Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Faculty of Landscape Architecture, Horticulture and Crop Production Science

Opportunities to improve farming systems to achieve adaptability to climate change

– Farmers' perceptions on climate change and diversification of cropping systems as an adaptive strategy in southern Skåne

Möjligheter för att förbättra jordbrukssystem för att uppnå anpassning till klimatförändringar

– Lantbrukares uppfattningar om klimatförändringar och diversifiering av odlingssystem som en anpassningåtgärd i södra Skåne

Carolina Rodriguez Gonzalez

Degree Project • 30 credits
Agroecology – Master's Programme
Alnarp 2015

Opportunities to improve farming systems to achieve adaptability to climate change

– Farmers' perceptions on climate change and diversification of cropping systems as an adaptive strategy in southern Skåne

Möjligheter för att förbättra jordbrukssystem för att uppnå anpassning till klimatförändringar – Lantbrukares uppfattningar om klimatförändringar och diversifiering av odlingssystem som en anpassningåtgärd i södra Skåne

Carolina Rodriguez Gonzalez

Supervisor: Georg Carlsson, SLU,
Department of Biosystems and Technology

Co-supervisors: Mozhgan Zachrison, SLU,
Department of Work Science, Business Economics and Environmental Psychology

Examiner: Erik Steen Jensen, SLU,
Department of Biosystems and Technology

Credits: 30 credits
Project Level: A2E
Course Title: Master's Thesis in Agricultural Science/Agroecology
Course Code: EX0789
Programme: Agroecology – master's programme

Place of Publication: Alnarp
Year of Publication: 2015
Cover Art: Joel Månsson (Relay intercropping of persian clover with winter wheat)
Online Publication: http://stud.epsilon.slu.se

Keywords: Farmers' perceptions, climate change, diversification cropping systems, mitigation, adaptation, participatory process.

Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Faculty of Landscape Architecture, Horticulture and Crop Production Science
Department of Work Science, Business Economics and Environmental Psychology

Foreword

During my previous bachelor studies in agronomy, I already had a course on agroecology within the program. Maybe it was rather superficial in the definition of the concept but I had the opportunity to hear Altieri discourse on agroecology and the social movement that led the recognition of this discipline. It was very interesting for me to begin the Masters in Agroecology. I was curious to know how the education would be of an approach that has been specifically attributed to a movement of peasants and that this approach is seen as an alternative to models of agriculture in developing countries, from the perspective of a developed country. I may say that this program has rephrased my ideas and expanded my knowledge in order to see agroecology as a philosophy that fits any farming system and which demands not only the assumption of concepts of agronomy but allows the flexibility to understand that these systems not only are based on the relationship of plant, soil and water but also extends to scrutinize factors in the economic, ecological and social environments. From that point of view, this knowledge gave me the opportunity to understand how complex farming systems are and how the human capital is the driving force in the food production. So to advance the process of adaptation to climate change, it is so important to recognize economic opportunities and consequences the perspectives and attitudes of farmers as the fundamental basis for the production of solutions that are suited to their needs. Not mine, nor those established by different regulations that are created with poor understanding of this rationality.

With this thesis I have tried to present the participants views and values. It is not easy because it expresses the opinions of the farmers, which is sensitive information. I have tried to be careful and critical about it. I was only interpreting what I heard to get an idea about the situation to be able to address a problem that concerns everybody.

Carolina Rodriguez
November 2015

Abstract

The purpose of this study was to gain knowledge about farmers' perception of how the climate change might impact agriculture in southern Sweden and therefore how cropping systems diversification could enhance the adaptation to climate change. 16 farmers including owners and managers of conventional and organic production systems and a consultant at SLU participated in the study. Other stakeholders from the agricultural sector were also part of the participatory process. The study was based on a qualitative research study including semi-structured interviews and the initiation of a process of participatory action research. In general, cropping systems have been influenced by various factors such as legislative frameworks from the EU and also at national level. These systems have advanced by the use of technology and have become intensive farming systems dependent on external inputs such as fertilizers and agrochemicals. The change in agricultural practices that promote sustainable production is occurring slowly and that may be due to the conservative behavior of farmers in general who are reluctant to change the way they farm. The perception of farmers on climate change was mainly attributed to natural processes rather than a consequence of human activity. However, many advances have been made in order to reduce GHG emissions particularly influenced by the national government. Farmers have realized the importance of improving soil health, as well as the water management and increased biodiversity. Farmers perceived diversification in cropping systems as the use of cover crops to keep the soil covered throughout the year. Although farmers did not see the introduction of new crops feasible at the moment, they were aware that the effects of climate change would bring opportunities to grow new crops. Finally farmers mentioned the importance of generating more knowledge about these new practices. In addition, government support with clear and concise policies that promote sustainable production practices that are in line with the needs and demands of the farmers are needed. This study indicates that understanding farming systems with a holistic approach, allow us to comprehend the effects of various social, economic and environmental aspects that influence farmers' decision making and also the choice of their farming approach. Although new CAP reforms and regulations at nation level have made room for aspects of environmental conservation, it is still unclear which is the most practical approach to implement these regulations. New practices have emerged towards improving sustainable production. However, the sector needs to understand the benefits of ecosystem services as well as the restriction of an entirely economic perspective. Furthermore, this study suggests that diversification is an adaptation strategy that would be possible to implement to address climate change in the region. It is necessary to promote the active participation of various stakeholders in order to find joint solutions that are tailored to local needs.

Keywords: Farmers' perceptions, climate change, diversification cropping systems, mitigation, adaptation, participatory process.

Table of contents

List of Tables

List of Figures

Abbreviations

Gt CO_2	Gigatonnes of carbon dioxide
CO_2 eq	Carbon dioxide equivalent
Mt CO_2 eq	Metric tones of carbon dioxide equivalent
Ppm CO_2	Parts per million
GHG	Greenhouse gas
EU	European Union
CAP	Common Agricultural Policy
CSA	Climate-smart agriculture
PAR	Participatory action research
CC	Climate Change

1 Background and Context

1.1 Background

1.1.1 Problem Background

With the rapid growth of the world population and intensification of modern agriculture, ecosystems have been affected strongly in the last fifty years. The effects can be summarized in the degradation of productive soils, reduction in water reservoirs, the decline in biodiversity by 75% and high pollution generated by agriculture (Neely & Fynn, 2012). According to the Millennium Ecosystem Assessment (2005), crop production, livestock and fish stock have vastly improved in the last fifty years. Agricultural intensification has successfully supplied food demand due to increased productivity per unit area (Bommarco *et al.*, 2013). However, this intensification has generated negative effects on the environment and at the same time have created a lack of control in the ecosystems, reducing their ability to maintain a natural balance as i.e. in the regulation of pests and maintenance soil health and biodiversity.

Since 1750, the concentration of GHG in the atmosphere has greatly increased by the human activities. It was estimated that CO_2 emission between 1750 and 2011 was 2040 ± 310 Gt CO_2. Approximately 78% of the CO_2 emissions were mainly due to combustion of fossil fuel and industrial processes during the period 1970 to 2011 (IPCC, 2014). Several studies show the degradation of ecosystem services due to human influence. The effect of climate change has a strong impact on the precipitation and hydrological systems due to melting polar ice and ocean acidification. In addition, climate change has already influenced the biological interactions and regulation of terrestrial and marine species (IAASTD, 2009).

