture. To provide a basis for analysis that reflects farmers' crop rotation, some parcel classes that represent a separate, more permanent system were excluded from the initial parcel dataset. These are found in table 5. Pastures were excluded from the dataset since these are rarely included in crop rotations with annual crops. Moreover, the benefits of these grasslands would be better assessed separately, and with species information that is not available as geographical data. Zones of protection fulfil a specific purpose of reducing nutrient runoff and are located at field edges or e.g. around surface water wells or hollows in the field (Swedish Board of Agriculture, 2017a).

Table 6. *Crop classes that were grouped together to create less of a bias in the dataset.*

Crop classes defined by the Swedish Board of Agriculture	New crop classes
Annual/biannual ley and cultivated grassland on arable land	Ley
Ley and cultivated grassland on arable land with ley crop not approved for agri-environmental payments	
Ley and cultivated grassland on arable land	
Spring wheat	Spring cereals
Spring barley	
Oat	
Winter wheat	Winter cereals
Winter barley	
Winter triticale	
Rye	
Spring oilseed rape	Spring oil crops
Spring turnip rape	
Oil flax	
Sunflower	
Winter oilseed rape	Winter oil crops
Winter turnip rape	
Table potatoes	Potatoes
Potatoes for processing of starch	
Soybean for fodder	Grain legumes
Soybean for oil	
Processing peas	
Green peas	
Field beans	
Sweet lupin	
Vetch	
Cereal/legume mix (more than 50% cereal)	Cereal/legume mix
Protein crop mix (legumes/cereal)	
Green fodder	
White mustard	Catch crop
Oil radish	
Sugar beets	Fodder and sugar beets
Fodder beets	

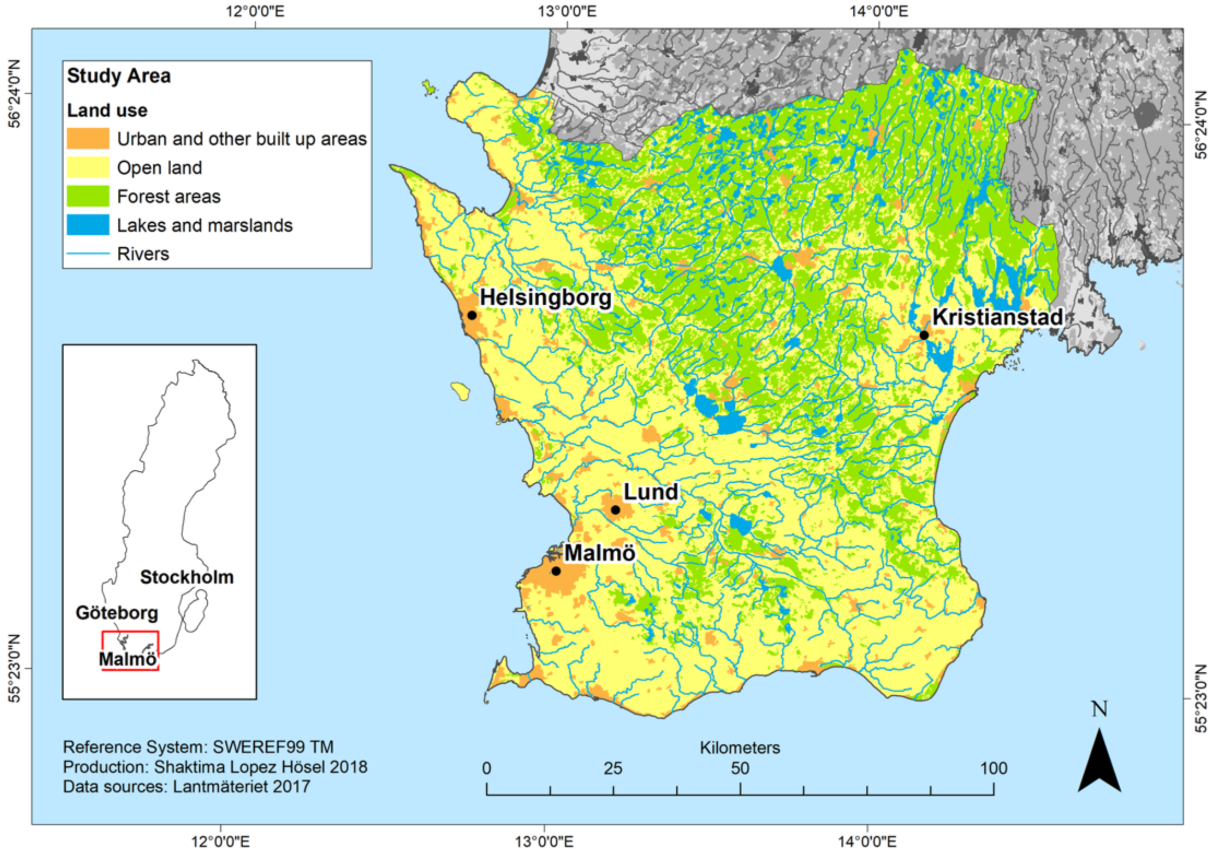

Figure 2. Study area. Primary land use in Scania.

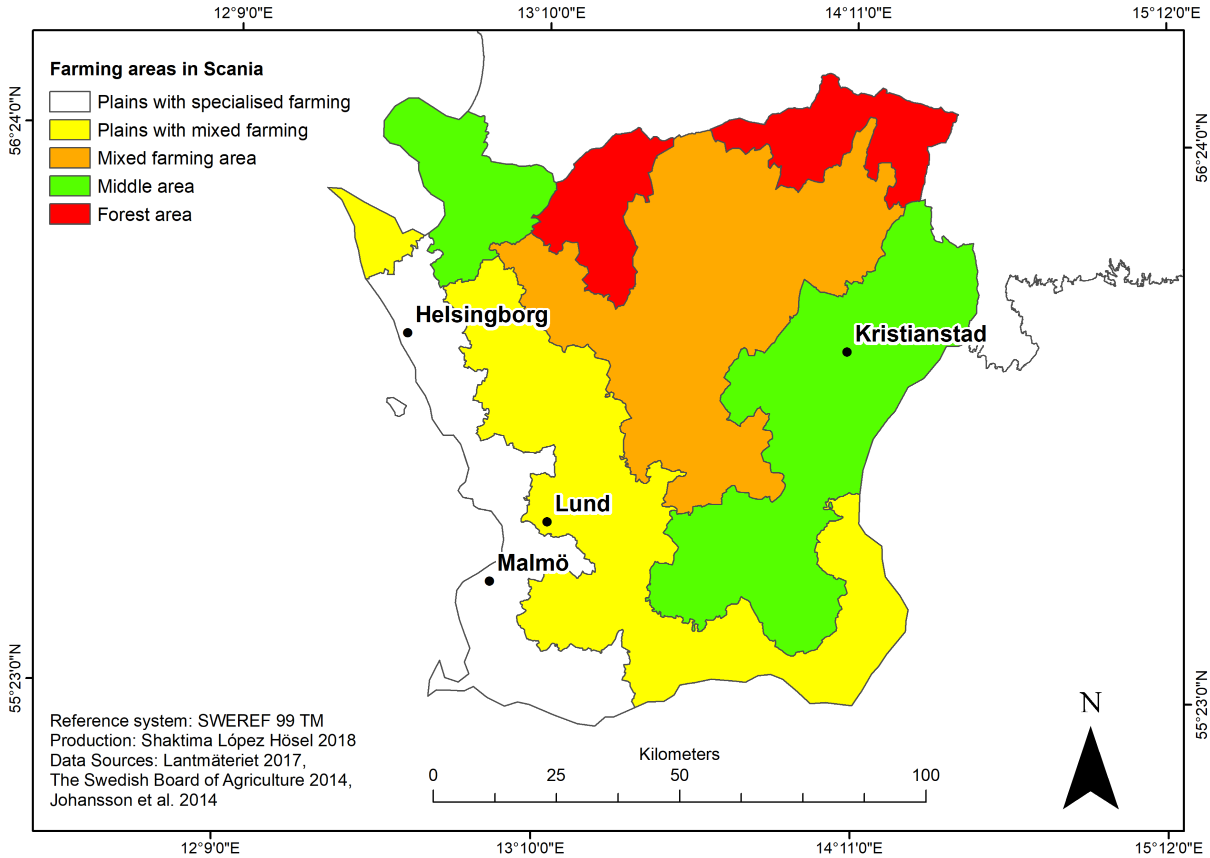

Figure 3. The five farming areas in Scania, based on (Johansson et al., 2014).

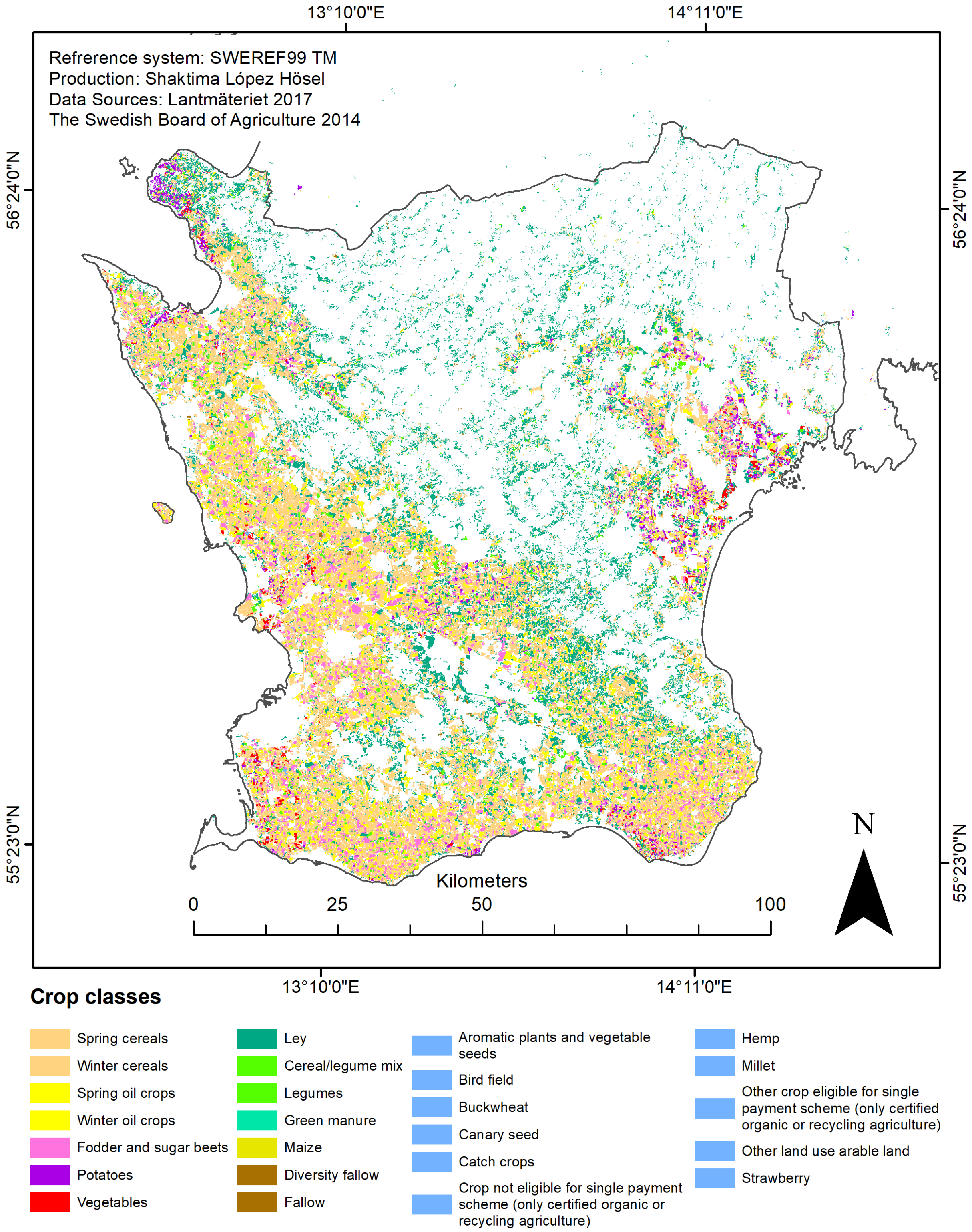

Figure 4. Crops grown by farmers in Scania in 2014. The map shows the distribution of the 25 crops classes, based on the 2014 parcel data. A few parcels are located out-side of Scania County, and some are not shown in this map.

Nevertheless, the classification implies a quite strong bias when used for studying crop diversity, with many crops not being defined at all, and cereal crops being quite differentiated. This results in a relative high crop diversity index for farmers who grow a couple of different cereal crops, while e.g. a diversity of different vegetables is not at all accounted for in the index. To balance the dataset and minimise this bias, a couple of crop classes were grouped together into new classes, which are shown in table 6. This resulted in a total of 25 classes, which are shown in the figure 4. Geographically, the map over crops grown by farmers in Scania in 2014 correlates well with the general features of the different farming areas, with predominantly ley in the woodlands of the mid-north of Scania, and with cereal, oilseed, and sugar beet dominating in the plains. Finally, the data was prepared so that each farm unit could be assessed for their crop diversity, meaning that parcels with the same user ID were merged into larger polygons representing each farm. This resulted in 7858 farm units.
Although these zones are cultivated with grasses and ley crops (Swedish Board of Agriculture, 2017a) that can provide other ecological functions as well, they are not considered part of the crop rotation, and were therefore excluded. Permanent crops such as fruit trees and short rotation coppice for bioenergy were excluded for the same reason. A few parcels without crop information were also excluded. These are most likely parcels that farmers have not applied subsidies for and which the Swedish board of agriculture could not identify the crop for through farmer surveys (Swedish Board of Agriculture, 2014). In total, 32 096 parcels were excluded from analysis, and the final dataset contained 102 175 parcels. Since some farmers have parcels in more than one county, a few parcels in neighbouring counties were also included in the dataset.

After the exclusion procedure 46 crop classes remained. While there is quite some differentiation in cereals and oil crops, there is no differentiation between e.g. vegetable crops, and no species information within the ley crop classes. The classification is simplified, and with a stronger focus on the commercial use and eligibility for payment scheme. This is very understandable considering that the primary use for the data is in fact approval for agricultural payments.

3.2.3 Data Analysis – Crop Diversity Assessment at Farm and Regional Level and Cluster Pattern Analysis

The data analysis was mainly performed in Excel and in the software environment ArcMap 10. In ArcMap 10 standard geoprocessing tools were used, as well as the extension Spatial Analyst. In Excel, crop diversity was calculated using the Shannon Diversity Index, after which the index was re-introduced in ArcGIS 10 for analysis of crop diversity pattern at regional level and correlation in crop diversity between neighbouring farmers. The tools and methods for the different steps of the analysis are described in the sections below.

Crop Diversity Assessment

Species diversity is defined as a measure that incorporates both species richness, i.e. the number of species in an assemblage (the group of species considered in a study), and their relative abundances

(Gotelli & Chao, 2013). The crop diversity assessment for this study was performed by calculating the Shannon diversity index for all farmers in Scania. The Shannon diversity index (also called Shannon-Wiener index, or Shannon entropy) is an index for species diversity that measures both the species richness and the evenness in species abundance, the latter referred to as species evenness (Magurran, 1996, 2004). The index is expressed as:

Shannon diversity index = $-\sum_{i=1}^{S} p_i \ln p_i$

Where S = the number of species in the community, Pi = the fraction of the entire community made up of species i, while ln is the **natural logarithm** of that number, and ∑ = sum from species 1 to species S (Gotelli & Chao, 2013; Magurran, 2004). For this study, each farmer represents a community and abundance of a species is expresses in hectares (n.b. when calculating the index for each farmer, all crops that are not present at the farm are excluded from the index calculation, instead of giving them the value 0, which would create an error in the calculation). The Shannon diversity index is one of the most commonly used diversity indices and originates from information theory in the 1940s. It has since been used in the fields of ecology, biology, economics, and linguistics, amongst others (Gotelli & Chao, 2013; Jost, 2006). The Shannon index was preferred before the similarly popular Simpsons index. While the Simpson's is more descriptive of evenness and dominant species, The Shannon is more sensitive to rare species, with regards to species richness (Aguilar et al., 2015; Gotelli & Chao, 2013). The index can be converted to the 'effective number of species', also called 'true diversity', or simply 'diversity'. The effective number of species is the number of equally-common species required to give a particular value of a chosen diversity index (Jost, 2006). It represents an estimate of the number of species dominating the population. Aguilar et al. (2015) used the Shannon diversity index to assess changes in crop diversity in US farmland, with data similar to the one used in this study. To find the true crop diversity they computed the effective number of species, or the effective number of crop species (ENCS), expressed as:

ENCS= $\exp^{(} -\sum_{i=1}^{S} p_i \ln p_i{}^{)}$

In this study, the crop diversity is expressed as ENCS.