Agriculture is one of the largest contributors to the land degradation and the emission of GHG. In a latest FAO report, it is estimated that the emission of gases from agriculture reached a total of 5,335 Mt CO_2 eq in 2011. Besides the fact that the emissions will reach a total annual of 6,300 Mt CO_2 eq in 2050, assuming an increase of 18% and 30% for 2030 and 2050, respectively (FAO, 2014). If GHG emissions are not reduced in the coming decades, it is clear that continued growth of these atmospheric concentrations will result in severe climate change for years to come. A number of mitigation strategies in the agricultural sector have been suggested for the purpose of stabilizing atmospheric concentrations to between 450-550 ppm CO_2 (Tubiello, 2012). In agriculture, the mitigation[1] could be achieved through improved management of farming systems such as 1) sequestration of atmospheric C in agricultural soils, resulting in increased soil organic carbon pools; and 2) reduction of greenhouse gas emissions to the atmosphere from agricultural operations (Rosenzweig & Tubiello, 2007).

In the different regions of the world, climate change will negatively affect crop yields. Agriculture depends mainly on inputs from natural resources to produce food, fiber, energy and other commodi-

1. Mitigation: An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC, 2001b).

ties. Therefore, due to climate variations, agriculture would be highly affected by these changes in the coming years, destabilizing agricultural development and society, especially the most vulnerable (Elbehri *et al.*, 2015; IAASTD, 2009). Climate actions are required today to improve the capacity to cope with climate change by focusing on the search of mix mitigation and adaptation[2] solutions. For that reason it is important to recognize the synergy between adaptation and mitigation strategies that help to develop options to minimize the impact of changing climate while meeting the socio-economic challenges to achieve the sustainable development (Tubiello, 2012; Rosenzweig & Tubiello, 2007). Table 1 shows possible adaptation strategies in agriculture.

In order to minimize the risk of climate change and ensure the production of food for nine billion people in 2050, it is necessary to implement strategies to increase sustainable food production and promote resilience (Elbehri *et al.*, 2015) while reducing environmental impacts on agro-ecosystems. In addition, it is also important to integrate the different stakeholders in the implementation of innovative solutions for the sustainable crop production (Østergård *et al.*, 2009). The lack of agroecological approaches in the farming systems has generated limitation in making joint decisions that help achieve sustainable development. This thesis is an example on how the inclusion of a participatory process can make it possible to transform current faming system approaches in the Skåne region towards better accordance with the goals of sustainable development. It is important to understand farmer's values and beliefs about climate change and sustainability but also which solutions can be generated from the participatory process in order to adapt to climate change and achieve sustainability. The inclusion of different stakeholders in a process of change that may benefit the society, enhance the empowerment of the community (Egger & Majeres, 1992), improving the mutual learning and transform the traditional approach (Greenwood & Levin, 1998).

1.1.2 Statement of the problem

Due to globalization and the massive increase in world population, farming systems will be forced to increase the production of food, feed, energy and other raw materials. This increase in the production of agricultural products could generate high pressures on ecosystems and further reduce the ability of these ecosystems to provide services to humanity. For this reason, the management of ecosystems and implementation of agricultural diversification are suggested as key aspects to ensuring food and environmental security. Nevertheless, some scientists discuss that agricultural diversification is not the only strategy available to tackle these challenges. Recently, sustainable intensification (e.g. reducing yield gaps) has been promoted in order to adapt to climate change and furthermore, allow us to understand the relationship between food production and the services these ecosystems provide (UNEP, 2011). However, this new strategy is not easily understood yet due to the complexity of terminology. The word 'intensification' is usually linked with some specific agricultural practices causing negative responses to the intensification of sustainable production approach (Godfray & Garnett, 2014).

It is evident that the climate variability may adversely affect agricultural production processes (Lin, 2011), agricultural diversification can be used as a strategy to improve the resilience of agricultural

2. Adaptation: Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2001b).

systems in a social, economic and environmental context. Agricultural diversification refers to the change from monoculture production to a production based on several crops or cropping systems in the regional agricultural production. The diversification of farming systems can improve productivity, food security, diminishes economic risks, conserves biodiversity and natural resources (Kremen & Miles, 2012), increasing income, reducing dependence on off-farm inputs and creates new agricultural businesses (FAO, 2013; SARE, 2012)

Table 1. *Adaptation strategies in agriculture.* Adapted from (Kurukulasuriya & Rosenthal, 2013; Tubiello, 2012; Howden *et al.*, 2007; Smit & Skinner, 2002)

	Adaptation measures	
Farm responses	Farm production	Crop diversification
		Livestock diversification
		Changes in the timing and intensity of production
		Agroforestry
	Soil and land management	Increased soil organic matter
		Conservation agriculture
		Use alternative fallow and low tillage practices
		Maintenance of a permanent soil cover
	Water management	Managing river basins for more efficient delivery of irrigation services
		Use of technology to "harvest" water and conserve soil moisture
		Use and transport water more effectively
	Nutrient and pest control management	Use varieties and species resistant to pests and diseases
		Improve quarantine capabilities and monitoring programmes
		Re-assessing fertilizer applications
Market responses	Household income	Diversify sources of household income
		Integration of activities such as livestock raising, tourism, etc.
	Innovative investment	Crop shares and futures
		Credit schemes
		Income stabilization programs
	Crop insurance	Purchase crop insurance to reduce the risks of climate-related income loss
Government responses	Agricultural subsidy and support programs	Modify subsidy, support and incentive programs
		Development of income stabilization options
		Modify crop insurance programs to influence farm-level risk management strategies
	Improvement in agricultural markets	Promotion of inter-regional trade in agriculture
	Resource management programs	Develop and implement policies and programs to influence farm-level land and water resource use and management practices
Technological development	Crop development	Development and promotion of new crop varieties and hybrids to increase the tolerance and suitability of plants to temperature, moisture and other relevant climatic conditions
	Climate forecasting	Develop early warning systems that provide daily weather predictions and seasonal forecasts
	Resource management innovations	Advances in water management techniques, including irrigation
		Develop farm-level resource management innovations

Crop diversification also serves as a strategy to maximize land use and management of natural resources for sustainable development of the region and country (Sichoongwe *et al.*, 2014). The increase of on-farm biodiversity encourages the capacity of agro-ecosystems to maintain soil fertility, regulates water use, reduce the pressure of pests and diseases, and uphold better yield (Scherr & McNeely, 2008). Crop diversification through intercropping, agroforestry and mixed cropping provides better alternatives for improving the stability of production and stimulates intensification of sustainable production with limited use of resources (Lithourgidis *et al.*, 2011; Malézieux *et al.*, 2009). Multiple approaches and practices have emerged with the purpose of increasing agricultural production while reducing the negative impact on the environment. A clear example is the use of legumes in different production systems as in organic production, agroforestry, permaculture and conservation agriculture[3]. Legumes are integrated into the farming systems in order to improve water cycles and nutrients in the soil, and also maximize crop residues (Neely & Fynn, 2012). Currently, the interest in healthier foods and people's awareness of consuming foods produced more environmentally friendly has created a chance on the reintroduction of alternative crops in the farming systems. The diversification of cropping systems also generates multiple benefits to economical (e.g. expansion of niche markets, raw products for food, feed and energy, diminishing economic risk, etc.) and environmental (lessen impact on natural resources) level by presenting more opportunities for farmers to improve their farming systems in order to achieve self-sufficient farming systems.