The conversion to effective number of crop species makes the index easier to interpret intuitively since it makes different communities with different species comparable in terms of diversity. This means that a community A with an effective number of species value of 2 is double as diverse as community B with an effective number of species value of 1. This is not the case for the Shannon Index before this conversion (Gotelli & Chao, 2013). If the effective number of crop species is equal to 1, this means that only 1 crop class is grown on the farm. But some of the crop classes in the data set actually consist of several crop species, and special attention was put on the crop class Cereal/legume mix. To acknowledge the ecosystem services provided by intercropping, this class was weighted by multiplying the parcel areas with 2, meaning that the parcels will appear to be twice as abundant. In crop rotations where the Cereal/legume mix is less abundant than other crops, this will positively affect the ENCS, and create a higher diversity for that farmer. The same weighting was also tested on the crop class Ley, but since ley parcels are generally both relatively large, as well dominating in some areas, this produced the opposite effect, and negatively affected many farmers crop diversity. The weighing leads to a dominance of ley that hides the diversity of other crops and creates a smaller distribution in ENCS-values. Therefore, only the crop class Cereal/legume mix was weighted in the final dataset.

Crop Diversity Pattern at Regional Level

To analyse the crop diversity pattern in Scania on a regional level, the county was divided into smaller areas. A vector layer of the five farming areas were created based on the zoning used by (Johansson et al., 2014). This zoning uses municipality borders and was created using municipality data from Lantmäteriet. The farming areas were chosen in favour of the eight production areas that are normally used for national agricultural statistics (see e.g. Statistics Sweden (2017)), since only three of the production areas cover Scania, while the five farming areas display more regional detail, and moreover presented a better match with the regional distribution of crops and crop diversity. The five farming areas are shown above in figure 3, section 3.1.2. The farming areas where used for the analysis of regional distribution, and further served as basis for the selection of farmer interviews, which is described in more detail in section 3.3.2.

Clusters of Neighbouring Farmers with High Crop Diversity

The ArcMap software offers a couple of analysis tools that can be used for assessing cluster patterns, e.g. Local Moran's I Spatial Autocorrelation (Esri, 2017b) and Getis-Ord Gi* Hot Spot Analysis (Esri, 2017a). These were at first explored for their potential of identifying possible local cluster of high crop diversity, e.g. areas where farmers with high crop diversity appear to be geographically coherent. But only general differences in cropping patterns between the different farming areas could be revealed with the tools, and these regional differences where already obvious. Instead, a simpler method of identifying clusters was chosen, namely to visually interpret locally coherent geographical areas with high ENCS values. This was performed by creating local mean ENCS values, which provides an image that at least indicates a local distribution pattern, even if clustering could not be statistically tested for. The local mean values were produced by first converting the vector layer with farmers ENCS values into raster, after which mean values were calculated for a 2,5 km radius, using the Neighbourhood Focal Statistics tool. This layer was then used to analyse the local distribution of crop diversity, as an indication for correlation in crop diversity between neighbouring farmers. When locally coherent geographical areas with high ENCS values had been identified, they were cross-referenced with the vector layer with farmers ENCS-values and manually verified or discarded as clusters. That way a single farmer with many parcels was not falsely identified as a cluster. The identified clusters also served as basis for the selection of farmer interviews, described in section 3.3.2.

3.3 Qualitative Data - Interviews with Farmers

Studying farmer's motivation for crop diversification implies exploring their own perspective of both their cropping system and their social-ecological context. This means trying to understand their lifeworld – how they perceive phenomena in their everyday life. Interviews are the core of such qualitative research, since they allow for the understanding of a social phenomenon through an actors own perspective (Kvale & Brinkmann, 2014). One of the most frequently used interview methods is the semi-structured interview (Bernard, 2006) which allows the researcher to study selected themes in the actor's lifeworld, through the actor's own descriptions and interpretation of those themes (Kvale & Brinkmann, 2014) The method is guided by open-ended questions, that allows for rich and descriptive statements by the actor, while restricting the interview to the themes of interest for the researcher (Kvale & Brinkmann, 2014). The method can be contrasted with unstructured interviews, where there is very little control over the respondents answer, and with structured interviews, which are often some type of verbally performed questionnaire (Bernard, 2006). While unstructured interviews would allow for trust to develop, and for respondents to open up in their own pace, such interviews are very time consuming (Bernard, 2006). Due to time limitations and the fact that the research topic demanded quite descriptive, qualitative data, semi-structured interviewing was regarded as the best, feasible option for studying farmers motivations for crop diversification.

3.3.1 Limitations

The qualitative data sample is limited to farmers that were possible to get in contact with and that agreed to be interviewed, why a couple of farmers with some of the highest ENCS-values could not be included. Nevertheless, the farmers who agreed to be interviewed all have an ENCS-value well above the mean value for the Scania region and can therefore still provide useful information about drivers for crop diversification in Scania. Due to time-limitations the sample size was limited to six respondents, and the interviews were limited to roughly 45 minutes long phone interviews. While the larger part of the interview was in the form of open-ended questions, a part of the interview also consisted of rankings of different motivations/practices, in order to reach answers about these themes quicker. This method can limit the respondent in giving descriptive answers, but it was preferred to present them this way, rather than not including the themes at all due to time constrains.

3.3.2 Data Collection

To obtain a dataset that could provide in-depth information about motivations for crop diversity, a small sample of informants with high crop diversity index-values was selected through purposive, non-probability sampling (Bernard, 2006), based on the crop diversity map. A list of Scania farmer's contact information was provided by the Statistics Unit of the Swedish Board of Agriculture. The document also included the same user ID for each farmer that is also included in the parcel data. With the use of this list, farmers with high crop diversity could be identified and approached for interviews.

The selection of farmers was limited to one production area, in order to avoid potential bias by factors that differ between production areas. Criterions for the chosen production area was a large number of farmers with an ENCS > 2,1, as well as presence of organic farmers with ENCS >2,1, to secure that a representative sample could be collected. In order of ENCS-value, farmers with a registered e-mail address was chosen in the first round of contact, as well as a number of organic farmers proportional to the area. The final sample included six male farmers from the same production area and was representative in terms of cluster/non-cluster location and conventional/organic farming. This was in order to be able to distinguish farmers in clusters/non-clusters provided different results in relation a possible correlation between neighbours, and if conventional and organic farmers presented very different motivations for crop diversity. An interview guide was developed based on the themes: 1) motivations for current cropping system, 2) ecosystem services provided by crop diversity and by the current cropping system, and 3) motivations and obstacles for further crop diversification. See appendix 1.

In the first and second theme the farmers were asked questions about their current cropping system, opinions about crop diversity, what motivates them in their choice of crops, and how they think their cropping system effects ecosystem services. Their description of their cropping systems were cross-references with the SAM applications from both the 2014, the year for which the crop diversity assessment was carried out, and for 2017, the most recent SAM application. In the final theme the respondents were asked what would motivate them to increase crop diversity at their farm, and if they considered seven suggested drivers as good motivations, see in table 7. The farmers were then asked what support and/or preconditions they thought they needed for increasing crop diversity, and what they thought about four suggested ones, also listed below in table 7.

Table 7. *Drivers, support mechanisms and preconditions suggested as possible motivations for crop diversification.*

Drivers	Support mechanisms/preconditions
New sales opportunities	New subsidies/payment scheme
Market demand	Knowledge/education
New regulation from the Swedish Board of Agriculture/EU	Reliable sale and profitability of new crop/s
Research results	That the new crop/s fits with the current farming system (e.g. with regards to machinery)
A clear positive effect on the farming system from the new crop/s	
Direct partnership with consumers	
Cooperation with other farmers	

The suggested drivers, preconditions and support-mechanisms are by default not *intrinsic* motivations, since they are all examples of some type of change in the farmers' environment, that could influence their decisions about their cropping system. They would therefore not be driven by personal interest and/or enjoyment, but by an external force. They can however be valued as either *external* or *identified* motivations, depending on if farmers value them as personally important, or simply a motivation to receive external rewards and meet with compliances. Finally, the farmers were asked what they perceived as obstacles for increasing crop diversity, and if they found any obstacles related to climate, environment, economy, or too short time to retirement. Their answers were analysed through the Cognitive Mapping Approach, presented below in section 3.3.3.

3.3.3 Data Analysis - Cognitive Mapping Approach

Cognitive Mapping is a qualitative modelling approach for studying social-ecological systems. A cognitive map is a mental model of people's knowledge and perception of a certain system. The map is created through identifying systems variables and the relationships between these variables (Özesmi & Özesmi, 2004). This approach has been used to map environmental problems in participatory ecosystem management (Vanwindekens, Stilmant, & Baret, 2013), and has also been applied to agroecosystems, e.g. to study farmers' practices and their perception of their farming systems (Fairweather, 2010) . Vanwindekens et al. (2013) further developed the Cognitive Mapping Approach for analysing Actors' Systems of Practice for mapping and analysing 1) farmer's sets of practices, 2) factors influencing these practices, 3) the elements effected by those practices, and 4) how these variables are linked to each other. They applied this model to a case study on grass forage management, and the approach was later used by (Garini et al., 2017) to study the drivers of adaptation of agroecological practices for winegrowers in Italy. Both Vanwindekens et al., (2013) and Garini et al., (2017) based their studies on in-depth interviews with farmers, but the latter also used Self-Determination as theoretical framework for their study and showed how to further categorise the motivations behind farmers' practices in terms of their degree of autonomy. In this study the production and coding of cognitive maps were guided by Vanwindekens et al. (2013) and by Garini et al. (2017). After the semi-structured interviews were performed and transcribed, the analysis process was carried out as follows: 1) coding, 2) individual cognitive mapping, and 3) social cognitive mapping. The whole process was carried out with the free version 8.2.3. of the qualitative data analysis software Atlas.ti (Scientific Software Development GmbH, 2018). In addition, Microsoft Excel 2011 Version 14.7.7. was used to further categorise and quantify relationships.

Coding

The interview transcriptions were coded by linking directional relationships between a motivation and a practice, or between a practice and an element affected by that practice. Motivations were immediately coded as extrinsic, identified or intrinsic (see figure 1, chapter 2.4), according to the main types of motivations in self-determination theory (Ryan & Deci, 2000), and relationships were also coded as positive or negative. The following statement is used as an example to illustrate the coding process (coded segments in bold):

> 'I like **introducing new interesting crops** now and then […]. We've increased **legumes** a little bit, especially faba bean, it's a crop that has worked well, and when we talk about **flowers and bees** and all that it's a very positive crop for the whole cropping system. So that's a crop I grow as much as I can of, for **protecting the cropping system from diseases** and all that. [T]hen it's a very **beautiful** crop to look at, there's a lot of **wildlife**

> in that crop. It's beautiful when you walk a summer's night and there's great activity of all sorts, bees, flies, butterflies […], so that's probably a very good crop for insects. [S]o I think it's a very good crop for **my wallet**, **for the environment**, for everything I think'.

The section is coded with three motivations; *economic revenue (identified)*, *interest (intrinsic)* and *beauty (intrinsic).* These are positively linked with the practices of *crop diversity* and *legumes* which in turn positively affects the elements associated *biodiversity, pollination, avoiding pests and diseases*, and *environmental benefits*. These linkages were created in Atlas.ti and the relationships were further marked with a 1+ or a 1– if these were identified as either positive or negative.

Individual Cognitive Mapping

The relationships established for each farmer were processed into two individual cognitive maps each, where the variables *motivations, practices,* and *elements effected by practices* are visually linked together with arrows, and with the + for positive effect and – for negative effect. One map illustrated how the farmer perceived his current cropping system (theme 1 and 2) and the other how he perceived the possibility of crop diversification (theme 3). The maps were produced with the network tool in Atlas.ti where the quotes linked to the codes are always retrievable, which allows for further interpretation during the mapping process.

Social Cognitive Mapping

From the individual cognitive maps, a social cognitive map was created in order to highlight the most central motivations and relationships for the six farmers. The code-to-code relationship were extracted from the individual cognitive maps and aggregated and quantified in Excel. Here, some further code processing was performed in order reduce the amount of codes and to be able to produce a map that was comprehensible. This meant that some codes were merged into one (sometimes a new) code, such as the codes *CAP* and *regulation* being merged into one; *regulation*. Some codes that were categorised with the same type of motivation, e.g. intrinsic, were also grouped together as one variable in the social cognitive map, if they were identified as being closely related, e.g. *enjoyment, curiosity, interest.* The re-coding process also meant shortening longer 'code chains' that exceeded three variables. E.g. certain crops that were mentioned in relation to crop selection or crop diversity, that in the individual cognitive maps were coded as *asparagus, strawberries, vegetables*, and so on, were after cross-checking quotes grouped together and re-coded as *crop diversity* or *crop selection*, instead of the initial codes representing a motivation for crop diversity/selection through a specific crop (e.g. vegetables). Thereafter, the final code-to-code relationships were quantified based on the number of interviewed farmers who mentioned this relationship, resulting in weight between 1+/- to 6+/- for each relationship. Finally, relationships with at least two mentions, e.g. 2+/- or higher, were included in the final social cognitive maps.

3.4 Validity and Reliability

Validity and reliability are important for evaluating the quality of any study. Internal validity describes the precision and accuracy of data, as well as the suitability of the chosen data and methods with regards to the research questions. In turn, external validity refers to how well the findings can be generalized to a context outside of the study. Lastly, reliability explains the possibility of repeating the research design and obtaining the same results (Denscombe, 2009). The validity and reliability of the quantitative and qualitative part of the study respectively, is presented below.

3.4.1 Quantitative Analysis – Crop Diversity in Scania

The data obtained from the Swedish Board of agriculture where studied for errors by comparing block-data, skiftesdata and SAM data, as well as manually examining the data in ArcMap. It was possible to identify geographical errors and adjust the method so that these would not affect the results from the crop diversity calculations. However, since the dataset does not contain each and every crop that is actually grown, it is not possible to measure the 'true' crop diversity. Moreover, the original crop classification of all crop data contained a bias towards some crop classes in terms of their detail level. Although re-classification was performed in order to create a balance between crop classes, the lack of crop detail reduce the accuracy of the crop diversity assessment. While some different crop groupings were tested and gave similar results, a grouping of crops different from the one presented in the study could lead to a different result, especially on a detailed level. Nevertheless, it was determined that the data provided enough detail and accuracy for a regional crop diversity assessment, where broader patterns where analysed, and that internal validity could be obtained. External validity is achieved by providing the reader with detailed enough account of the data processing, for the research to be repeated. Due to the fact that agriculture is heavily regulated, and farmers are obliged to report their crops to receive farm subsidies, the sample is thought to be close to equal the true population. This means that the chosen methods would provide the same results, would the study be repeated, thus ensuring reliability through representative sampling.

3.4.2 Qualitative Analysis - Farmers' Motivation for Crop Diversity

By creating the respondent sample based on the crop diversity map, farmers are not chosen based on the researchers' subjective evaluation of farmers' crop diversity but based on a rigorous quantitative assessment. It is therefore credible that chosen respondents serve the purpose of providing information on motivations for crop diversity, thus contributing to internal validity (Bernard, 2006). The selection of farmers was limited to one production area. This means that the potential bias that could come from factors that differ between production areas is reduced. Differences between the respondents cropping systems are hence less dependent on environmental factors and are more related to their own motivations. On the other hand, this reduces the strength to which these findings can be generalized to farming areas that differ from the one chosen, and affects the external validity negatively (Denscombe, 2009).

However, the generalizability of the respondents' motivations for further crop diversification is not believed to be affected, at least not to the same degree.

Regarding the validity of the interviews, this is something that is hard to verify; only the respondents themselves have the correct knowledge about their perceptions. But several measures were taken to as far as possible assess the credibility of the data collected through the interviews. Firstly, the information was confirmed by the interviewer repeating and summarising the respondent's answers throughout the interviews. Secondly, method triangulation was carried out by cross-referencing SAM applications with the farmers own description. Thirdly, informant triangulation was used by developing themes from the data, and by emphasising the perceptions and ideas that were repeated by several of the respondents. Finally, a transcript of the interview was shared with the respondent, who had the ability to dispute and correct the content, before confirming and approving the final version. These three verifications contribute to validity (Denscombe, 2009). Still, some aspects of the backgrounds and the dynamics of the student and the respondents in the interviews are seen as possible weaknesses in this study. This is related to the student's cultural/geographical, as well as educational background being very different from the respondents. The master student is a young woman with an urban upbringing and lifestyle, and her educational background is within environmental sciences. The respondents on the other hand are (most of them) upper middle age men from a rural background, where they've spent all of their lives in agriculture, including their education. This could create elements of distrust to the interviewers understanding of the respondent's lifeworld, as well as a defensive stance taken by respondent, based assumptions about an oppositional nature between agriculture and environmentalism, especially since many questions regarded ecosystem services. Moreover, the differences in academic/trade terms and overall langue might result in different understandings of ecosystem services, although the student' asked the respondents to account for their familiarity with the topic and presented her definition of the term. Related to this is also the risk of the 'interviewer effect', where the respondent tries to answer according to what he thinks the interviewer wants to hear (Denscombe, 2009). Besides preparing for the interviews, by researching techniques and having other researchers suggest adjustments to language and presentation in the interview guide, these personal identity aspects where beyond the student's control, and are thought to possibly affect the credibility of the interview data.

Finally, reliability of the qualitative analysis is established by providing a rich description of the methods, by coding and quantifying the interview data according to the developed themes, and by presenting central codes and themes in cognitive maps as part of the results. This way, the reader has the possibility to examine the research process and the lines of investigation that led to the student's conclusions (Denscombe, 2009).

4 Results

This chapter presents the findings for crop diversity in Scania and farmers' motivation for crop diversity. In the first part of the chapter, farmers' crop diversity is displayed in ENCS values, which were obtained from the crop diversity index calculations. The regional crop diversity patterns are described in relation the five farming areas in Scania, and local geographical clusters of farms with high crop diversity are presented. In the second part of this chapter, the results from the farmer interviews are presented. The farmers motivations for crop diversity and diversification are described in terms of self-determination; extrinsic, identified and intrinsic. A variety of citations are provided to allow the reader to 'hear' the farmers viewpoints in their own words. Cognitive maps of the farmers' motivation are also provided, both to show how the results were compiled and to present the results in a more illustrative way.

4.1 Crop Diversity Pattern at Regional Level

The crop diversity analysis revealed some general differences between the five farming areas. The Forested areas in the north show very low values with a mean ENCS value of only 1,08. This reflects that ley single-cropping systems dominate these areas. The plains show the highest mean ENCS values, with a mean of 1,57 in the Plains with specialised farming, and 1,48 in the Plains with mixed farming. The distribution of crop diversity in the plains is quite homogenous, with overall medium to high ENCS values (yellow to red), but there are some areas where the local mean values diverge from this pattern, which appears as either red (high ENCS) or green (low ENCS) spots on the map in figure 5. The Mixed farming area is dominated by low ENCS values but does show some areas with medium to high values in transition towards the Middle area and the Plains with mixed farming. The Middle area shows the largest variation in in the distribution of crop diversity. The eastern parts of the Middle area have some quite large areas with high crop diversity, where the highest ENCS value in Scania, of 2,62 is also found. The areas with very high crop diversity are contrasted with some areas with low crop diversity, with ENCS values of 1 or close to 1, both in the Eastern and the central parts of the Middle area. This could be explained by the very mixed farm profile, with both ley, cereal and mixed cropping systems.

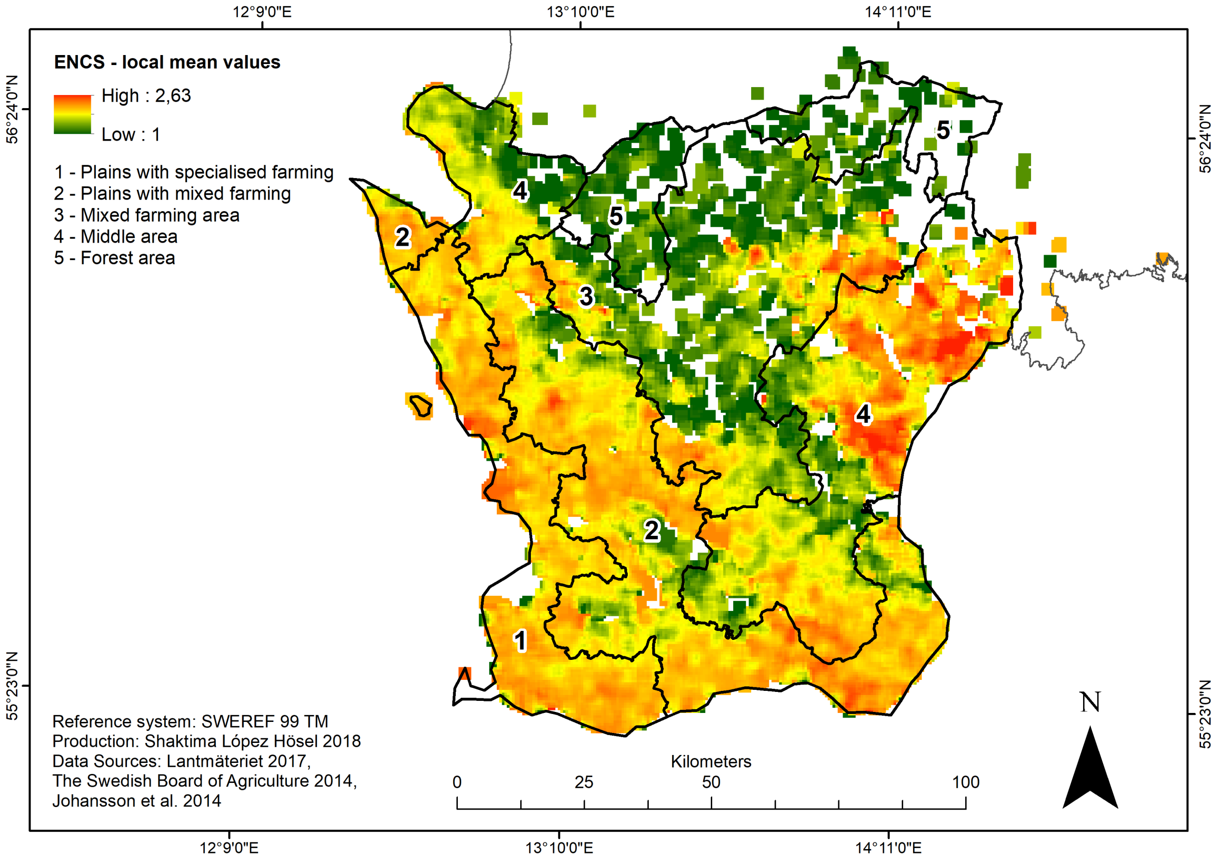

Figure 5. A simplified map over crop diversity in the five different farming areas. The map shows local ENCS mean values based on a radius of 2,5 km.

The regional analysis showed quite some differences in crop diversity between the different farming areas, but it also reveals some more local distribution patterns, with some smaller areas with noticeably high or low ENCS values, that diverge from the overall pattern of the farming region in which they are located. The map in figure 5. give an indication of possible clusters of farmers with high crop diversity, and together with the vector map with farmers ENCS-values, clusters were identified. The results of the cluster analysis are presented below in section 4.1.2.

4.1.1 Clusters of Neighbouring Farmers with High Crop Diversity

When the ENCS values per farmer were analysed in regard to their relation to neighbouring farmers, as well as local mean ENCS values, 7 geographically coherent local clusters of farms with high ENCS values were identified. These are shown in the map in figure 6.

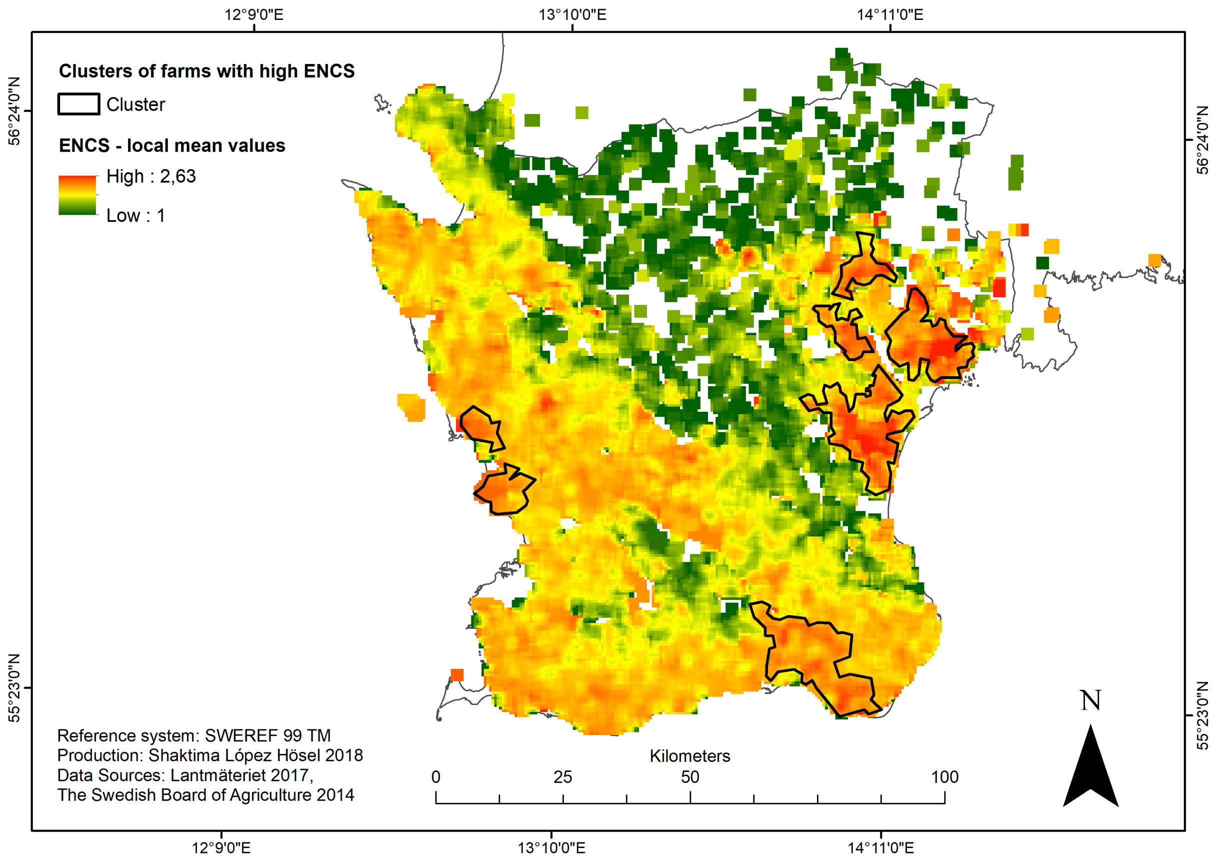

Figure 6. Geographically coherent local clusters of farmers with high crop diversity.

These clusters of farmers with high crop diversity stand out from the general distribution of farmers' crop diversity in their surrounding area, which is more or less scattered. Two big clusters with some of the highest local mean ENCS values are located in the Middle area. Two smaller clusters with high local mean ENCS values are also located on the border between the Middle area and the Mixed farming area. Two smaller clusters are located in the Plains with specialised farming, and one bigger cluster is located in the Southeast, on the border between Plains with mixed farming and Middle area. In other words, the majority of the clusters are found in the eastern part of Scania, most of them around the Kristianstad area (northern Middle area). Most of the highest ENCS values, as well as local mean ENCS values are also found inside the clusters in this area.

The analysis shows that many diverse cropping systems appear to be clustered. Nevertheless, it does not reveal why they are clustered, or why these farmers have chosen a diverse cropping system. Reasons could range from local environmental factors such as soil quality, to traditions, neighbouring farmers effecting each other's crop choices, or some other motivation. The results from semi-structured interviews with farmers where these questions were further explored, are presented below in section 4.2.

4.2 Farmers Motivation for Crop Diversity

Out of the six farms, four were located in a cluster in east Scania, while two were located outside the clusters, but also in east Scania. All six farmers where men between the ages 35-69 years. Their farm size varied between ca. 90 and 500 ha in 2014, with an average of 287 ha. Their ENCS values varied between 2,11 and 2,34, with an average of 2,22 ENCS. All farmers hired one or more extra workers during high seasons, and most of them also had 2-3 full-time employees, in two cases these were the farmers' sons. All of them had a farming background and had worked with farming all their lives.

On an average the farmers cultivated seven crops, and most of them also had some of their land lying in fallow. Most of the farmers said that their crop rotation varied a lot, but generally it was at least four years. All farmers grew potatoes, rapeseed and sugar beets on a 4-year rotation, and all of them also had at least a few hectares of ley. All farmers also had both winter and spring cereal crops, mainly wheat and barley but some also rye and oats. Four farmers grew some kind of bean or pea crop and two farmers had strawberry fields. Some kind of vegetable crop was grown by four of the farmers, including carrot, onion, lettuce, beetroot, parsnip and asparagus. One vegetable grower kept all his vegetables on a 6-year rotation, while another one had a 4-year rotation, except for carrot and onion that were grown in an 8-year rotation.

4.2.1 Social Cognitive Map - Current Cropping System

The aggregated social cognitive map for all six farmers is illustrated in figure 7.
All respondents mentioned two or more positive effects that crop diversity had on ecosystem services in their current agroecosystems.

Harvest and *associated biodiversity* where mentioned by three farmers, while two farmers mentioned *avoiding pests and diseases* and *sustainability of farming systems* as positive effects, although most mentioned different effects as interconnected:

> *Farmer 3:*
> 'The more different crops the better. Less diseases and more organisms and things in the soil that catalyses positive effects to the next crop […], it's positive for the harvest, for the crops and for the soil'.

While one farmer said it was not crop diversity per se that contributed to ecosystem services, but individual crops, he also said that having a varied crop sequence is very important:

> *Farmer 6:*
> 'You can't have a too un-diverse cropping sequence, then you won't get any harvest […], you have got to have a diverse cropping sequence, otherwise you can't farm'.

When discussing motivations for their current cropping systems and crop choices, the motivations were both identified and intrinsic, the strongest being *economic revenue* (identified) and *interest* (intrinsic).

> *Farmer 2:*
> […] I grow what I find interesting [and] that's vegetables. It's interesting because I can affect [vegetables]. Cereals, well I grow those just because it's not too much work. But I guess it's [vegetables] that motivates me; otherwise I wouldn't be keeping on. If I only grew cereals I wouldn't have continued as a farmer'.