Despite all benefits that arise from the diversification of cropping systems; it is very complex to understand the reasons why farmers do not adapt diversity as an alternative to improve the development and management of farming systems. Darnhofer *et al.* (2010) stated that diversity is not objectively definite but depends especially on the ability of farmers to build innovative and creative strategies. In the context of climate change there are similarities. Despite the high request of taking action to adapt to climate change, there is still a lack of action of agricultural systems to include new approaches and new practices that would detract against the effects of climate change. Some reasons are framed by doubt, complexity and also because the responsibility should be assumed by others (Fleming & Vanclay, 2010). The intention of this study is to contribute with new ideas that may help to fill in the gap of understanding participatory process in climate change adaptation through applying participatory action research methods, exploring farmers insights regarding climate variability, which constrains farmers are facing with the implementation of new practices and how diversification can be seen as a strategy to adapt to climate change. Folke *et al.* (2003) describe how diversity strengthens the socio-ecological systems with the ability to withstand in the face of change. Furthermore, the participation of different stakeholders is important to ensure better understanding and managing of complex farming systems (Østergård *et al.*, 2009).

1.1.3 Purpose of the study

The aims of this research study are 1) to gain knowledge about farmers' perception of how climate change may impact agriculture in southern Sweden on one hand, and if and how cropping system diversification can enhance the adaptation to climate change on the other hand, and 2) based on the analyses of farmers' perception of these questions suggest a use participatory action research approach

3. Conservation agriculture is an approach to improve the management of agro-ecosystems. CA is characterized by three principles Minimising soil disturbance, permanent organic soil covered and diversification of crop species (FAO, 2013).

that will promote strategies and solutions for diversification of cropping systems to enhance sustainability and adaptation to climate change.

1.1.4 Research questions

The overall research question of this thesis is *how to enhance farmers' awareness about climate change and possibilities to improve sustainability and CC adaptability in farming systems in southern Skåne through diversification of cropping systems?*
The following sub-questions are formulated to provide more detailed answer to the overall research question.

1. Which types of cropping systems are common among farmers today?
This question aims to understand the farming approach that the famers have chosen but also to get an overview of the current farming systems in the region. It also includes values and traditions from the farmers and the historical development of the cropping systems in the region.

2. What are the farmers' perceptions of CC in general and more specially about CC adaptability and resilience of their current cropping systems?
The question aims to know how familiar the farmers are with the terms climate change and resilience but also identifies the farmers' awareness of climate change and knowledge about climate variation.

3. What is the impression that farmers have regarding the diversification of cropping systems?
This questions focuses on identifying which alternative crops could be feasible to introduce in the current farming systems, what interest farmers have regarding diversifying their cropping systems and the motivations that lead the farmer to make changes in the way they are farming.

4. Which factors in a social, economic and environmental context are most important in influencing farmers' decisions on diversifying their cropping systems?
The question focuses on identifying issues and opportunities that the farmers could have in the integration of new crops in their cropping systems and to obtain an overview of what would be a more sustainable farming system.

5. What kind of conditions and guarantees do farmers require regarding the integration of new crops in cropping systems?
The aim of this question is to know the opinion of the farmers in order to implement more diversified cropping systems, which impediments could come up during the transition process and which support is necessary in order to achieve the implementation of new cropping systems.

6. Which participatory action and research activities can be suggested to support farmers' innovation of cropping systems in a CC-adaptation perspective?
This question aims to analyze how the use of participatory action research approaches empower farmers to participate in joint solutions regarding climate change adaptation, and also to identify aspects that motivate or restrict the participation in such projects.

1.1.5 Scope of the thesis

The study includes collection of different information regarding approaches, practices and management of the current farming systems in southern Skåne in a social, environmental and economic context. In addition, the perception of farmers regarding climate change and agricultural policies that drive the farming systems in Europe will be emphasized. The reflection of the participatory process will also be included, where farmers are discussing the diversification of cropping systems as a strategy for climate change adaptation. The scope of this thesis is wide but suitable with the goal of bringing questions that make farmers think about how they will face the issue of climate change. Furthermore understanding values, beliefs and attitudes of these farmers will give a holistic view for promoting change in order to ensure resilience within the farming systems. Moreover, this research is going to act as a part of the Climate-CAFE project (Climate Change Adaptability of cropping and Farming systems for Europe). The project involves collaboration between different countries from the European union and the objective is to develop strategies for climate change adaptation of the farming systems around Europe using a climate smart perspective. Some of the participants from this research study will collaborate in the implementation of adaptation pilots from the Climate-CAFE project.

1.1.6 Outline of the thesis

This report is divided into six chapters. Part of the first chapter provides the reader with an overview of the agriculture in the Skåne region and the future scenarios of the impacts of climate change on the agricultural sector. Furthermore, the influence of agricultural policies by the European Union and national government in the sector is also presented. The second chapter contains the theoretical and conceptual framework that are based on the literature review on previous studies and theories relating to systems thinking, the concept of sustainable development and the different approaches that may be suitable for farming systems in the region as well as the concepts related to climatic smart agriculture, and finally, participatory approaches relating to agricultural research. The third chapter describes the methodology used to approach this research. A qualitative approach was chosen for data collection and analysis. Semi-structured interviews were conducted with 16 farmers and one consultant. In addition, a workshop with the stakeholders was conducted at the end of the study to initiate a participatory process. The fourth chapter presents the findings from the interviews and examining in detail the views and perspectives of the participants and the reflections generated during the workshop. Discussion of results based on the outlooks of literature is presented in the fifth chapter. Last chapter presents the conclusions and recommendations for further research. And for the closing remarks, there is reflection on the researcher's learning outcomes and personal experience on participatory processes.

1.2 Context

1.2.1 Agriculture in Skåne

Skåne is a region in southernmost Sweden characterized by agricultural activities. The area used for agriculture in Skåne is about 450,000 hectares corresponding to 17% of the total agricultural land in Sweden. Currently, there are more than 9000 agricultural enterprises of which 28% are animal produc-

tion sector, 39% are within crop production and 33 % are classified as mixed animal and crop production or small scale farming systems (Länsstyrelsen-Skåne, 2015). One quarter of the national agricultural production is produced in Skåne (Johansson *et al.*, 2014) including one and a half million tons of grains and 300,000 tons of milk. It is estimated that 21,000 people are employed full or part time in the region's agricultural production (ibid). Skåne like many regions in Europe has shown a strong decline in number of farm holdings, many small and medium farms have disappeared resulting in the expansion of large-scale farming systems. Besides, most of the farmers are elderly, about 54% are over 55 years old and only 5% are young people under 35 (ibid). Nonetheless, it is important to highlight that Skåne has many competitive advantages as an agricultural region. It has good characteristics in terms of soils, climate and is also located near markets and export bindings, high labor dynamics are also found here.

The region presents large differences regarding structure, crop yields, livestock density and land use. In the southwest, the farming is intensive and with high crop yields while livestock production and pastureland are very low. In the northern part it is completely the opposite. The southeast part is also characterized by intensive crop production but at the same time there is a considerable amount of animal production (ibid). The crop production is intensely based on cereals. The main crops are wheat, barley, sugar beets, oilseed rape and potatoes. The major crops grown in the region are shown in (Table 2).

Table 2. *Use of arable land, total production and yield for the major crops in Skåne in 2014*. Source: (SCB, 2015).

	Area (ha)	Total production (tons)	Yield (tons/ha)
Crops			
Winter wheat	99 792	836 600	8.4
Spring wheat	6 762	39 200	5.8
Rye	13 397	97 200	7.3
Winter barley	4 708	32 400	6.9
Spring barley	72 614	425 900	5.9
Field beans	2 370	5 800	3.5
Peas (for processing)	6 940	*	*
Oilseed rape	46 337	175 300	3.8
Sugar beets	32 700	2 406 700	73.6
Potatoes	10 427	386 627	38.1
Corn	6 240	5 200	7.1
Total arable land	444 413		
Pasture and Meadow	55 292		

* No information available.