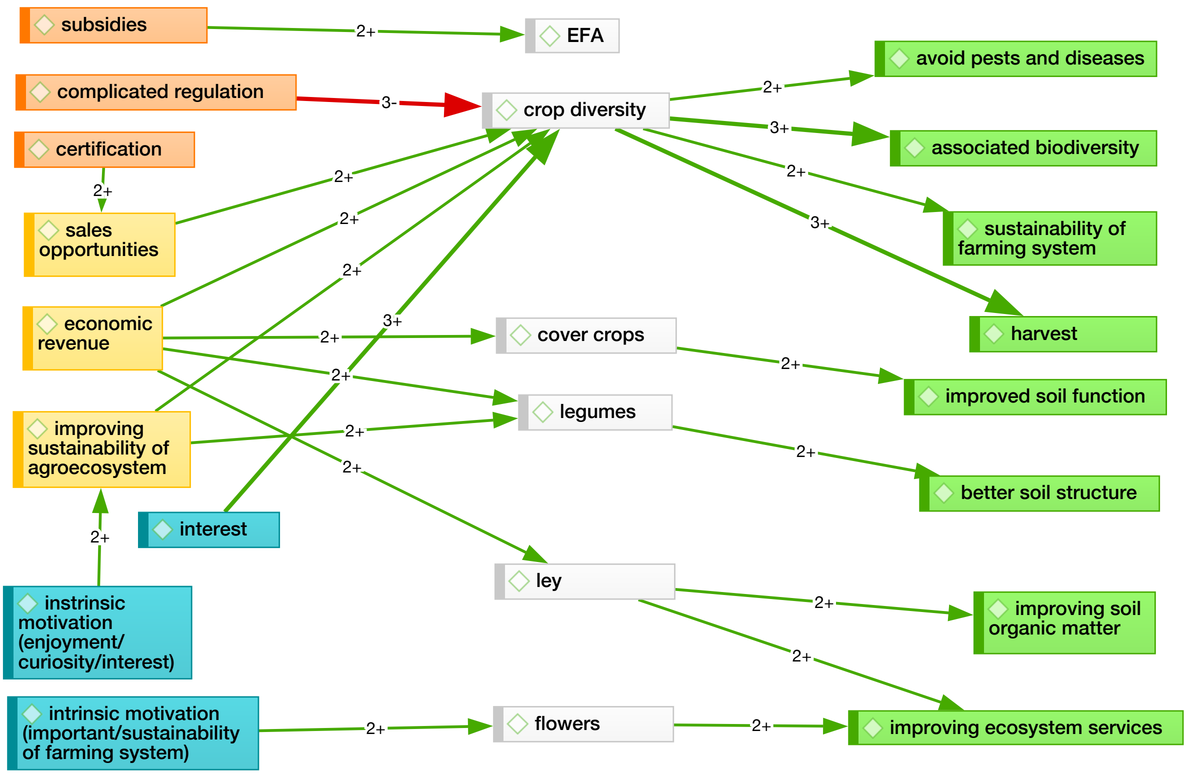

Figure 7. Social Cognitive Map – motivation for farmers' current cropping system and crop diversity. Extrinsic motivations are shown in orange, identified motivations in yellow, and intrinsic motivations in blue. Farmers' crop practices are shown in grey, and the ecosystem services affected by these are shown in green. Numbers on the arrows show the number of farmers who mention the relationship, and the colour red/green and symbol −/+ represent if the relationship is positive or negative.

Cover crops, leys and legumes were all mentioned for their positive effects on different soil ecosystem services such as soil organic matter, soil structure and function. While one farmer was removing peas from his cropping system due to losing his contract with a big food processing company another farmer was increasing legumes crops, encouraged by both identified motivations (*economic revenue*) and intrinsic motivations (*beauty*):

Farmer 3:

'We've increased legumes a little bit, especially faba bean, it's a crop that has worked well, and when we talk about flowers and bees and all that it's a very positive crop for the whole cropping system. So that's a crop I grow as much as I can of, for protecting the cropping system from diseases and all that. Then it's a very beautiful crop to look at, there's a lot of wildlife in that crop. It's beautiful when you walk a summer's night and there's great activity of all sorts, bees, flies, butterflies […], so that's probably a very good crop for insects. [S]o I think it's a very good crop for my wallet, for the environment, for everything I think.'

This farmer was determined to reduce off-farm nitrogen and to try to make the cropping system be more resilient to take care of problems itself, without the need of inputs. When asked what motivated him in his selection, he revealed that besides *economic revenue,* he was above all driven by *interest* and *curiosity*:

Farmer 3:

'Honestly, I guess it's interest in both the farm and in being a farmer, I think I have the best job in the world. That is the basis for it, so that's sort of the driver, to improve and to obtain a bigger harvest with less input. And that's because personally [I think] it's fun to grow crops, and it's fun to farm. [I]n summary the goal is to create a cropping system that solves the problems of weeds and nutrient supply, without using a bunch of steel and diesel. Because when I reach that, my wallet grows, and the environment is happy. So, I guess that's the motivation for my cropping system. Of course, there are some economic aspects behind, but to be honest, a big motivation is to see if it's possible to reduce diesel and to increase harvest'.

Just as farmer 3, farmer 5 expressed intrinsic motivations, *interest* and *enjoyment,* as drivers for having a diverse cropping system. He was enthusiastic about improving the sustainability of the agroecosystem, but he meant that the lack of revenue for such a cropping system was a big obstacle:

Farmer 5:

'For me it has been a matter of interest, it's fun to grow a little bit of everything, it's nice. […] But then I have to say, I have been very enthusiastic about these things [crop diversity and ecosystem-services], but unfortunately the economic reality is that agriculture is lagging behind, so I have to put in a huge work effort to get such damn small income in return. So sadly, I have to say, since I won't live to become 200 years, and I don't have any family who wants to take over, the motivation to do what is right decreases, you become more of a cash-crop farmer'.

For two farmers, the demand for vegetables certified as organic or IP (Swedish IPM certification scheme), was the motivation for growing different vegetable crops, contributing to crop diversity. But they didn't necessarily value it so strongly or believe that the all the requirements in the certification schemes actually improved ecosystem services. One of the farmers explained that the good sales opportunities motivated him to introduce organic vegetable crops to his system:

> *Farmer 1:*
> ‘Primarily, poor economic revenue [has the strongest impact on my crop choices]. And I guess that's why we started with organic. We have some light soils where cereals bring too low of a return, so then you have to try something else. […] There’re always some people who feel relieved by not having to apply toxins, and sure, there’s always an insecurity with [pesticides], so that can be positive. But [for me] the values are not that strong.’

Farmer 2 kept a diverse cropping system due to the good revenue and sales opportunities for vegetables, although, he thought that his crops didn’t fit well together, and that having many vegetables worsened the soil structure since it involves more tilling. To comply with IP requirements, he had to plant flower strips, but saw no environmental benefit of this: ‘I don't’ have great belief in it. It’s the same with catch crops, I’m not convinced it’s the right way, but we get subsidies for it, so we’re forced to have them’. In other words, besides his interest in vegetables, the intrinsic motivations for crop diversity weren’t that strong.

Regulation was generally not associated positively. It was perceived as too complicated and not contributing to improved ecosystem services. Two farmers expressed that the excessive regulation was negatively affecting their engagement for crop diversity and for improving sustainability of their cropping system in general.

> *Farmer 5:*
> ‘With all the bureaucracy and everything, it’s very time-consuming to deal with all the complicated administration […] and the slightest mistake and then it costs you. It’s a tuff environment to work in, so it’s not very attractive for young people”.

The general motivation for introducing EFAs was to comply with regulation to get subsidies, and while some farmers didn’t think so much of it, others felt more strongly about it.

> *Farmer 3:*
> ‘Brussels and the whole regulation should be reformed, because it prevents environmental benefits. […] How it is implemented in practice is so wrong it’s crazy. The environment would have benefited more if [the people in] Brussels had worked less. Because their regulations, such as the greening with the [non-cultivated] field margins, it’s the world’s biggest fiasco’.

He continues to explain how his neighbour was forced to till his old leys and sow new ones to comply with the requirements of the EFA fallow:

Farmer 3:

'Then you really wonder. That's more negative than positive for the environment. It's probably rooted in good intentions, but it doesn't work. […] It would have been better if they changed the regulations so that the farming community could come up with [environmental] measurements and apply for subsidies for those'.

While regulations certainly steered the farmers' crop choices to a certain degree, there was a strong sense of inconsistencies between this extrinsic motivation and actual benefits to the farming system and ecosystem services from these regulations. Compliance with regulation was overall only motivated by the economic benefits from the payment scheme. The direct market incentives seemed like stronger motivations for having a diverse cropping system, especially for growing different types of vegetables. And while some saw the lack of sales opportunities or economic revenue as a barrier, others were directly motivated by sales opportunities to have a diverse cropping system. Regarding the intrinsic motivations for their cropping system, they motivated crop diversity overall trough the incorporation of vegetables, legumes and flowering crops.

Finally, the farmer interviews did not indicate that the cluster pattern was a result of neighbouring farmers effecting each other's crop choices. All farmers besides one stated that they were influence by neighbouring farmers cropping system to some small degree, in terms of exchanging knowledge or taking note of how well neighbouring farmers' new crops performed. But farmers in high crop diversity clusters did not seem to be influenced any more than farmers located outside clusters. Therefore, other explanations such as e.g. soil type or local tradition might better explain the cluster pattern.

4.2.2 Social Cognitive Map - Crop Diversification

The social cognitive map for crop diversification is illustrated below in figure 8.

New sales opportunities, *economic revenue* and *marked demand* were considered as very important drivers by all farmers, and therefore recognised as *identified motivations*. Lack of these preconditions where identified as some of the biggest obstacles to crop diversification. Some of the other presented motivations were met with more mixed opinions, such as direct partnership with consumers. One farmer who seriously considered such a sales model mentioned having tried to set up a partnership with the school in his municipality, but that there were too many obstacles for this kind of small-scale operation.

Farmer 3:

'It would have been really fun if I could have sold some potatoes to schools […]. I've met with the municipality and discussed it. They do want to buy local, but it sounds easier that it is When you look into it there's unfortunately many obstacles. I can't just bring a bag [of potatoes], first they need to be cleaned [in an approved space] and everything for it to be permitted for delivery to the municipality. […] To get some sort of added value I would have to deliver 20 tons a week. Then I thought, what if I delivered to all the schools? Well, then they say that I have to be able to deliver all year round. […]. So, there are a lot of obstacles, but I think it can be solved, I see it very positively. […]. But when you start to think about how to make it work, you run out of time. But it's positive, I'm all for it.'

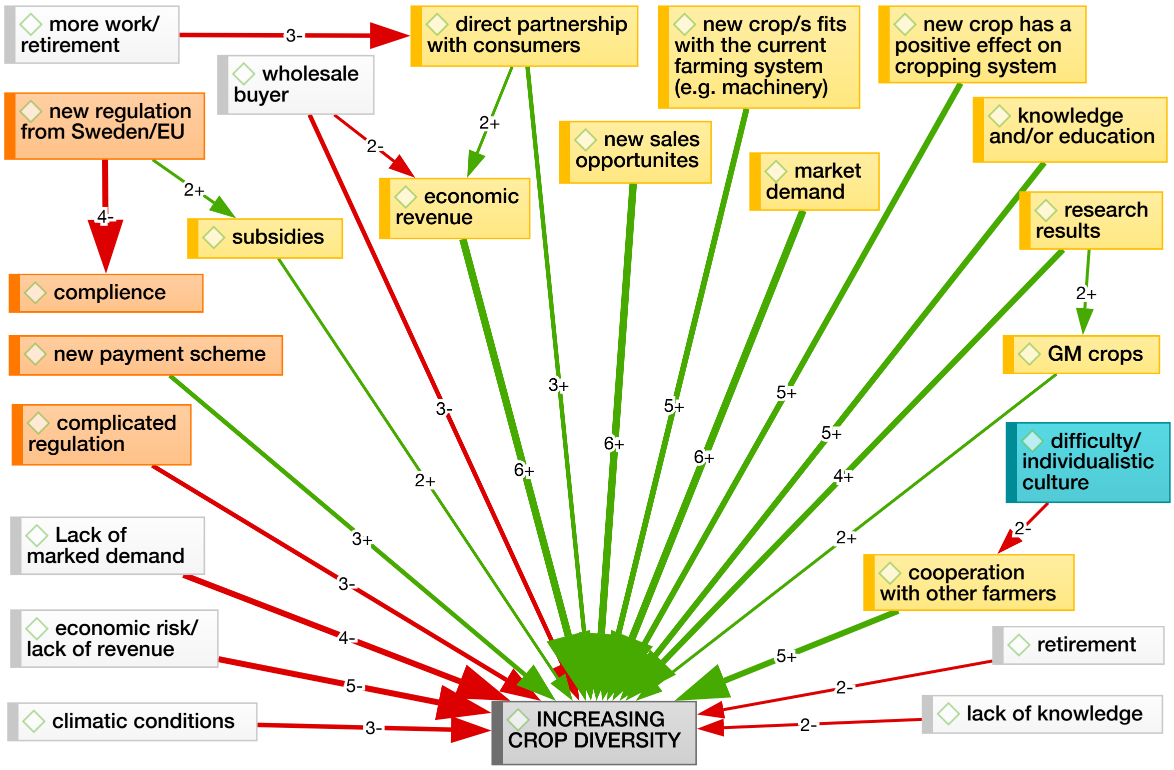

Figure 8. Social Cognitive Map - motivations for crop diversification. Extrinsic motivations are shown in orange, identified motivations in yellow, and intrinsic motivations in blue. Grey boxes are obstacles to crop diversification mentioned by farmers. Numbers on the arrows show the number of farmers who mention the relationship, and the colour red/green and symbol −/+ represent if the relationship is positive or negative.

While most farmers thought that it in theory was a good thing (*identified motivation*), they also mentioned that this would entail a lot of extra work, and half of the farmers saw this as a direct obstacle (out of which one would not consider it also due to retiring in a few years). One farmer explained why he would not consider direct partnership with consumers:

Farmer 1:
'You need to have so many contacts and consumers, otherwise it fluctuates too much. It's not easy. We have some big wholesalers who always struggle with this, and I know how much work they have with this. […] There's probably those who can manage it, but I wouldn't get into it, […], you have to be an idealist to do so. […] And maybe I don't have the social skills [either].'

On the other hand, selling to a wholesale buyer means lower profitability, and that small-scale crops are not marketable. This was identified as an obstacle to crop diversification by three farmers (out of which two would not consider a direct partnership with consumers).

> *Farmer 5*:
> ‘If I can’t load 45 tons, and in addition I have to be able to do that quickly, then I’m not even considered interesting as supplier. […] It has changed a lot; the truckers stand there and time you when you load cereals. […] So that’s a big problem. But of course, it can be solved through cooperation between several small-scale farmers. And that’s a possibility, some already do that.’

Again, in theory all farmers thought that farmer cooperation could have positive effects on crop diversity, but few seemed eager to establish such collaborations. Farmer 5 had an idea about why that is:

> Farmer 5:
> ‘Well, that’s something that’s very hard. And it is strange in a way, there should be preconditions for it, because there is much to exchange. But there are so many obstacles too and I think it has to do with attitude. I mean, there is more than one reason to work in agriculture. But collaborating a lot with other people, it’s not one of them. One of the main reasons is to be able to do what you want and that you have a place you like, that you want to take care of and be responsible for yourself. If you’re a dynamic person with no problems working with other people, well then there are many other jobs. […] I think that deep down you don’t want to. Many people say, “I was forced to collaborate to manage”, that’s sort of how it is, hehe.’

No farmer was entirely positive about the idea of a new regulation from either the Swedish Board of Agriculture or EU to promote crop diversification. Their reaction to this question was in general that whatever regulation the authorities came up with, they just had to comply with it in order to get their farm subsidies. But two farmers thought that such economic incentive could have a positive effect on crop diversification, but when asked about if a new/changed payment scheme could support crop diversification, they both answered that they though a simplification of the payment scheme could benefit crop diversification. One of them suggested changing the CAP direct payments from hectare-based to be based on ‘green’ production, in other words support for crops that produce ecosystem services. The other one wanted to see less regulation from Swedish authorities:

> Farmer 6:
> ‘There are so many rules and regulations that other countries don’t have. Our production is much more expensive [because of Swedish regulations] and we can’t compete. And then you quit. And soon we’re not self-sufficient even 50 %. [If there wasn’t so much regulation], then you would have dared [to grow more different crops], because then you could afford a loss. You don’t dare to that in the same way today.’

Almost all farmers agreed that if any changes were to be made to the payment scheme to improve crop diversity, it should come with some sort of simplification. Besides this question, most farmers thought that *knowledge/education, reliable sale and profitability of new crop/s,* and that *the new crop/s fits with the current farming system (e.g. with regards to machinery)* were all important preconditions for crop diversification. They were perceived as in accordance with their own values and needs, in other words as *identified motivations*. Farmers welcomed more knowledge and education, and two farmers saw their own lack of knowledge as an obstacle for increasing crop diversity. 'More knowledge and more cooperation [could motivate me to increase crop diversity]', said farmer 4. When asked where the knowledge should come from the farmer replied: *'From the industry, [...] from LRF*[2]*. I pay money to them, I think they should [deliver this knowledge].'* He also emphasised that it was important that farmers were not simply told to do things, but that knowledge was mediated in a way that farmers could really understand and see the benefits of a certain measurement or crop. Another farmer also mentioned that there was a lot of knowledge out there that didn't reach those that could benefit from it. He stressed the importance of knowledge held by the farming community, the authorities and the scientific community reaching farmers in the right way and the right time for it to be put in practice.

Research was considered by all farmers as an important driver for crop diversification *(identified motivation),* but two thought that research on GM crops was most valuable. One of them considered that introduction of GM crops in Sweden could possibly also have the opposite effect. Farmer 5: 'In some cases it could make small-scale niche crops more attractive. In other cases, it could contribute to even bigger monocultures […]'. Only three farmers considered climatic conditions as an obstacle for crop diversification, out of two meant that the climate in their region prevented them from growing certain crops, while the third referred to having dry soils, which made his farming system to sensitive for certain crops.

In summary, *new sales opportunities*, *economic revenue* and *marked demand* were found to be the most important identified motivations out of the seven presented in the interviews. Although half of the respondents thought that establishing a direct partnership with consumers could be a way to increase crop diversity, the other half would not consider this since they thought this would require too much work. On the other hand, selling to wholesale buyers means that small-scale crops are not marketable, which is an obstacle for crop diversification. While this in theory could be solved through cooperation between farmers, it seemed that farmers found this difficult, either because of the extra work it would imply, or possibly because of an individualistic culture in the farmer community. This suggests a lack of intrinsic motivation, such as enjoyment or interest in cooperation.

Most farmers meant that a simplification of regulations would have a positive effect on crop diversity, since this could e.g. lower the financial risk of trying new crops or enable small-scale direct sales with consumers such as local institutions in the municipality. The idea of a *new payment scheme* or *new regulations from Sweden or EU* was to a great degree associated with compliance, and only identified as *external motivations* to receive financial rewards.

[2] The Federation of Swedish Farmers

5 Discussion

In this chapter, the main findings are discussed in relation relevant literature. The crop diversity assessment is discussed in relation to its applicability in future crop diversity studies, and the interview results are explored in relation to current Swedish food strategies and food trends, as well as expert recommendations and modelling of future diets and production systems. Finally, some opportunities for farmers' crop diversification are identified.

5.1 Crop Diversity in Scania

The analysis of crop diversity pattern at regional level in Scania seems to correlate well with the general features of the five farming areas. The pattern showed a fairly diverse cropping systems in the plains and low crop diversity farmers in the woodland areas in the north, where single ley cropping system dominates. The findings that the middle area holds most of the farms with high crop diversity, as well as most of the clusters of farmers with high crop diversity, makes this an interesting area for future studies on crop diversity. Although the main and continued production focus in this area is milk and pig production, and ley and cereal crops dominate the area, there seems to be an interest in incorporating more crops in the cropping system. How this affects local ecosystem services compared to other areas would be interesting to study further, since high index values doesn't necessarily reflect a higher quality of ecosystem services, per se, but are assumed to be more resilient than farms with low index values.

If the more crop diverse farms are big farms, the impact on scale dependent ecosystem services, such as pollination or associated biodiversity, might not be as big as if crop diversity is present at a smaller scale. While the crop diversity map gives an indication of regional pattern of farmers crop diversity, it does not reflect the actual crop diversity at a field scale. This is because farmers land can be spread out, and although a parcel contains the same crop as its surrounding parcels, the parcel can show a higher ENCS value than its surrounding, due to the farmers other crops, in a different location. Moreover, when comparing farm-based index-values between farms, the significance of farm and parcel size is inevitably disregarded. The index only measures crop richness and evenness within one farm at the time and based on total crop area. This means that a big farm with very big parcels can have the same index value as a small farm with small parcels, as long as the crop richness and evenness are the same. The smaller farm might have a more positive effect on biodiversity and ecosystem services due to its higher landscape complexity (Tscharntke et al., 2005), but this would be overlooked by the index. For studies examining the relationship between crop diversity and ecosystem services, it would therefore be more accurate to produce a crop diversity index that is landscape-based (e.g. based on 1 km cells) instead of a farm-based index. Nevertheless, the farm-based index is more suitable for studies regarding farmers' decision-making about crops and effects of agricultural policies, such as the crop diversification requirement in the greening, or other future policies.

It is important to also acknowledge that due to the lack of detail in the data, the index might underestimate crop diversity at farms where leys, cover crops and other intercrops are grown. What different grasses and legumes that are included in a ley parcel is not disclosed and can therefore not be taken into account based on available data, neither in a farm-based nor in a landscape-based index. However, it is expected that increased crop detail is introduced in the SAM application from 2017, with sub codes specifying the crop in classes such as *vegetables, green manure* and *other land use arable land* (Swedish Board of Agriculture, 2019b). Basing the index calculation on these sub-codes could greatly improve the reliability of crop diversity indices in future studies.

5.2 Farmers Motivation for Crop Diversity

According to self-determination theory, an extrinsically motivated behaviour, such as complying with the CAP, is not as likely to last when this regulation is removed as if the behaviour was identified, or above all intrinsically motivated (Ryan & Deci, 2000). Those who have intrinsic motivations for crop diversity are therefore the most likely to try to achieve economic revenue through a diverse cropping system, even if say the CAP does not promote this behaviour. The interviewed farmers associated regulation with compliance and had little trust in the CAP and the Swedish regulation to deliver better conditions for crop diversification, or for supporting ecosystem services in general. Their opinions are not unfounded; researchers and environmental and civic society organisations have pointed out that the CAP is ineffective in supporting biodiversity and ecosystem services (+130 Civil Society Organisations, 2017; Leventon et al., 2017; Pe'er et al., 2017), that the CAP is promoting large-scale and specialized farming and that the incentives for diversification are far too weak to have any substantial effect (IPES-Food, 2016; Pe'er et al., 2017). This reflects how market forces also affect farmers by pushing them towards large-scale specialised farming (Chavas, 2008; Eurostat, 2016), and that the lack of market demand, sales opportunities and economic revenue for diverse cropping systems are barriers to crop diversification. With these three factors scoring highest as possible motivations for future crop diversification, it is of great interest to explore these drivers further. Although many obstacles were mentioned, there were presently both identified and intrinsic motivations for crop diversity, especially for cropping systems with vegetables and legumes. IP and organic vegetables in particular were further motivated by the identified motivations market demand and economic revenue. Diversifying with organic (and IP) vegetable crops could have a positive effect on ecosystem services through the reduction of agrochemicals, and in turn more associated biodiversity, along with increase in flowering plants for the benefit of wild pollinators (Dänhardt et al., 2013). Increasing crop diversity with legume crops would moreover contribute to the internal nitrogen supply, decreasing the need for external nitrogen and improving soil fertility (Gliessman, 2007). In addition, if legumes are introduced as an intercrop with cereal, it has the potential to suppress weeds and increase harvest of both crops (Hauggaard-Nielsen et al., 2001).

Having recognised the strongest identified and intrinsic motivation for crop diversity - legumes, (organic) vegetables - and diversification - market demand, sales opportunities economic revenue - the opportunities for crop diversification strategies based on these are explored further below.

5.3 Opportunities for Supporting Crop Diversification

Within the framework of Sweden's food strategy, the government has set the goal of increasing production and consumption of organic food so that by 3030, 30% of agricultural land is certified organic and 60% of food consumption in the public sector consists of organic products. This is aimed at improving the Sweden's environmental quality objectives 'a non-toxic environment', 'a varied agricultural landscape' and 'a rich diversity of plant and animal life' (Swedish Ministry of Enterprise and Innovation, 2018). The Swedish Board of Agriculture has written an action plan for reaching these goals. Some of the measures include promoting food processing of organic primary production and increasing organic food served within the public sector (Swedish Board of Agriculture, 2018a). The largest share of organic food consumption in Sweden is private consumption. The Swedish Board of Agriculture estimates that there is potential, both in primarily production and in food processing to increase sales of organic food products within the product categories with the biggest sales shares, out of which vegetables is one category. Today a large share of organic vegetables is imported, and to achieve the goals set in the action plan, there needs to be a substantial increase in Swedish organic vegetable production. Already now the food processing industry is experiencing a shortage in organic primary products, and they are currently not able to satisfy the demand without the import of organic food product from other countries (Swedish Board of Agriculture, 2018a). With the grocery sales of vegetarian food products significantly increasing in recent years, and the sales of dried beans and lentils increasing with 34% between 2011 and 2016 (The Swedish Food Retailers Federation, 2016) there also seems to be an opportunity for increasing Swedish grain legume production.

While the Swedish Food Strategy and food retail trends shows the potential for increasing the production of grain legumes and organic vegetables on a national level, such conversion does not necessarily lead to diversification at farm level in all cases. As mentioned by the respondents, the demands in scale and efficient delivery when selling to wholesalers is obstacles for crop diversification. The Swedish Board of Agriculture, (2018a) concluded that to increase the sales of organic through food retail, there is a need to lower the prices through increased quantities. While this would stimulate consumption of organic products, there is a risk that it would still promote specialisation at the farm level. There are different farmer-consumer initiatives in Sweden that counteract this trend. Two larger initiatives are Community Supported Agriculture, where consumers commit to buy produce from a farmer for a longer period of time (Andelsjordbruk Sverige, n.d.) and 'REKO-Ringar' (REKO-rings)[3], a direct sales-mechanism where consumers pre-order products online, which farmers then delivered to a pick-up point where consumers can collect the goods (Hushållningssällskapet, n.d.a). Both these initiatives reduce financial risk and provide a better price for the farmer and opens up for diversification with small-scale production of vegetables in particular. In addition, it also brings consumers and producers closer together (Andelsjordbruk Sverige, n.d.; Hushållningssällskapet, n.d.a) which builds knowledge and appreciation for the work and value of sustainable food production among consumers (Gliessman, 2007). These movements are growing in Sweden and are also gaining support from the authorities (Hushållningssällskapet, n.d.b; Molin, 2018; Swedish Board of Agriculture, 2018b). In Västra Götaland County, the county board managed a CSA pilot project between 2015-2018. Their goal was to establish the concept of CSA in Västra Götaland, to support producers who were interested in the business model and to gather knowledge and information that could be shared to the rest of Sweden (Molin, 2018). In their project, the majority of the pilot CSA producers where women under 40, who focused on small-scale, diversified vegetable production. Based on the outcomes, the project manager considered CSA to be an important business model to attract young people with interest in local and sustainable food to the agricultural sector (Molin, 2018).

Nonetheless, for several of the respondents in this study, the extra workload that these sales systems entail was seen as an obstacle. There is therefore of great interest to develop direct sales solutions that take some of the workload and logistical burden away from the farmer. One such solution is through food policies and public procurement in local governments. The public sectors opportunity to deliver both environmental and health benefits to the public while also supporting local agriculture has in recent years received attention (De Schutter, 2014; Morgan, 2008; Renting & Wiskerke, 2010; Wiskerke, 2009). For farmers, a sales contract with a municipality could provide greater revenue and stability and lower the risk involved with establishing new crops and converting to organic (Swedish Board of Agriculture, 2018a). The Nordic nutrient recommendation promotes a dietary change implicating limiting red meat and increasing intake of pulses and vegetables (Nordic Council of Ministers, 2014), and recent literature is linking a more plant-based diet both to public health and to environmental sustainability (Willett et al., 2019). A recent study has also estimated that Sweden has the ecological capacity to provide such a diet based on domestic, and even organic production. The modelled future scenarios presented in the study entailed a substantial reduction in meat consumption coupled with an increase between 156 % and four times the current consumption of vegetables and grain legumes (Karlsson et al., 2017). There are therefore strong incentives for local governments to create food policies that promote a more plant-based, local as well as organic diet. Out of the whole public sectors purchase of food

[3] REKO stands for 'Rejäl Konsumtion', which can be translated to wholesome and substantial consumption. Reko also means decent in Swedish.

products, the share of organic products produced in Sweden is only 21%. These products consist mainly of eggs, meat and dairy (Swedish Board of Agriculture, 2018a), and there is great potential to increase the share of locally produced organic legumes and vegetables.
Increasing purchases of local products in public procurement has been, and is still seen by many municipalities as impossible under the EU directive 2004/18EC, which is realized through the Swedish Public Procurement Act, 2007:1091 — LOU (Granvik, 2012). This is because setting the specific requirements for locally produced food is considered discriminatory and against free trade in Europe. But there are other qualities that can be given priority in the procurement that can indirectly favour local producers violating the EU directive, and there are several examples of municipalities that have found a ways to increase their purchase of locally produced food (Granvik, 2012). Some of the more central strategies seems to be 1) developing a food policy that centres around qualities such as e.g. freshness, un-processed, seasonal food, minimum environmental impact from packaging and 2) developing a coordinated transportation and distribution system and 3) Splitting the procurement into smaller contracts, making it possible for small-scale producers to respond to bids (European Union, 2016; Granvik, 2012; The Federation of Swedish Farmers Skåne, Livsmedelsakademien, & Region Skåne, 2015). Borlänge municipality e.g., have since long ago removed transportation from the procurement of food products and established a centre for co-distribution. They also made it possible to respond to part of a bid, e.g. for only one institution instead of the whole municipality. This has made it possible for small-scale local producers with limited quantities and delivery capacity to compete with wholesalers (Granvik, 2012; The Federation of Swedish Farmers & Ekologiska Lantbrukarna, 2009).

More and more municipalities are consciously integrating aspects of health, environmental sustainability and local consumption in their food policies that include seasonal and organic vegetables, as well as more plant-based protein instead of meat, see e.g. Malmö (Malmö Municipality, 2010) and Södertälje municipality (Södertälje Municipality, 2010, 2016). But there are still many challenges in realising policy into practice. Malmö Municipality is still having problems with creating conditions for local small- and medium-scale farmers to sell their products to the municipality, and they are still struggling with providing kitchen staff with skills and knowledge about what vegetables are in season and how to create plant-based menus (Gunilla Andersson, Helen Nilsson, & Kambanou, 2015). As municipalities are gaining knowledge in how to realise their policies through public procurement, there needs to be more communication and efforts to attract and facilitate for local producers to respond to bids, and to remove the burden of transportation from away from the farmer (Granvik, 2012).

6 Conclusions and Recommendations

The crop diversity analysis showed that based on crop data from the Swedish Board of Agriculture and a biodiversity index, it is possible illustrate general cropping system patterns at a regional level. It is also possible to identify farms with a crop diversity that differ from the general pattern in their farming area and in their local surrounding. This can provide a basis for future studies investigating the correlation between crop diversity and other factors; social, ecological or economic, such farmers' decision-making and changes in agricultural policies and payment schemes. The crop diversity map can also be used as a tool for identifying particular areas of interest for further studies.

For studies examining the relationship between crop diversity and ecosystem services, it is recommended to produce a crop diversity index that is landscape-based instead of a farm-based index, so that the index reflects the crop diversity at a field scale and take parcel size into account. Moreover, certain consideration should be taken to the underestimation of crop diversity and ecosystem services at farms where leys, cover crops and other intercrops are grown, when the index is based on the Swedish Board of Agricultures main crop codes. Crop data with more detailed sub-codes, which are available as from SAM applications from 2017, might provide a more accurate crop diversity index.