The majority of the faming systems in the region are conventional farming systems that have been intensified and specialized during the last 50 years. Those farming systems are depending of external inputs such as chemical fertilizers, heavy machines and pesticides (Stenmark, 2015). Skåne presents the highest use of mineral fertilizer compared to the other agricultural areas in Sweden (Figure 1). Due to the industrialization of agriculture in the region and the use of these external inputs, the landscape has changed dramatically, with a strong decline in areas of natural and semi-natural habitats. Although crop yields have increased, the negative impacts on natural habitats are noticeable. The effect of agri-

culture has led to decreased diversity and number of species by the loss of their natural habitats (Dänhardt *et al.*, 2013; Björklund *et al.*, 1999).

There are many challenges that current farming systems face on uncertainty of climate change. According to the last report Climate Assured Skåne different effects of climate change on agriculture in the region are highlighted (Hall *et al.*, 2015):

- The effects of climate change on agricultural production in Skåne could show positive effects in terms of crop production due to the extension of the length of growing seasons and increased growth bringing with it the opportunity to grow new crops and varieties but on the other hand the effect of warmer winters and variability in rainfall could increase the impacts by insects, disease and weed infestations.
- Agricultural intensification and increased crop production increase the risk of aggravating current problems such as loss of biodiversity, GHG, infiltration of fertilizers and pesticides, and furthermore loss of natural habitats.
- Several ecosystems processes will also be affected directly by the climate change in the agricultural landscape consequently resulting in the disruption of the ecological balance of these ecosystems.

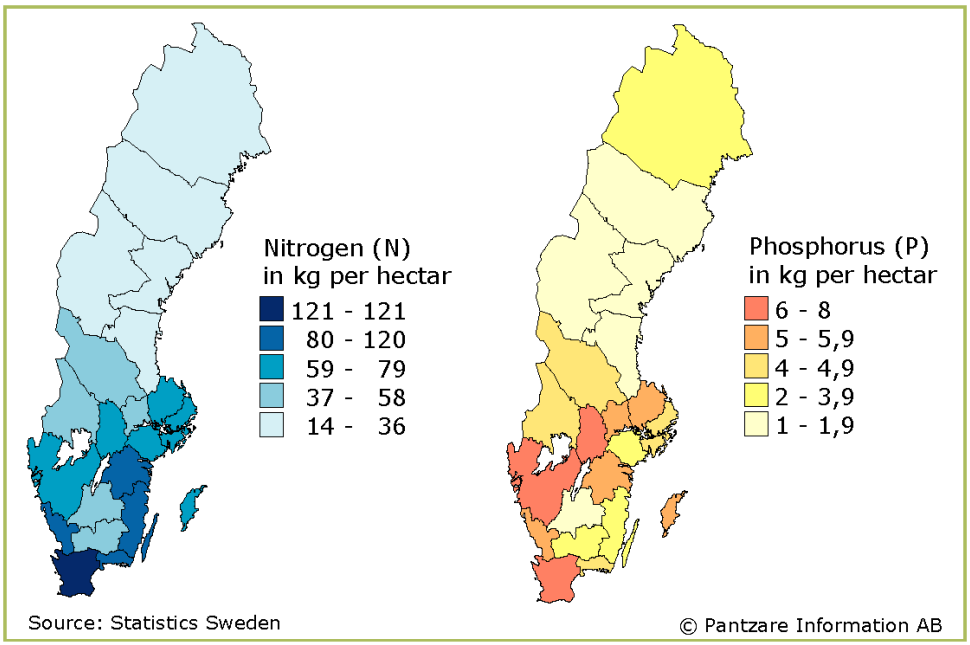


Figure 1. Sales of fertilizers for agricultural and horticultural production in the form of nitrogen and phosphorus in Sweden during 2013-2014.The values are given in kg per hectare of utilized arable land. Source: (Regionfakta)

1.2.2 Common Agricultural Policy (CAP)

The common agricultural policy in the European Union is an important driving force in agricultural development in Europe. During the past twenty years, these reforms have had several changes. Sweden joined the agricultural policies of the European Union in 1995. This document will refer to the latest EU agricultural reform "the CAP from 2014 to 2020" (European Commission, 2013).

The overall objective of the CAP is to provide a political framework to help farmers meet the challenges in agricultural production. Within this framework there are three objectives:

- Viable food production
- Sustainable management of natural resources
- And climate action and balanced territorial development.

The new reform focuses on achieving high levels of quality food production taking into account the preservation of natural resources in the European Union. This new reform includes a more holistic approach in order to maintain the structure of the two pillars of the CAP reform. The first pillar consists of the direct payments to farmers and market management measures and pillar 2 was developed for improving the structural and environmental performance of agriculture, which also includes rural development (Cantore *et al.*, 2011). Furthermore, the new reform embraces flexibility for Member States to set budgeting and implementation of this reform to a more suitable national context.

Another important change in the new regulation is the differentiation in per hectare of SPS (Single Payment Scheme) payments, with the aim to redistribute payments between farmers, e.g., young farmers, smaller farming systems or those who are located in disadvantaged areas may receive an additional payment (Ciaian *et al.*, 2014).

Finally the CAP reform introduces a new element for Pillar 1, the Green Direct Payment (figure 2). This is summarized by the inclusion of three compulsory green actions; maintenance of permanent grassland, the 5% ecological focus areas and crop diversification. Currently, there are different perceptions by farmers regarding this new Greening policy, however it is important to highlight that the implementation of this reform will bring advantages for the development of new agricultural practices that achieve the goals of sustainable development.

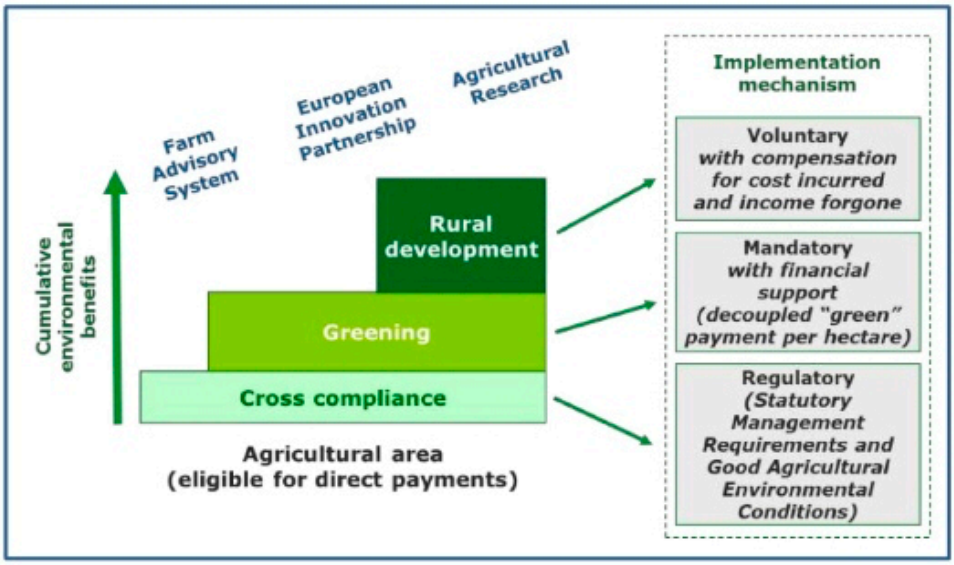


Figure 2. The new greening architecture of the CAP. Source: DG Agriculture and Rural Development (European Commission, 2013).

1.2.3 Swedish Rural Development Programme

The rural development programme 2014-2020 is designed by Sweden but approved by the European Union. This program is framed within the Europe 2020 strategy, smart, sustainable and inclusive economy. This program aims to benefit and develop the rural areas in the country where the environment, sustainable development and innovation are of relevance (Jordbruksverket, 2014).