The interviews with farmers that had a crop diversity index value that stood out from the general crop diversity pattern in Scania, provided some insight to farmers' motivations and possible opportunities for crop diversification. While *regulations* to some degree steered crop choices, it was mainly associated with compliance, and it was to a larger degree seen as an obstacle for further crop diversification. Out of the seven drivers suggested in the interviews, *New sales opportunities*, *economic revenue* and *market demand* were identified as the strongest motivations for diversifying beyond the farmers' current crops. Farmers also thought that establishing a direct partnership with consumers could be a way to increase crop diversity, but the extra workload was seen as an obstacle. On the other hand, selling to wholesalers was seen as an obstacle for crop diversification, since small-scale crops are not marketable through wholesale.

The interviews reflected how marked system dynamics pushes farmers towards specialised production, and that the limited sales opportunities and revenue for diverse cropping systems is a barrier to crop diversification. Alternative sales structures for grain legumes and organic vegetables where discussed in relation Sweden's food strategy, retail trends as well literature arguing for a plant-based diet, and its production potentials in Sweden. Alternative sales structures included CSA, REKO-rings, and in particular public procurement. These have potential to support crop diversification by reducing financial risk and increase revenue for small scale legume and vegetable crops. While CSA and REKO-rings might attract young people with an interest in entering the agricultural sector, it involves a higher workload of communication and distribution. Public procurement on the other hand might be more attractive for established farmers looking to diversify since these contracts can be design in such a way that municipalities/cities provide the distribution-systems, thus freeing the farmer from this workload. Moreover, local governments have a mandate to increase the share of organic food products in public meals, and many local food policies already aim at increasing the share of vegetables and plant-based protein. Finally, public procurement is based on legally binding contracts, which provides financial security and stability over several years.

In summary, the crop diversity assessment revealed some general regional differences between farming regions. Such regional differences can to a certain degree explain why farms are more or less diverse, but cluster of farms with higher crop diversity than the surrounding area suggest that there are also other reasons. The analysis of farmers' motivations suggested that a combination of market aspects and intrinsic motivations, such as farmers own interest and valuing of crop diversity, are contributing factors. Developing alternative sales mechanisms such as CSA, REKO-rings and public procurement of locally and small-scale produced crops has the potential to support farmers that have intrinsic motivations for crop diversity but are constrained by the current market forces towards specialization.

References

+130 Civil Society Organisations. (2017). Civil society statement on the reform of European agricultural policies - good food, good farming – now! Retrieved from https://www.foeeurope.org/sites/default/files/agriculture/2017/csos_common_statement_on_european_agricultural_policies.pdf

Aguilar, J., Gramig, G. G., Hendrickson, J. R., Archer, D. W., Forcella, F., & Liebig, M. A. (2015). Crop Species Diversity Changes in the United States: 1978–2012. *PLoS ONE*, *10*(8), 1–14.

Albizua, A., Williams, A., Hedlund, K., & Pascual, U. (2015). Crop rotations including ley and manure can promote ecosystem services in conventional farming systems. *Applied Soil Ecology*, *95*, 54–61. https://doi.org/10.1016/j.apsoil.2015.06.003

Altieri, M. A. (1999). The ecological role of biodiversity in agroecosystems. *Agriculture, Ecosystems & Environment*, *74*(1), 19–31. https://doi.org/10.1016/S0167-8809(99)00028-6

Altieri, M. A., & Nicholls, C. I. (2005). *Agroecology and the Search for a Truly Sustainable Agriculture* (1. ed). Mexico D.F., Mexico: United Nations Environment Programme. Retrieved from http://www.fao.org/agroecology/database/detail/en/c/893010/

Altieri, M. A., & Toledo, V. M. (2011). The agroecological revolution in Latin America: rescuing nature, ensuring food sovereignty and empowering peasants. *The Journal of Peasant Studies*, *38*(3), 587–612. https://doi.org/10.1080/03066150.2011.582947

Andelsjordbruk Sverige. (n.d.). Andelsjordbruk Sverige. Verkar för den hållbara utvecklingen av andelsjordbruk (CSA) i Sverige. [Community Supported Agriculture Sweden. Working for sustainable development of community supported agriculture (CSA) in Sweden. Retrieved 21 January 2019, from http://www.andelsjordbruksverige.se/

Bachmann, L., Cruzada, E., & Wright, S. (2009). *Food security and farmer empowerment: a study of the impacts of farmer-led sustainable agriculture in the Philippines.* Los Baños: Masipag-Misereor.

Bernard, H. R. (2006). *Research methods in anthropology: qualitative and quantitative approaches* (4. ed.). Lanham, MD: AltaMira Press.

Björklund, J., Limburg, K. E., & Rydberg, T. (1999). Impact of production intensity on the ability of the agricultural landscape to generate ecosystem services: an example from Sweden. *Ecological Economics*, *29*(2), 269–291. https://doi.org/10.1016/S0921-8009(99)00014-2

Börjeson, A. (2009). *Samla in mångfalden. Verksamhetsredovisning för POM 2009 [Collect the diversity. Activity report for POM 2009].* (No. 2010:11). Retrieved from http://www2.jordbruksverket.se/webdav/files/SJV/trycksaker/Pdf_rapporter/ra10_11.pdf

Carpenter, S., Walker, B., Anderies, J. M., & Abel, N. (2001). From metaphor to measurement: resilience of what to what? *Ecosystems*, *4*(8), 765–781. https://doi.org/10.1007/s10021-001-0045-9

Chavas, J. (2008). On the economics of agricultural production. *Australian Journal of Agricultural and Resource Economics*, *52*(4), 365–380. https://doi.org/10.1111/j.1467-8489.2008.00442.x

Coordination Nationale des Organisations Paysannes du Mali, La Via Campesina, Movimiento Agroecológico de América Latina y el Caribe, Réseau des organisations paysannes et de producteurs de l'Afrique de l'Ouest, World Forum of Fish Harvesters and Fishworkers, World Forum of Fisher Peoples, … More and Better. (2015). Declaration of the international forum for agroecology, Nyéléni, Mali: 27 February 2015. *Development*, *58*(2), 163–168. https://doi.org/10.1057/s41301-016-0014-4

Dänhardt, J., Hedlund, K., Birkhofer, K., Bracht Jørgensen, H., Brady, M., Brönmark, C., … Smith G., H. (2013). *Ekosystemtjänster i det skånska jordbrukslandskapet [Ecosystem services in agricultural landscapes of Scania].* (No. 01 CEC SYNTES). Lund University. Retrieved from https://www.cec.lu.se/sv/sites/cec.lu.se.sv/files/ekosystemtjanster_upplaga2_2015_lag.pdf

De Schutter, O. (2014). *The power of procurement. Public purchasing in the service of realizing the right to food. Briefing note 08 - April 2014. UN Special Rapporteur on the right to food.* United Nations. Retrieved from http://www.srfood.org/en/the-power-of-procurement-public-purchasing-in-the-service-of-realizing-the-right-to-food

Denscombe, M. (2009). *Forskningshandboken: För småskaliga forskningsprojekt inom samhällsvetenskaperna [The good research guide - for small-scale research projects].* (2. ed.). Lund: Studentlitteratur.

Esri. (2017a). Hot Spot Analysis (Getis-Ord Gi*). Retrieved 1 November 2017, from http://desktop.arcgis.com/en/arcmap/10.5/tools/spatial-statistics-toolbox/hot-spot-analysis.htm

Esri. (2017b). Spatial Autocorrelation (Global Moran's I). Retrieved 1 November 2017, from http://pro.arcgis.com/en/pro-app/tool-reference/spatial-statistics/spatial-autocorrelation.htm

European Commission. (2013a). *Overview of CAP Reform 2014-2020. Agricultural Policy Perspectives Brief No. 5.* Retrieved from https://ec.europa.eu/agriculture/sites/agriculture/files/policy-perspectives/policy-briefs/05_en.pdf

European Commission. (2013b). Memo. The common agricultural policy (CAP) and agriculture in Europe – frequently asked questions. Farming in Europe – an overview. Retrieved 6 December 2017, from http://europa.eu/rapid/press-release_MEMO-13-631_en.htm

European Commission. (2016). Rural development 2014-2020. Retrieved 6 December 2017, from https://ec.europa.eu/agriculture/rural-development-2014-2020_en

European Commission. (2017). Agriculture and rural development > Direct support > Greening. Retrieved 23 October 2017, from https://ec.europa.eu/agriculture/direct-support/greening_en

European Coordination Via Campesina. (2014). *Agroecology. Transforming society through food production and the peasant struggle.* Retrieved from http://www.eurovia.org/wp-content/uploads/2016/03/ECVC-declaration-on-Agroecology-08-05-2014.pdf

European Union. (2016). *Att köpa grönt! En handbok om miljöanpassad offentlig upphandling [Bying green! A handbook on green public procurement].* (3. ed.). Luxembourg: Publications Office of the European Union. Retrieved from http://ec.europa.eu/environment/gpp/pdf/handbook_2016_sv.pdf

Eurostat. (2014). Agriculture statistics - the evolution of farm holdings. Retrieved 11 January 2018, from http://ec.europa.eu/eurostat/statistics-explained/index.php/Agriculture_statistics_-_the_evolution_of_farm_holdings#Analysis_of_farms_according_to_farm_size_in_terms_of_area

Eurostat. (2016). Agri-environmental indicator - specialisation. Retrieved 11 January 2017, from http://ec.europa.eu/eurostat/statistics-explained/index.php/Agri-environmental_indicator_-_specialisation#Key_messages

Fairweather, J. (2010). Farmer models of socio-ecologic systems: application of causal mapping across multiple locations. *Ecological Modelling*, *221*(3), 555–562. https://doi.org/10.1016/j.ecolmodel.2009.10.026

FAO. (1996). *World Food Summit - Food for All. Rome 13-17 November 1996.* Retrieved from http://www.fao.org/docrep/x0262e/x0262e00.htm#TopOfPage

FAO. (2009). *International Treaty on Plant Genetic Resources for Food and Agriculture.* Retrieved from http://www.fao.org/3/a-i0510e.pdf

FAO. (2011). *Global food losses and food waste – Extent, causes and prevention.* Rome. Retrieved from http://www.fao.org/docrep/014/mb060e/mb060e00.pdf

FAO. (2017). *The future of food and agriculture – Trends and challenges.* Rome. Retrieved from http://www.fao.org/3/a-i6583e.pdf

FAO. (2018). Ecosystem Services & Biodiversity (ESB). Retrieved 9 October 2018, from http://www.fao.org/ecosystem-services-biodiversity/en/

FAO, & Platform for Agrobiodiversity Research. (2011). *Biodiversity for Food and Agriculture Contributing to food security and sustainability in a changing world.* Retrieved from http://www.fao.org/fileadmin/templates/biodiversity_paia/PAR-FAO-book_lr.pdf

Foley, J. A., Ramankutty, N., Brauman, K. A., Cassidy, E. S., Gerber, J. S., Johnston, M., … Zaks, D. P. M. (2011). Solutions for a cultivated planet. *Nature*, *478*(7369), 337–342. https://doi.org/10.1038/nature10452

Folke, C. (2016). Resilience (Republished). *Ecology and Society, Vol 21, Iss 4, p 44 (2016)*, (4), 44. https://doi.org/10.5751/ES-09088-210444

Folke, C., Carpenter, S., Elmqvist, T., Gunderson, L., Holling, C. S., & Walker, B. (2002). Resilience and sustainable development: building adaptive capacity in a world of transformations. *Ambio*, (5), 437. http://dx.doi.org/10.1579/0044-7447-31.5.437

Francis, C., Lieblein, G., Gliessman, S., Breland, T. A., Creamer, N., Harwood, R., … Poincelot, R. (2003). Agroecology: the ecology of food systems. *Journal of Sustainable Agriculture*, *22*(3), 99–118. https://doi.org/10.1300/J064v22n03_10

Garibaldi, L. A., Steffan-Dewenter, I., Winfree, R., Aizen, M. A., Bommarco, R., Cunningham, S. A., … Klein, A. M. (2013). Wild pollinators enhance fruit set of crops regardless of honey bee abundance. *Science (New York, N.Y.)*, *339*(6127), 1608. https://doi.org/10.1126/science.1230200

Garini, C. S., Vanwindekens, F., Scholberg, J. M. S., Wezel, A., & Groot, J. C. J. (2017). Drivers of adoption of agroecological practices for winegrowers and influence from policies in the province of Trento, Italy. *Land Use Policy*, *68*, 200–211. https://doi.org/10.1016/j.landusepol.2017.07.048

Gliessman, S. R. (2007). *Agroecology: the ecology of sustainable food systems* (2. ed.). Boca Raton: CRC Press.

Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., … Toulmin, C. (2010). Food security: the challenge of feeding 9 billion people. *Science*, *327*(5967), 812. https://doi.org/10.1126/science.1185383

Gotelli, N. J., & Chao, A. (2013). Measuring and estimating species richness, species diversity, and biotic similarity from sampling data. In *Encyclopedia of Biodiversity.* (2., Vol. 5, pp. 195–211). Waltham, MA: Academic Press. Retrieved from http://chao.stat.nthu.edu.tw/wordpress/paper/97.pdf

Granvik, M. (2012). The localization of food systems — an emerging issue for Swedish municipal authorities. *International Planning Studies*, *17*(2), 113–124. https://doi.org/10.1080/13563475.2012.672796

Gunderson, L. H. (2000). Ecological resilience - In theory and application. *Annual Review of Ecology and Systematics*, 425. https://doi.org/10.1146/annurev.ecolsys.31.1.425

Gunilla Andersson, Helen Nilsson, & Kambanou, M. (2015). *Utvärdering av Malmö Stads policy för hållbar utveckling och mat. Hur långt har vi kommit när halva tiden har gått? [Evaluation of the policy on sustainable development and Food in Malmö. How far have we come when half the time has passed?]*. Malmö Environmental Department. Retrieved from https://malmo.se/download/18.5f3af0e314e7254d70ed2431/1491300076645/Halvtidsutv%C3%A4rdering+matpolicy+20151104+just+MN+synpunkter.pdf

Gustafsson, H., & Johansson, C. (2008). *Reducerad jordbearbetning [Reduced tilling].* Retrieved from http://webbutiken.jordbruksverket.se/sv/artiklar/reducerad-jordbearbetning.html

Hauggaard-Nielsen, H., Ambus, P., & Jensen, E. S. (2001). Interspecific competition, N use and interference with weeds in pea–barley intercropping. *Field Crops Research*, *70*(2), 101–109. https://doi.org/10.1016/S0378-4290(01)00126-5

Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics*, 1. http://dx.doi.org/10.1146/annurev.es.04.110173.000245

Hushållningssällskapet. (n.d.a). REKO-ringar i Sverige > Det började i Finland [REKO-rings in Sweden > It started in Finland]. Retrieved 20 January 2019, from http://hushallningssallskapet.se/reko/starta-och-driva-reko-ring/det-borjade-i-finland/

Hushållningssällskapet. (n.d.b). REKO-ringar i Sverige [REKO-rings in Sweden]. Retrieved 20 January 2019, from http://hushallningssallskapet.se/reko/

IPES-Food. (2016). *From uniformity to diversity: a paradigm shift from industrial agriculture to diversified agroecological systems.* (No. 2). Retrieved from http://www.ipes-food.org/images/Reports/UniformityToDiversity_FullReport.pdf

Johansson, G. A., Jonasson, L., Rosenqvist, H., & Yngwe, K. (2014). *Skånskt lantbruk. En snabb blick in i framtiden till år 2025 [Agricuture in Scania. Aquick look into the future to the year 2025].* The Rural Economy and Agricultural Societies & The County Administrative Board of Scania. Retrieved from http://hushallningssallskapet.se/wp-content/uploads/2014/12/skanskt-lantbruk-2025-johansson-et-al-2014.pdf

Jost, L. (2006). Entropy and Diversity. *Oikos*, (2), 363–375. http://dx.doi.org/10.1111/j.2006.0030-1299.14714.x

Karlsson, J., Röös, E., Sjunnestrand, T., Pira, K., Larsson, M., Bente, H. A., … Brubæk, S. (2017). *Future nordic diets. Exploring ways for sustainably feeding the nordics.* (No. 2017:566 TemaNord). Copenhagen.