There are six priorities within the program:

- Promotion of knowledge transfer and innovation in agriculture.
- Improvement of the profitability and competitiveness of all types of agricultural business and innovation of agricultural technologies.
- Improvement of animal welfare, risk management in agriculture and the organization of the food chain.
- Restoration, preservation and enhancement of ecosystems linked to agriculture.
- Promotion of resource efficiency and supporting the transition and climate resilient economy in the agriculture and food sector.
- Promotion of social development and economic development in the rural areas.

Apart from this program of rural development, it is important to underline that the national government has also established a system of environmental objectives containing a generational goal. The aim of the generational goal is to hand over to the next generation a society in which the major environmental problems are solved without increasing environmental or health problems outside the borders of Sweden (SCB, 2012). Within this generational goal are 16 environmental quality objectives. Some of the objectives of environmental quality have an important connotation in the agriculture sector: a varied agricultural landscape, reduced climate impact, zero eutrophication, good-quality groundwater and a rich diversity of plant and animal life (Hall *et al.*, 2015 p.95; Naturvårdsverket, 2013)

2 Theory, concepts and tools

This chapter provides the theory, concepts and tools for the study. In the first part the theory of systems thinking is described. The second part contains the concept of sustainable development and the most appropriate approaches to agricultural systems in face of climate change like agroecology and climate-smart agriculture. Finally, the participatory action research methodology is showed as an effective approach that allows the inclusion of the community in solving the problems that are affecting the world today.

2.1 Systems thinking approach

System thinking is a holistic approach, which focuses on analyzing a system. Ison (2008 p. 140) defines a systems as "*a perceived whole whose elements are interconnected*". Eksvärd (2009) states how natural systems consist of all the components and processes that are part of a system. Seen from a systems thinking approach, these systems are connected due to the impact between the components and processes that at the same time are affected by other parts and processes within the system. In other words, the systems thinking approach focuses on studying the constituent parts and the interactions between these parts within a system as a whole and in which new processes and behaviors occur.

Unlike the traditional approaches of analysis, such as reductionism, where elements of the systems are broken down into individual pieces and analyzed separately, systems thinking is characterized by seeing the world as a whole with components that are connected to each other and in which the separation of its elements would cause a lack of full understanding of these elements (Bradburn, 2014). Indeed, systems thinking can be effective to solve problems with a high degree of complexity. Richmond (1994 p. 139) defines systems thinking as "*the art and science of making reliable inferences about behavior by developing an increasingly deep understanding of underlying structure*". Therefore to address many of the problems of the modern society, such as climate change and the various issues that have emerged due to the actions that were taken in the past with a more conventional approach in the agricultural sector, give the lead to systems thinking to tackle these problems in a more efficient manner in which the holistic vision helps us generate positive results where many actors are involved. For this reason, **the study includes a systems thinking approach that help to draw the whole picture of the farming systems.** The social, economic and environmental aspects from the perspective of farmers were taken into account to understand how farmers deal with complex problems such as climate change.

2.2 Sustainable development

Sustainable development is a dynamic process of adaptation and has been defined by multiple authors. However one of the most common definitions of sustainable development was defined by the (World Commission on Environment Development, 1987 p. 43) as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*". This defini-

tion seeks to understand sustainable development as a process of change in which exploitation of resources; technological development and institutional change are adjusted to a changing future as well as to present needs. United Nations secretary-General's high-level panel on Global sustainability (2012) highlights the importance of sustainable development as a concept that sees the whole picture and which demands recognition, understanding and action of the interactions between the economy, environment and society. Although there are different indicators of sustainability, this concept has considerable freedom in their interpretation. Lichtfouse *et al.* (2009) state that despite the recognition of sustainable development in global interest, it is still unclear how these interests can be achieved in practice. In the world, progress in improving sustainability has improved but has not been sufficient to achieve the objectives of sustainable development, which implies that more action is needed in order to achieve this development. Societies and their environments change as a result of an evolutionary process, therefore a sustainable society must adapt to those changes in order to generate a continuous, viable and vigorous development (Bossel, 1999). The sustainable development approach is an adaptation and learning process, which seeks to improve our actions. It is important to recognize that the fundamental objective of the European Union is to maintain sustainable development. The sustainable development approach has been implemented in several of the policies and strategies of the Union. In particular, the European Union has promoted initiatives on climate change adaptation and integrated green economies with low carbon emissions (European Commission, 2015). **This document takes the definition of sustainable development as an essential concept to understand how the decisions made by farmers produce an impact on society and how diversification of farming systems can be a powerful strategy to achieve a more sustainable society.** The sustainable development principles helped to build confidence, spirit and fairness in the participatory process.

2.3 Agroecology

Agroecology is considered as the combination of different disciplines such as agronomy, ecology and social sciences for the analysis of agroecosystems. This concept emerged as an alternative to the negative impacts of conventional agriculture in a social and environmental context (Méndez *et al.*, 2012). The Agroecology term was mostly recognized in the 70s when the concepts of ecology were included in the analysis of agricultural systems. Agroecology was developed through the years receiving a great reception by social movements in Latin America. The influence of this discipline helped to foster the concept of sustainability in agriculture (Gliessman, 1998). Wezel *et al.* (2009) identify different factors influencing the definition of agroecology; these factors are defined by the historical evolution and epistemology resulting in different interpretations worldwide. Among these factors are:

- The existence of strong social or environmental movements,
- The existence of different scientific traditions and their evolutions, and
- The search for frameworks and concepts to describe new types of practices or movements.

There is not one single definition for agroecology, however this concept unites various scientific, institutions and social movements. Therefore, the term agroecology has a different meanings as a scientific discipline, agricultural practices and social movement (ibid). Altieri (1983) coined the word agroecology as "*a unique discipline that outlines the basic ecological principles to study, design and manage*

agroecosystems from a holistic point of view". Years later, Gliessman (1998) concluded that agroecology provides the knowledge and methodology necessary to develop an agriculture that is, on the one hand, environmentally friendly, and on the other hand, highly productive and economically viable. Another definition of agroecology is defined as "*the study of the interactions between plants, animals, humans and the environment within agricultural systems*" (Dalgaard *et al.*, 2003 p. 42). Naturally, the first conceptions of agroecology are still prevalent today. Conversely, a group of well-known agroecologists have redefined the term of agroecology as "*the integrative study of the ecology of the entire food system, encompassing ecological, economic and social dimensions*" (Francis *et al.*, 2003 p. 100). This new definition encompasses an interdisciplinary field that allows facing the challenges of food production in the future. In brief, Agroecology, which uses a multidimensional thinking (Rickerl & Francis, 2004) can address social, economic and environmental issues associated with the complexity of food systems.

Nowadays there are several concerns related to agricultural production. During a workshop on agroecology conducted by the Joint Research Centre in Milan, discussions were held on how agroecology could support EU agriculture to meet long-term goals concerning sustainable food production. As a student of agroecology I see a great importance in including the agroecological approach as a significant potential to meet the challenges of agricultural production and also to increase the sustainability of these systems. **In this thesis, the agroecological approach helped to acquire a holistic view of how different factors are influencing cropping systems and, more importantly, that farmers play a vital role as stewards of the land and biodiversity**. It is important to understand the complexity of agricultural systems from an ecological and socioeconomic perspective. Equally important is the farmers' own perceptions and decision-making in relation to managing cropping systems for better adaptability to climate change.

2.4 Climate-smart agriculture

Climate-smart agriculture is defined as "*agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes GHGs (mitigation), and enhances achievement of national food security and development goals*" (FAO, 2010 p. ii). This set of strategies integrates the dimensions of sustainable development in a social, economic and environmental context addressing the challenges of climate change and food security. The CSA contains three pillars (FAO, 2013):

- Sustainably increasing agricultural productivity, to support equitable increases in farm incomes, food security and development;
- Adapting and building resilience[4] of agricultural and food security systems to climate change at multiple levels; and
- Reducing greenhouse gas emissions from agriculture (including crops, livestock and fisheries).

4. Resilience is the tendency of a social–ecological system subject to change to remain within a stability domain, continually changing and adapting yet remaining within critical thresholds (Folke *et al.*, 2010).

CSA approach requests to produce technical, financial and political conditions to achieve sustainable agriculture[5] with the purpose of ensuring food security under the pressures of climate change. Recently, the CSA has integrated landscape approach, which is based on the principles of ecosystem management and sustainable land and water use. Therefore, this approach aims to: (i) address the existing complexity between food security and climate change promoting synergies and decreasing trade-offs; (ii) fit into local contexts of each country with their specific social, environmental and economic situations; (iii) invoke the participatory integration of different stakeholders, researches and policymakers; and (iv) recognize barriers to adaptation among stakeholders with regard to policies, strategies and incentives for creating resilience in face of stresses and shocks linked to climate change (ibid). However, one of the biggest challenges in implementing the CSA in managing farming systems is reaching out to a safe operating space for humanity (Rockstrom *et al.*, 2009). This will require a change in governance, support adaptive management and use of natural resources which are supported from political, social and economic settings (Neufeldt *et al.*, 2013). Steenwerth *et al.* (2014) state that a strong involvement of the scientific community is required in order to produce scientific metrics and a science-policy dialogue. They also stress the importance of including farmer-led innovative approaches and social learning, which help understanding farmer's beliefs on climate change and furthermore empower communities to adapt and mitigate to climate change. At the last Global Conference on Science Climate- Smart Agriculture (Montpellier, France, 2015) participants recognize that "CSA is now a framework that mobilizes synergies and can lead to innovative and comprehensive solutions at local, regional and global levels" (The Montpellier Statement, 2015). **The CSA strategy provides this thesis with alternative views on how to improve cropping systems in a more climate-oriented manner.**

The CSA gives great opportunities to improve agricultural systems and increase the resilience of these systems to climate change. It requires a strong political governance to promote knowledge and action of these strategies achieving food security and social equity in the agricultural sector. A sector, which for many years has been the target of misguided policies of agricultural development that have resulted in social and environmental detriment.

2.5 Participatory action research

It is important to clarify that PAR is a methodology. However this approach was helpful for the study to understand the participatory process, involving farmers in the pursuit for climate change adaptability.

Originally, Kurt Lewin introduced the term action research in 1946 describing it as "*a comparative research on the conditions and effects of various forms of social action, and research leading to social action*" (Lewin, 1946 p. 35). Participatory action research is an approach under the banner of action

5. Sustainable agriculture is difficult to pin up but according to the *Toward Sustainable Agricultural Systems in the 21st Century* report there are four generally agreed upon goals that help define sustainable agriculture: Satisfy human food, feed, and fibre needs, and contribute to biofuel needs. Enhance environmental quality and the resource base. Sustain the economic viability of agriculture. Enhance the quality of life for farmers, farm workers, and society as a whole (National Research Council, 2010 p. 4).

research, which is "*simply a form of self-reflective enquiry undertaken by participants in social situations in order to improve the rationality and justice of their own practices, their understanding of these practices, and the situations in which the practices are carried out*" (Carr & Kemmis, 1986 p. 162). PAR emerged as part of a new inter-dialogue between researchers who criticized modernity, capitalist ideas and social systems within social life (Kemmis & McTaggart, 2005). Generally, participatory action research involves a spiral of self-reflective cycles (Figure 3). Among the steps are: planning a change, action and observation of the process and consequences of this change and the reflection of this process. Subsequently, a new cycle begins where the original plan has been revised followed by the sequence of steps described above and still continuously generating new cycles. The process itself is characterized by being open and receptive. Participants are not just subjects of research who must follow the steps devotedly but rather, have the ability to develop "*in practice*" and at the same time "*understand*" these practices and "*situations*" in which they practice (ibid).

Brydon-Miller *et al.* (2003 p. 25) stated that the "*action research is not merely about doing good, it is also about doing things well*". That means that if the research is conducted without cooperative communication with the different stakeholders it is probably useless. PAR is not a "*method*" or a "*procedure*", but rather a set of assurances which can be seen and discussed and where the principles of social inquiry are applied (McTaggart, 1994 p. 315).

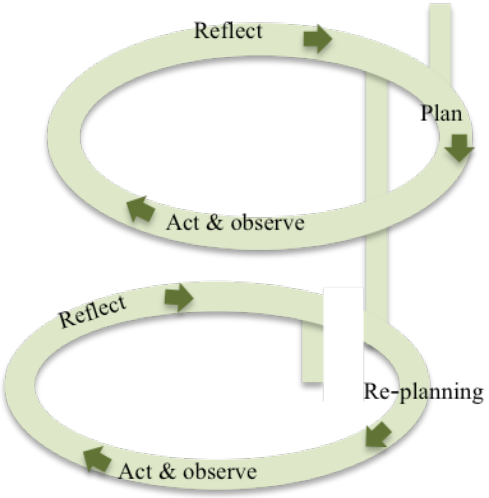


Figure 3. Action research spiral. Source: Adapted from (Kemmis & McTaggart, 2005)

In conclusion, PAR is a valuable methodology that allows the researcher to advance both in science and practice (Whyte, 1989), taking action and making changes in a form of reflective inquiry assumed by the participants with the purpose of improving the fairness, consistency and the sufficiency of their own social practices (McTaggart, 1994).

3 Methodological approach

This chapter provides an overview of the research design and the methods used to collect the data in this study, particularly in the context of using participatory approaches to stimulate discussion addressing climate change in agricultural systems.

3.1 Research design

This is a qualitative research study. The qualitative research methods allow us to understand the views, opinions and experience of people acting in a social context. This type of information is difficult to attain using quantitative methods (Guest *et al.*, 2013).The overall aim of this research was to understand the perceptions of farmers in face of climate change and the possibilities to adapt to climate change through the diversification of cropping systems. Understanding the complexity of these systems and simultaneously collect the values, beliefs and attitudes of the participants was therefore of large importance in this study, which motivated the choice of a qualitative research approach. Creswell (2009) stated that this research method emphasizes research from a complex and holistic analysis of words rather than quantifying the data from the view of informants and is conducted in a natural setting. The collection of relevant data and the interpretation of the data were inductive rather than deductive, where the theory is an outcome of the research rather than the opposite (Bryman, 2012). This study also includes the initiation of a PAR process. While all the steps of the PAR spiral could not be performed within the timeframe of a MSc thesis, this generated the starting point of a PAR process. This approach sought to cover the complexity of this study creating awareness among the participants about the impacts of climate change and their reflection on adaptation options. The underlying rationale was based on ontological assumptions, where reality is participative and epistemological considerations, where the participatory analysis and action enhances socially formed knowledge (*critical subjectivity)* (Loewenson *et al.*, 2014; Heron & Reason, 1997). This study is thus based on the use of several complementary methods, namely analysis of scientific literature, semi-structured interviews, reflection diary and a final workshop together with interviewed farmers and other actors.