Kay, S. (2016). *Land grabbing and land concentration in Europe. A research breif.* Amsterdam: Transnational Institute.

Klein, A., Vaissiere, B., Cane, J., Steffan-Dewenter, I., Cunningham, S., Kremen, C., & Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops. *Proc. R. Soc. B-Biol. Sci.*, *274*(1608), 303–313. https://doi.org/10.1098/rspb.2006.3721

Kremen, C., Williams, N. M., & Thorp, R. W. (2002). Crop pollination from native bees at risk from agricultural Intensification. *Proceedings of the National Academy of Sciences of the United States of America*, *99*(26), 16812–16816. https://doi.org/10.1073/pnas.262413599

Kvale, S., & Brinkmann, S. (2014). *Den kvalitativa forskningsintervjun [InterViews: Learning the Craft of Qualitative Research Interviewing].* (3. ed.). Lund: Studentlitteratur.

Leventon, J., Schaal, T., Velten, S., Dänhardt, J., Fischer, J., Abson, D. J., & Newig, J. (2017). Collaboration or fragmentation? Biodiversity management through the common agricultural policy. *Land Use Policy*, *64*, 1–12. https://doi.org/10.1016/j.landusepol.2017.02.009

Lin, B. B. (2011). Resilience in Agriculture through Crop Diversification: Adaptive Management for Environmental Change. *BioScience*, *61*(3), 183–193. https://doi.org/10.1525/bio.2011.61.3.4

Magdoff, F., & van Es, H. (2009). *Building soils for better crops – sustainable soil management.* (3. ed.). SARE Outreach Publications. Retrieved from http://www.sare.org/Learning-Center/Books/Building-Soils-for-Better-Crops-3rd-Edition

Magurran, A. E. (1996). Diversity indices and species abundance models. In *Ecological diversity and its measurement.* (Repr.). London: Chapman & Hall.

Magurran, A. E. (2004). An index of diversity... Chapter 4. In *Measuring biological diversity*. Oxford: Blackwell.

Malmö Municipality. (2010). *Policy för hållbar utveckling och mat. [Policy for sustainable development and food].* Retrieved from https://malmo.se/download/18.2d03134212cf2b7c00b800011592/1491305301781/Matpolicy+f%C3%B6r+webb.pdf

Matthews, A. (2016). *Research for AGRI Committee – the future of direct payments. In: Research for AGRI Committee - CAP Reform Post-2020 - challenges in agriculture.* Directorate-General For Internal Policies. Policy Department B: Structural and Cohesion Policies. Retrieved from http://www.europarl.europa.eu/RegData/etudes/STUD/2016/585898/IPOL_STU(2016)585898_EN.pdf

Méndez, V. E., Bacon, C. M., & Cohen, R. (2013). Agroecology as a transdisciplinary, participatory, and action-oriented approach. *Agroecology and Sustainable Food Systems*, *37*(1), 3–18. https://doi.org/10.1080/10440046.2012.736926

Miljömål. (2016). Giftfri Miljö > Indikatorer > Växtskyddsmedel [A non-toxic environment > Indicators > Agrochemicals]. Retrieved 24 October 2017, from http://www.miljomal.se/Miljomalen/Alla-indikatorer/Indikatorsida/?iid=139&pl=1

Molin, L. (2018). *Slutrapport. Andelsjordbruk – säkrad avsättning för lokalproducerade livsmedel [Final report. Community supported agriculture - securing market for locally produced food].* County Administrative Board of Västra Götaland. Retrieved from https://www.lansstyrelsen.se/vastra-gotaland/lantbruk-och-landsbygd/utveckling-av-landsbygder/kompetensutveckling-och-radgivning/foretagande-pa-landsbygden.html#0

Morgan, K. (2008). Greening the Realm: Sustainable Food Chains and the Public Plate. *Regional Studies*, *42*(9), 1237–1250. https://doi.org/10.1080/00343400802195154

Nordic Council of Ministers. (2014). *Nordic nutrition recommendations 2012. Integrating nutrition and physical activity. 5. ed.* (No. 2014:002 Nord). Retrieved from http://norden.diva-portal.org/smash/record.jsf?pid=diva2%3A704251&dswid=8158

Östman, Ö., Ekbom, B., & Bengtsson, J. (2003). Yield increase attributable to aphid predation by ground-living polyphagous natural enemies in spring barley in Sweden. *Ecological Economics*, *45*(1), 149–158. https://doi.org/10.1016/S0921-8009(03)00007-7

Özesmi, U., & Özesmi, S. L. (2004). Ecological models based on people's knowledge: a multi-step fuzzy cognitive mapping approach. *Ecological Modelling*, *176*(1), 43–64. https://doi.org/10.1016/j.ecolmodel.2003.10.027

Pe'er, G., Lakner, S., Müller, R., Passoni, G., Bontzorlos, V., Clough, D., … Zinngrebe, Y. (2017). *Is the CAP Fit for purpose? An evidence-based fitness-check assessment. CAP Fitness Check: Executive Summary.* Leipzig: Stichting BirdLife Europe and the European Environmental Bureau (EEB). Retrieved from http://eeb.org/not-fit-for-purpose-ngos-present-fitness-check-of-the-common-agricultural-policy/

Peters, R. D., Sturz, A. V., Carter, M. R., & Sanderson, J. B. (2003). Developing disease-suppressive soils through crop rotation and tillage management practices. *Soil Agroecosystems: Impacts of Management on Soil Health and Crop Diseases*, *72*(2), 181–192. https://doi.org/10.1016/S0167-1987(03)00087-4

Peterson, G., Allen, C. R., & Holling, C. S. (1998). Ecological resilience, biodiversity, and scale. *Ecosystems*, *1*(1), 6–18. https://doi.org/10.1007/s100219900002

Pisa, L., Amaral-Rogers, V., Belzunces, L., Bonmatin, J., Downs, C., Goulson, D., … Wiemers, M. (2015). Effects of neonicotinoids and fipronil on non-target invertebrates. *Environmental Science and Pollution Research*, *22*(1), 68–102. https://doi.org/10.1007/s11356-014-3471-x

Pretty, J. (2003). Agroecology in Developing Countries: The Promise of a Sustainable Harvest. *Environment: Science and Policy for Sustainable Development*, *45*(9), 8–20. https://doi.org/10.1080/00139150309604567

Rabow, S. (2017). *Bekämpningsmedel i skånska grundvatten. Redovisning av resultaten från den regionala miljöövervakningen 2016 [Pesticides in the groundwaters of Scania. Results from the regional environmental monitoring in 2016].* The County Administrative Board of Scania. Retrieved from http://www.lansstyrelsen.se/skane/SiteCollectionDocuments/Sv/publikationer/2017/bekampningsmedel-grundvatten-Skane-2016.pdf

Renting, H., & Wiskerke, J. S. C. (2010). New emerging roles for public institutions and civil society in the promotion of sustainable local agro-food systems. In *WS4.4 – Transitions towards sustainable agriculture: from farmers to agro-food systems. 9th European IFSA Symposium, 4-7 July 2010* (pp. 1902–1912). Vienna. Retrieved from http://edepot.wur.nl/146104

Rockström, J., Steffen, W., Noone, K., Persson, A., Chapin, F. S., Lambin, E. F., … Foley, J. A. (2009). A safe operating space for humanity. *Nature*, *461*(7263), 472–475. https://doi.org/10.1038/461472a

Rosset, P. (2008). Food sovereignty and the contemporary food crisis. *Development*, *51*(4), 460. https://doi.org/10.1057/dev.2008.48

Rosset, P. (2011). Preventing hunger: change economic policy. *Nature*, *479*(7374), 472. https://doi.org/10.1038/479472a

Rundlöf, M., Nilsson, H., & Smith, H. G. (2008). Interacting effects of farming practice and landscape context on bumble bees. *Biological Conservation*, *141*(2), 417–426. https://doi.org/10.1016/j.biocon.2007.10.011

Rusch, A., Bommarco, R., Jonsson, M., Smith, H., & Ekbom, B. (2013). Flow and stability of natural pest control services depend on complexity and crop rotation at the landscape scale. *Journal of Applied Ecology*, (2), 345–354. https://doi.org/10.1111/1365-2664.12055

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*(1), 68–78. https://doi.org/10.1037/0003-066X.55.1.68

Scientific Software Development GmbH. (2018). Atlas.ti. Qualitative data analysis. Retrieved 25 May 2018, from https://atlasti.com/

Smith, R., Gross, K., & Robertson, G. (2008). Effects of crop diversity on agroecosystem function: crop yield response. *Ecosystems*, *11*(3), 355–366. https://doi.org/10.1007/s10021-008-9124-5

Södertälje Municipality. (2010). Kostpolicy inom förskola, grundskola och gymnasieskola. [Food policy for primary, secondary and high school]. Retrieved from https://www.sodertalje.se/globalassets/styrande-dokument/kostpolicy-skola.pdf

Södertälje Municipality. (2016). Maten – nyckeln till en bättre framtid [Food – the key to a better future]. Retrieved from https://www.sodertalje.se/contentassets/d393a33a1fcf4b94b3eaf16bdf45d37e/sk_kostenheten_20s_swe_print.pdf?_t_id=1B2M2Y8AsgTpgAmY7PhCfg%3d%3d&_t_q=Maten+%e2%80%93+nyckeln+till+en+b%c3%a4ttre+framtid&_t_tags=language%3asv%2csiteid%3a11fc2f43-3ea5-4dae-8e7b-c17b6f94eca6&_t_ip=62.199.99.71%3a60112&_t_hit.id=SodertaljePublic_Models_Media_GenericMedia/_67195ad8-b65d-4084-a765-a156f8e04955&_t_hit.pos=8

Soilservice. (2012). *SOILSERVICE. Conflicting demands of land use, soil biodiversity and the sustainable delivery of ecosystem goods and services in Europe.* Soil Ecology Group, Department of Ecology, Lund University. Retrieved from https://www.biology.lu.se/sites/biology.lu.se/files/finalpubl.pdf

Statistics Sweden. (2013). Markanvändningen i Sverige, 2010: Mindre än tre procent av marken i Sverige är bebyggd [Land use in Sweden 2010: Less than three procent of the land in Sweden is built up]. Retrieved 14 November 2017, from https://www.scb.se/sv_/Hitta-statistik/Statistik-efter-amne/Miljo/Markanvandning/Markanvandningen-i-Sverige/12850/12857/Behallare-for-Press/Markanvandningen-i-Sverige-2005-367523/

Statistics Sweden. (2014). Statistikdatabasen > Miljö > Markanvändningen i Sverige (MaiS) > Markanvändning > Jordbruksmark och skogsmark efter region och markanvändningsklass. År 1951 - 2010 [The Statistics Database > Environment > Land use in Sweden > Land use > Agricultural land and forest by region and land use class. Year 1951- 2010]. Retrieved 14 November 2017, from http://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__MI__MI0803__MI0803A/MarkanvJbSk/?rxid=71f3f5a9-510a-4116-a3de-f9d1f5b50a56

Statistics Sweden. (2015). Agricultural statistics 2015. Retrieved 10 November 2017, from http://www2.jordbruksverket.se/download/18.7914403215ba2c445969dfc1/1493296338667/jo011501v2.pdf

Statistics Sweden. (2017). *Jordbruksstatistisk sammanställning 2017 med data om livsmedel – tabeller [Agricultural statistics 2017 with food data – tables].* Retrieved from http://www2.jordbruksverket.se/download/18.695b9c5715ce6e19dbbeb7c3/1498809539729/JS_2017.pdf

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., … Sörlin, S. (2015). Planetary boundaries: guiding human development on a changing planet. *Science*, *347*(6223). https://doi.org/10.1126/science.1259855

Swedish Board of Agriculture. (2012). *Vässa växtskyddet för framtidens klimat. Hur vi förebygger och hanterar ökade problem i ett förändrat klimat [Sharpening pest-management for the future climate. How we prevent and manage increasing problems in a chaning climate].* (No. 2012:10). Retrieved from http://webbutiken.jordbruksverket.se/sv/artiklar/vassa-vaxtskyddet-for-framtidens-klimat.html

Swedish Board of Agriculture. (2014). *Jordbruksmarkens användning 2014. Preliminär statistik [Use of agricultural land in 2014, preliminary statistics].* (No. JO 10 SM 1402). Retrieved from https://www.jordbruksverket.se/webdav/files/SJV/Amnesomraden/Statistik,%20fakta/Arealer/JO10/JO10SM1402/JO10SM1402_ikortadrag.htm

Swedish Board of Agriculture. (2016a). *Sysselsättning i jordbruket 2016 [Farm labour force 2016].* (No. JO 30 SM 1701). Retrieved from http://www.jordbruksverket.se/webdav/files/SJV/Amnesomraden/Statistik,%20fakta/Sysselsattning/JO30/JO30SM1701/JO30SM1701.pdf

Swedish Board of Agriculture. (2016b). *The greening of CAP in practice – costs versus environmental benefits.* (No. 2016:18 Eng.). Swedish Board of Agriculture. Retrieved from http://www2.jordbruksverket.se/download/18.2a30f77d15a72e32f338e0ec/1488188317727/ra16_18eng.pdf

Swedish Board of Agriculture. (2017a). Villkor för skyddszoner [Requirements for zones of protection]. Retrieved 9 November 2017, from http://www.jordbruksverket.se/amnesomraden/stod/jordbrukarstod/miljoersattningar/skyddszoner/villkor.4.6c64aa881525004b53bdcd1f.html

Swedish Board of Agriculture. (2017b). Basfakta om svenskt jordbruk [Basic facts about Swedish agriculture]. Retrieved 10 November 2017, from https://www.jordbruksverket.se/omjordbruksverket/statistik/statistikomr/jordbruksstatistisksammanstallning/basfaktaomsvensktjordbruk.4.116e9b9d159b31e6cb936b4a.html

Swedish Board of Agriculture. (2018a). *Åtgärdsplan för att öka produktion, konsumtion och export av ekologiska livsmedel - rapport från ett regeringsuppdrag om ekologiska livsmedel [Action plan for increasing production, consumption and export of organic food - report from an official mandate on organic food].* (No. 2018:16). Retrieved from https://www2.jordbruksverket.se/download/18.6412fcaf162e485c3c1b4ecf/1524546625771/ra18_16.pdf

Swedish Board of Agriculture. (2018b). Jordbruksverket svarar om Rekoringar: Vi vill väl [The Swedish Board of Agriculture replies about REKO-rings: We mean well]. Retrieved 21 January 2019, from https://www.jordbruksverket.se/omjordbruksverket/pressochmedia/debattartiklar/debattartiklar/jordbruksverketsvararomrekoringarvivillval.5.1a84f4121619cc92fa51059d.html

Swedish Board of Agriculture. (2018c). Ordlista för SAM-ansökan och jordbrukarstöden [Glossary for SAM-application and farm subsidies]. Retrieved 26 March 2018, from http://www.jordbruksverket.se/amnesomraden/stod/jordbrukarstod/saminternet/ordlistajordbrukarstod.4.21c2582e14bfe30e87433528.html

Swedish Board of Agriculture. (2019a). Ekologiska fokusarealer [Ecological focus areas]. Retrieved from http://www.jordbruksverket.se/amnesomraden/stod/jordbrukarstod/stodochersattningar/forgroningsstod/villkor/ekologiskafokusarealer.4.2587b71d1525a28283862174.html

Swedish Board of Agriculture. (2019b). Grödkodlista för SAM ansökan [Crop code list för SAM application]. Retrieved 26 January 2018, from http://www.jordbruksverket.se/download/18.1cd096db168542f857a7bd14/1547719744099/Gr%C3%B6dkodslista%202019.xlsx