3.2 Participants

Both purposive and convenience sampling was used to choose the respondents to this research study (Bryman, 2012). Initially, a database of potential respondents was generated focusing on farms mostly dedicated to the production of cereals and sugar beets and also an easy accessibility for the researcher. Around a hundred farmers (the term ‘farmers’ hereafter including both owners and managers of farms) were invited to participate in this research study. First, an email with a detailed description of the research study was sent out to the farmers. Due to the poor response to the emails, the farmers were also contacted by phone. In total, 16 farmers agreed to participate in the interview study. Additionally, one interview with a consultant was conducted. All interviewed persons were men.

3.3 Qualitative methods

3.3.1 Semi-structure interviews

Semi-structured interviews are based on key questions listed in an interview guide. But at the same time it contains leeway for the interviewer to go into detail (Bryman, 2012). The interviews were conducted with 16 farmers, 8 owners and 8 managers in the following municipalities: Skurup, Trelleborg, Eslöv, Ystad, Svedala, Lund and Staffanstorp. Also one interview was carried out with a consultant who works as a project leader at the Swedish Centre for Agricultural business management but also at the Extension Competence Centre at SLU. Semi-structured interviews were chosen for their flexibility but also because they give the interviewer the opportunity to get an idea of how the respondents perceive the social environment and also how they understand issues and forms of behavior (ibid). The interviews were conducted between May and August 2015, and were led using an interview guide consisting mainly of open-ended questions (Appendix 1a). In addition to the interview guide, further questions were asked to follow-up the respondents' replies. The majority of the interviews were performed in English, although sometimes respondents expressed their views in Swedish. A few interviews were done entirely in Swedish. Each interview lasted around two hours. Before the interview, all participants were informed about the objectives of the research study. Also a written consent (see appendix 1b) was obtained in order to explain and agreed on the way that the information generated during the interview would be used.

All interviews were transcribed and sent to participants in order to be validated. These transcripts helped to facilitate the analysis in more detail later on. Notes were taken during the interview and after the interview as part of a reflection diary to help the analysis and as part of the PAR approach. Three of the interviews were conducted in collaboration with another student of the Masters Programme of Agroecology, whose MSc thesis was performed with similar methodology but on a different topic.

3.3.2 Workshop

A workshop with farmers and other stakeholders was conducted at the end of the study, as part of the participatory process and in coordination with the research project Climate-CAFE (Climate Change Adaptability of Cropping and Farming systems for Europe). Respondents who participated in this research study and additional stakeholders, selected among farmers and other actors in the agricultural sector in the region were invited to this workshop. The main goal of the workshop was to obtain information about farmers' demands for climate change adaptation options, for further analyses within the Climate-CAFE project. The more specific objectives of the workshop were 1) to discuss the different points of views regarding the strategies needed to improve cropping systems capacity for adaptation to CC and 2) to present and discuss the results of the interviews. Activities were also conducted with the participants to identify strategies to adapt to CC according to different scenarios and to discuss drivers and barriers for different CC adaptation strategies.

Before the workshop, a meeting was held with the team of Climate-CAFE Denmark. During this meeting various aspects were discussed on how to conduct the workshop, what kind of information would

be valuable to collect, how to facilitate the discussion between participants and what kind of information would be relevant to show to participants about the effects of climate change.

3.4 Data analysis

Data were analyzed through thematic analysis. Transcripts of the interviews were carefully read through several times to get a general "*sense*" of information and reflection on its meaning (Creswell, 2009 p. 191). Core themes and subthemes were obtained from the data and were identified from repetitions, metaphors, similarities, differences and missing data, as proposed by (Bryman, 2012). Within the PAR approach, reflection is important not only of the stakeholders but also of the researcher. Therefore, after each interview, respondents were asked about their thoughts on the interview and how easy or difficult the questions were to answer. Additionally, a reflective diary was kept with field notes during the research process, which contributed to the analysis of the results. Also, during the workshop the reflections made by the stakeholders and the possibilities of action decisions within the participatory process were taken into account.

3.5 Reliability and Validity

Creswell (2009) described how validity plays a more important role in qualitative inquiry more than reliability and generalization. However, by adopting the PAR approach, the reliability and validity is enhanced through honesty, transparency and the obligation of openness by the researcher and the methods (Bacon *et al.*, 2005; McTaggart, 1998). In this study, there was space to openly listen to the participants during the interviews and the workshop, given a holistic approach by the researcher to assess the local situation from a socio-economic and environmental context. Moreover, there was room for self-awareness and reflection (Whyte, 1989), which was tracked through the reflective diary and which helped the reliability of the results. Possible bias could arise in the selection of the study population; in this case the people who chose to participate in this study demonstrated willingness in generating changes that address the climate change adaptation trough enhancing sustainable production. Another bias may have been the language and the accuracy of the translations because some interviews had a mixture of English and Swedish, or were conducted entirely in Swedish. However transcriptions of interviews were sent to the respondents for validation. The results were presented at the workshop and the participants ranked possible strategies for adaptation. Furthermore, all participants were informed about the research process and were given a written consent to participate in this study. In conclusion, this study tried to understand how the participants addressed the issue, and that the knowledge generated took into account the cultural context of the group involved. (Loewenson *et al.*, 2014)

3.6 Reflections

This study does not include all the steps from PAR, then why choose such a time-consuming and demanding methodology? A simple reason is that this study aimed to improve awareness of farmers on

CC and possible solutions that would arise regarding the adaptation to CC and achievement of sustainability. Most of the concepts and theories described in chapter two highlights the importance of promoting participation processes in which different stakeholders generate collective solutions in a local context. These processes not only empower rural communities but also serve as reference for policy-making that is designed in line with the communities needs. For that reason, the use of a PAR approach allowed to include the participation of some stakeholders in search of solutions that are accurate for them. Another point to discuss in this reflection is the collaboration with another student from the program. This collaboration was meant to enhance the efficiency of the interviews, as respondents were in the same target area. Thus, it sought to not interrupt the work of farmers doing an interview twice. A positive comment was to share experiences with other students and enhance the learning process when working in groups. Nevertheless, even though we had a similar methodology, there is a possibility that the collected data may have been biased due to influence by the theme of my colleague.

4 Results

In this section, the results of the interviews are presented in text. Also the inputs from the Climate-CAFE workshop are presented. Quotes are direct citations from respondents and are presented in order to illustrate the respondents' views. In addition, citations that are provided in Swedish were translated literally. Some of the respondents' answers were edited during the transcriptions to be easily readable, but the nature of the participants' responses still remains.

4.1 About the stakeholder

Respondents were between 26 and 66 years old. They have had some education in agriculture, particularly as farmer foremen (gårdsmästare), agricultural and rural management (lantmästare), agro-economists, agronomists and economists. All participants came from farmers' families and have more or less been farming all their life. Most of the farm owners have inherited their farms from their parents. Three of the participants were Danish. Some of the participants demonstrated work experience abroad such as in USA, Australia and other countries of the EU. The respondent farms ranged from 98 ha to 4000 ha. All mentioned to have some kind of pasture within the farming systems. Besides, participants from large-scale farms had forests as well. Some respondents had some form of collaboration with neighbors or colleagues, sharing land, machinery and workload. Respondents were distributed in different municipalities in southern Skåne as shown in Table 3.

Table 3. *Number of respondents from each municipality in the Skåne region.*

Municipality	**Respondents**
Eslöv	3
Lund	1
Skurup	4
Staffanstorp	1
Svedala	1
Trelleborg	4
Ystad	2

4.2 Research questions 1. Cropping systems today

This section describes how current cropping systems are constituted in southern Skåne. Views, values and beliefs are given as a way to portray factors and driving forces that influence the decisions of farm owners and managers when choosing their farming approach.