Swedish Ministry of Enterprise and Innovation. (2018). *Regeringsbeslut. Uppdrag att, inom ramen för livsmedelsstrategin, inrätta samordningsfunktion för ekologiska livsmedel samt utarbeta en åtgärdsplan och etappmål. [Government Decision. The official mandate to, within the framework of the Food Strategy, establish a coordinating function for organic food, as well as drawing up an action plan and stage goals].* (No. N2018/02711/JM). Retrieved from https://www.jordbruksverket.se/download/18.5bd82a281633701bda72b63a/1525702939322/Regeringsuppdrag%202017-06-15%20LMS%20samordning%20Eko.pdf

Swedish Ministry of Rural Affairs. (2013). Nationell handlingsplan för hållbar användning av växtskyddsmedel för perioden 2013–2017 [National strategy for sustainable use of plant protecting agents for the period 2013–2017]. Retrieved from http://www.regeringen.se/49bb90/contentassets/ee5f3bf2f56e4227ac31e739b9e3dda8/nationell-handlingsplan-for-hallbar-anvandning-av-vaxtskyddsmedel-for-perioden-2013-2017

Tester, M., & Langridge, P. (2010). Breeding Technologies to Increase Crop Production in a Changing World. *Science*, *327*(5967), 818–822. https://doi.org/10.1126/science.1183700

The County Administrative Board of Scania. (2016). *Skånska åtgärder för miljömålen – regionalt åtgärdsprogram för miljökvalitetsmålen 2016–2020 [Scania measures for the environmental objectives - regional action programme for environmental quality objectives 2016-2020].* Retrieved from http://www.lansstyrelsen.se/skane/SiteCollectionDocuments/Sv/publikationer/2016/Skanska_atgarder_for_miljomalen_2016-2020.pdf

The County Administrative Board of Scania. (2017). Fakta om skånsk miljö Miljötillståndet i Skåne 2017. Retrieved from http://www.lansstyrelsen.se/skane/Sv/publikationer/2017/Sidor/miljotillstandet-skane-2017.aspx

The Federation of Swedish Farmers, & Ekologiska Lantbrukarna. (2009). *Smartare Logistik. Lokal mat på väg [Smarter logistics. Local food on its way].* Retrieved from https://www.upphandlingsmyndigheten.se/globalassets/upphandling/goda-exempel/lokal-mat-pa-vag.pdf

The Federation of Swedish Farmers Skåne, Livsmedelsakademien, & Region Skåne. (2015). *Skånsk handbok för livsmedelsupphandling. Goda exempel, smarta metoder och nya vägar för den offentliga måltiden [Skåne handbook for public procurement of food. Good examples, smart methods and new ways for the public meal].* Retrieved from https://utveckling.skane.se/siteassets/publikationer_dokument/skansk_handbok_for_livsmedelsupphandling.pdf

The Government Office for Science. (2017). *Foresight. The future of food and farming. Final project report.* London. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/288329/11-546-future-of-food-and-farming-report.pdf

The Swedish Food Retailers Federation. (2016). *Svensk Dagligvaruhandels kvartalsrapport [The Swedish Food Retailers Federation quarterly report].* (No. Q1 2016). Retrieved from https://www.svenskdagligvaruhandel.se/wp-content/uploads/SVDH.kvartalsrapportQ12016.pdf

Thrupp, L. A. (2000). Linking agricultural biodiversity and food security: the valuable role of agrobiodiversity for sustainable agriculture. *International Affairs*, *76*(2), 265. https://doi.org/10.1111/1468-2346.00133

Tscharntke, T., Klein, A. M., Kruess, A., Steffan-Dewenter, I., & Thies, C. (2005). Landscape perspectives on agricultural intensification and biodiversity – ecosystem service management. *Ecology Letters*, *8*(8), 857–874. https://doi.org/10.1111/j.1461-0248.2005.00782.x

Tsiafouli, M. A., Thébault, E., Sgardelis, S. P., de Ruiter, P. C., van der Putten, W. H., Birkhofer, K., … Hedlund, K. (2015). Intensive agriculture reduces soil biodiversity across Europe. *Global Change Biology*, *21*(2), 973–985. https://doi.org/10.1111/gcb.12752

Vanwindekens, F. M., Stilmant, D., & Baret, P. V. (2013). Development of a broadened cognitive mapping approach for analysing systems of practices in social–ecological systems. *Ecological Modelling*, *250*(Supplement C), 352–362. https://doi.org/10.1016/j.ecolmodel.2012.11.023

Wezel, A., Bellon, S., Dore, T., Francis, C., Vallod, D., & David, C. (2009). Agroecology as a science, a movement and a practice. A review. *Agronomy for Sustainable Development*, *29*(4), 503–515. https://doi.org/10.1051/agro/2009004

Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., … Murray, C. J. L. (2019). Food in the anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *The Lancet*, (Online), 1–47. https://doi.org/10.1016/S0140-6736(18)31788-4

Wiskerke, J. S. C. (2009). On places lost and places regained: reflections on the alternative food geography and sustainable regional development. *International Planning Studies*, *14*(4), 369–387. https://doi.org/10.1080/13563471003642803

Withgott, J., & Brennan, S. (2011). Agriculture, biotechnology, and the future of food. In *Environment. The Science Behind the Story.* (4th ed., pp. 251–279). San Francisco, CA: Pearson Education Inc.

Acknowledgements

First, I would like to thank the six farmers who dedicated their time and shared their though and experiences with me. Thanks to my supervisors Georg Carlson, Carolina Rodriguez Gonzalez and Anders Larsolle for making this project possible. A special thanks to Carolina, who saw the potential in exploring crop diversity with GIS and initiated the project.

I also want to thank my boyfriend, family and friends for all their support. A special thank you to my friend and agroecology colleague Linn O'Connell for proof reading and giving insightful comments on my manuscript. Thank you to my boyfriend Nick for bearing with me during this tiring process. And thank you to my mother for encouraging me to explore my passions and to my grandparents for always supporting me in my studies.

I want to dedicate this work to my grandfather who passed away during the writing process.
He was such a loving and giving person, who dedicated himself completely to his family. Me perusing higher education was important to him, and I know he would have been so proud of me for graduating.

Appendix 1. Interview Guide

I. Short Presentation of Ecosystem Services

For my master thesis, I have chosen to study crop diversity. Increasing crop diversity in cropping systems can contribute to improved ecosystem services, e.g. services from nature that are beneficial to society and to agriculture. Some examples are pollination, circulation of nutrients, carbon sequestration, conserving nutrients in the soil, regulating of water flows, climate change buffering and biological pest management.

II. Brief farmer profile

- Age?
- Years in the business and at this farm?
- Number of employees/farm workers?
- Do you have animals?
- If yes, what animals?
- Do you practice organic farming, and if yes, since when are you KRAV-certified?
- Are you the only one taking decisions about crops and crop rotation?
- Are there others that are involved in deciding?
- Would you describe you cropping system as very similar to other farmers' in the area, or do you think that you are doing something different?

III. Current cropping system/crop diversity

- What crops do you grow?
- How long is your crop rotation?
- Have you made any changes to your cropping system the last 10 years?
- 5 years?
- Has your crop rotation looked pretty much the same during this time?
- Have you taken any measures to increase crop diversity?
- Have you taken any specific measures for ecosystem services/environmental protection? *E.g. EFAs, flower strips for pollination, intercropping or specific crop sequence, plants that attract beneficial insects, etc.*

IV. The cropping systems' effect on ecosystem services

- In your opinion/based on your observations, how does your cropping system affect the environment/ecosystem services?
  E.g. soil health, pests/diseases, SOM, pollination, etc.

Negative effect	Slightly Negative effect	Indifferent/ no effect	Slightly positive effect	Positive effect
1	2	3	4	5

- Have you noticed any changes in ecosystem services on your land, or in your local environment?
- Have you made any own measurements (on SOM for example) that confirm some environmental benefits of your cropping system? Or other observations on pests, water/nutrient retention, etc.

- How do you think crop diversification at your farm would change the effect on ecosystem services?

Negative effect	Slightly Negative effect	Indifferent/ no effect	Slightly positive effect	Positive effect
1	2	3	4	5

V. Motivations and driver for current cropping system

- What are your motivations/drivers for choosing your current cropping system? Can be both enabling and limiting forces.
- *E.g. market demand/opportunities, economic security, tradition, values, neighbours, location, CAP/Swedish regulations…*

- What driver/s would you say have the strongest influence on your cropping system?

- Do you think that what/how other farmers in your area grow have an influence on your cropping system? Can you explain how?

VI. Motivations and driver for crop diversification

- What are your thoughts on crop diversity?
- Benefits or disadvantages to the environment/society/your farming system?

- Would you want to grow more/less crops? Why?

- Any concrete plans?

- What are the obstacles for crop diversification in your opinion?
  E.g. climate/local environmental conditions, market related, other economic circumstances, other…

- What would motivate you to diversify your cropping system?

Motivation	**Negative effect**	**Slightly negative effect**	**No/ Indifferent effect**	**Slightly positive effect**	**Positive effect**
New sales opportunities	1	2	3	4	5
Market demand	1	2	3	4	5
Regulations from SJV/EU	1	2	3	4	5
Research results	1	2	3	4	5
More clear positive effects on the farming system	1	2	3	4	5
Direct partnership with consumers	1	2	3	4	5
Collaboration with other farmers	1	2	3	4	5
Other, state:	1	2	3	4	5

- What support/preconditions would you need to diversity your cropping system?

Support	Not at all important	Partially important	Very important
Knowledge/training	1	2	3
New subsidies/payment scheme	1	2	3
Secure sale and profitability of new crop/s	1	2	3
That the new crop/s fits with the current farming system (e.g. with regards to machinery)	1	2	3
Other, state:	1	2	3

VII. Any other comments or thoughts?

Appendix 2. Written Consent Form

a) In Swedish – Skriftligt Samtyckesformulär

Deltagande i intervju till examensarbete i Agroekologi vid Sveriges Lantbruksuniversitet, Alnarp, Vårterminen 2018

Mastersstudent: Shaktima López Hösel

Deltagarens namn: Telefon: E-post:

Information om studien
Studien har som syfte att kartlägga mångfald av odlade grödor hos jordbrukare i Skåne län. Kartläggningen baseras på den s.k. skiftesdatan, vilket är geografiska data från jordbruksverket, samt den klassificering av grödor som jordbruksverket använder vid SAM-ansökan. Vidare är syftet med studien att undersöka jordbrukares motivationer och socialekonomiska möjligheter för en varierad växtföljd. Detta undersöks genom kortare intervjuer med jordbrukare i Skåne län.

Studiens huvudfrågeställning är följande:

➢ Varför är odlingssystem olika när det kommer till mångfald av grödor?

Del-frågeställningar:

1. Hur ser den geografiska spridningen av odlad mångfald ut på regional nivå?
2. Finns det likheter i odlad mångfald mellan grannodlare?
3. Vilka är jordbrukares motivationer och drivkrafter för att odla en varierad växt-följd?

Förväntningar på deltagaren
Mastersstudenten utför en telefonintervju med deltagaren på ca 45 min.

Deltagaren har rätt att ta del av resultatet från intervjun och bekräfta om denne kan stå bakom resultatet eller inte. Deltagaren har också rätt att när som helst dra sig ur studien, om denne av någon anledning inte längre vill delta.

Behandling av data
Telefonintervjun kommer att spelas in med en ljudinspelare. Mastersstudenten kommer sedan att transkribera intervjun. Därefter får deltagaren ta del av transkriptet och korrigera eventuella missförstånd eller feltolkningar, innan materialet godkänns.

Deltagaren kan välja att delta anonymt, eller att godkänna att hans eller hennes namn kan användas i eventuella citat i studien.

Anonym ☐ Använd mitt namn ☐

Jag har läst igenom ovanstående villkor och samtycker till att delta i studien:

____ Datum _______ / _______ /2018
Deltagarens underskrift och namnförtydligande

____ Datum _______ / _______ /2018
Mastersstudenten underskrift och namnförtydligande

b) In English

Participation in interview for master thesis in Agroecology at the Swedish University of Agricultural Sciences, Alnarp, spring semester 2018.

Master student: Shaktima López Hösel

Participants name: Phone number: Email:

Information about the study
The aim of the study is to map the crop diversity of farmers in Scania. The map-ping is based on the so-called parcel data, which is geographical data from the Swedish Board of Agriculture, as well as the crop classification used in the SAM-application. Furthermore, the aim is to study farmers motivations and socioeconomic possibilities for diversified cropping systems. This study is carried out through shorter interviews with farmers in Scania.

The main research question is:

➢ Why are cropping systems more or less diverse in terms of crop diversity? Del-

Sub questions:

1. What does the geographic distribution of crop diversity look like at a regional level?
2. Are there similarities in crop diversity between neighbouring farmers?
3. What motivations and drivers do farmers have to diversify their cropping systems?

Expectations of participant
The master student will perform a 45-minute-long phone interview with the participant.
The master student will share the results of the interview with the participant, who will have the right to confirm if he stands behind the results or not. The participant also has the right to withdraw from the study at any time if he no longer wishes to participate.

How your data is treated

The phone interview will be recorded with a sound recorder. The master student will transcribe the interview and then share the transcript with the participant. Participant will have the opportunity to correct misunderstandings or misinterpretations if any, before approving the text material.

The participant can choose to be anonymous, or to consent to that his/her name can be used any potential quotes in the thesis.

Anonymous ☐ Use my name ☐

I have read the terms and agree to participate in the study:

____ Datum _______ / _______ /2018

Signature and name of the participant

____ Datum _______ / _______ /2018

Signature and name of the master student

Appendix 3. Full List of Crop Codes 2017

Crop Code	Crop
1	Winter barley
2	Spring barley
3	Oat
4	Winter wheat
5	Spring wheat
6	Cereal/legume mix for forage/silage
7	Winter rye wheat
8	Rye
9	Maize
10	Buckwheat
11	Cereals field experiments
12	Mixed grain
13	Cereal/legume mix (more than 50%)
14	Canary seed
15	Millet
16	Cereals for green fodder/silage
17	Bird field
20	Winter oilseed rape
21	Spring oilseed rape
22	Winter turnip rape
23	Spring turnip rape
24	Sunflower
25	Oil crops field experiments
26	Oilseed rape with high erucic acid content
27	White mustard
28	Oil radish
29	Spring rye wheat
30	Green peas
31	Processing peas
32	Field beans
33	Sweet lupin
34	Protein crop mix (legumes/cereal)
35	Beans
36	Vetches
37	Chickpea
38	Soybean for oil

Crop Code	Crop
39	Soybean for fodder
40	Oil flax
41	Common flax
42	Hemp
43	Other beans
45	Table potatoes
46	Potatoes for processing of starch
47	Sugar beets
48	Fodder beets
49	Ley and cultivated grassland on arable land with ley crop not approved for agri-environmental payments
50	Ley and cultivated grassland on arable land
51	Annual/biannual ley and cultivated grassland on arable land
52	Pasture (not arable land)
53	Meadow
54	Forest grazing
55	Mountain pasture (which does not give entitlement to farm and compensation payments)
56	Grazed alvar
57	Ley on on arable land (contract with forage drying)
58	Grass seeds for ley (annual)
59	Grass seeds for ley (perennial)
60	Fallow
61	Mountain pasture (which gives entitlement to farm and compensation payments)
62	Clover seed
63	Energy grass
65	Willow
66	Adjusted zone of protection (Barrier zone)
67	Poplar
68	Hybrid aspen
69	Diversity fallow
70	Strawberry
71	Other berry production
72	Fruit production
74	Vegetables
77	Zone of protection (Barrier zone)
78	Nursery with production of permanent crops
79	Aromatic plants and vegetable seeds
80	Green fodder
81	Green manure
82	Wetlands
83	Christmas tree production

Crop Code	Crop
85	Horticulture (not vegetables, fruits or berries)
86	Crop not eligible for single payment scheme (only certified organic or recycling agriculture)
87	Other crop eligible for single payment scheme (only certified organic or recycling agriculture)
88	Other land use arable land
89	Mosaic pasture (Semi-open pasture and ley)
90	Land poor in grasses
95	Pasture and meadow under restauration
96	Mosaic pasture and other land poor in grasses