4.2.1 Cropping systems. Overview

The farms of the participants were mostly conventional farming systems, only four participants were growing organically. One of the farms is in a transition to convert the whole farm into organic, and the other three, have both conventional and organic production. Most of the cropping systems are represented by a 4-years rotation, which consists of sugar beets, barley, oilseed rape and wheat (in that order). Wheat can be replaced by rye or triticale, the same as oilseed rape by peas. For some farmers this

rotation is extended to five years due to the production of potatoes. This crop rotation can also vary because some participants have been introducing grasses in the rotation in particular, red fescue and rye grass. Crop rotation in organic production may be different compared to conventional. The crop rotation in organic production is between 6 and 8 years. Participants argued that the rotation is not fixed, and includes cover crops as much as possible. In organic production in addition to producing traditional crops, beans, oats and carrots are also included in the cropping system. Most of the products are sold to alcohol, bread, sugar and vegetable oil industries or seed companies.

4.2.2 Farmers values, traditions and knowledge

All of the participants acknowledged their passion for the work they do and highlighted the freedom they have in their work but also stressed the importance of making a living from the agriculture. Furthermore they referred to the importance of passing on a healthy farm to future generations, with good economy and in good condition. From this point, large-scale farms or estates ensure more easily the continuity of the farming business compared to smaller farms that have uncertain future of their productions because their children are not interested in farming.

> "*The next thing will also be doing it in the right way so that you don't just focus on where the money comes from but also what you are passing further for the next generation.*" (Manager, Trelleborg)

Some participants highlighted how the lack of innovation in farming systems in the region is influenced by the values of farmers. In that way, they said that the agricultural sector and farmers in general are very conservative and that this is mainly due to cultural reasons and tradition. Furthermore, some of the respondents explained that older farmers are often more conservative than younger farmers and the cause may be related to a question of generation.

> "*Farmers are normally very conservative; they don't want to take any risks.*" (Manager, Eslöv)

> "*Så tradition är så djup rotat i lantbruket. Jag vet inte egentligen varför men det är samtidigt något som påverkar människan i allt vi gör. De flesta lantbrukare känner nog såhär: -jag kan inte sluta plöja och hur skulle det ser ut, alla grannar kommer att tycka att jag är knäpp i huvude*t". (Manager, Skurup)
>
> — "*So, tradition is so deep rooted in the agriculture. I really don't know why but at the same time, this is something that affects us in everything we do. Most farmers probably feel like this: I can't stop ploughing, how would that look; all the neighbors would think that I'm crazy.*" (Manager, Skurup) —

The consultant explained that the lack of innovation among farmers is due to many of them being taught by older generations and have used that knowledge for a long time. Many of these techniques would need to be improved or replaced by more innovative practices, so he remarked that it is important that farmers get other perspectives.

It was mentioned by all participants how knowledge is acquired and shared by farmers. Some rely on their own experience but also on the recommendations of the advisers. Around one third of the participants expressed dissatisfaction due to the shortage of advisers on issues related to new agricultural practices, such as conservation agriculture including e.g. no-till cultivation. However, the vast majori-

ty of participants shared knowledge with colleagues or neighbors. In addition, they said that farmers are interested in talking about their knowledge and experiences. In contrast, there was a participant who mentioned the following statement:

> "*Farmers are not supportive with other farmers; they are not used to work together. Every farmer is working in his own farm and doing the best for himself.* " (Owner, Skurup)

Another important source of knowledge today is the Internet; participants said that the Internet is useful to learn about new techniques through videos and so on. Besides the lack of time to meet with colleagues, the Internet fits their needs even more. They also said they participate in meetings with other farmers but not very often.

4.2.3 Socio-economic and environmental context

European regulations through the CAP, and national policies are the legislative framework that has influenced agricultural production and the economy of the sector according to the participants. Thus, agriculture in the region has been affected by those incentives and regulatory systems; rising land prices because subsidies that are linked to the land would eventually go to landowners, creating competition in land rent and accessibility. Farmers also believe that the new CAP reform and the greening payment promote practices of production and land use, which damage the environment and therefore increasing the effect of climate change. The participants expressed their disagreement with those regulations that have been created without farmers' consent and which has forced them to adapt every year to those new regulations.

> "*The new rules for the subsidies "Gårdsstöd" work in the opposite way. Greening Payment (Förgröningsstödet) with ecological focus areas, work the other way increasing the emissions in the reality.*" (Owner, Svedala)

> "*Subsidies are pretty bad because they make the land prices and the prices of rented land higher*." (Owner, Trelleborg)

Clearly, all participants agreed that it is difficult to make new changes in the production because they depend literally of those regulations and further argued that without the payment of subsidies, perhaps their agricultural companies could be more competitive, certainly, if they receive better payment in their products.

> "*In Sweden you have a legislation that allows farmers to get a refund on a lot of the carbon emission taxes from diesel, so you have very little motivation to try biodiesel*." (Manager, Skurup)

Several participants also noted on inequality in regulations among EU countries. They concluded that Sweden is very strict with the regulation and for that reason a lot of the agricultural production, particularly the animal production has been disadvantaged.

"*The problem is that there's very strict regulation of how you should produce things in Sweden. But at the same time, you can import whatever you want.*" (Owner, Ystad)

"*Animal production is going down in the country for the rules. Politicians don't want that we raise animals; it's easier to buy from abroad.*" (Owner, Svedala)

One of the most important aspects for the participants is the economy. They argued how important is to have good profits for the purpose of performing year after year. For instance, the factors that influences farmers' decisions when choosing crops is linked mainly to the market and the prices. Many explained that they are not making that much money today due to low crop prices. Some of them pointed out the wheat as one of the products that have better prices. For participants producing potatoes, the potatoes are one of the main crops because they can get good prices. For other participants, the price of sugar beet has declined. On the other hand, quite a few participants said that the high price of land limits the expansion of their business; in other words, you need more area if you want to be more profitable. Some farmers commented that high land prices make it more difficult for young farmers to access to land and starting a farming carrier.

[Income] "*is going up and down due to the grain market prices*." (Manager, Eslöv)

"*The prices are so different in the different crops, some years we cut down on the barley and we have more grass instead.*" (Manager, Ystad)

The consultant also agreed in stating that only 50% of agricultural production is profitable and, on average, farmers are losing money. The price of land has risen and farmers have borrowed to the losses. One way to finance this is that they get tax reductions. So the consultant poses the rhetorical questions how competitive are we? Are we going to have a strategy that will nourish farming?

Many mentioned that buyers influence the decisions of cropping systems, particularly crop varieties and how it should be grown. In the case of participants growing organically, one of the participants mentioned the growing demand for organic products. Almost half of the participants stated on the lack of recognition of the farmers' role and absence of inclusion of the agricultural sector as an important part in the national economy.

"*The biggest challenge is the low price of the crops. To lift the price up and let the people know that the Swedish farmers are important and do good things. The agricultural sector should be recognized as an important sector for the economy in the country.*" (Owner, Eslöv)

Concerning production capacity and environmental issues, all farmers agreed to have higher soil compaction due to the large machines used in agricultural production, specifically in the production of sugar beets. For several participants biodiversity is related to living organisms in the soil. For others, it is difficult to measure how much biodiversity is lost due to the impact of the agricultural systems. But undoubtedly, quite a few farmers agreed that their actions are having a negative impact on the environment. Nevertheless, they are aware of farming in a more friendly way with the environment. In particular, many argued the positive sides of certain rules related to the care taking of the environment.

For example, buffer zones which help to lessen the runoff of pesticides and fertilizers into the watersheds.

> "*It's the rationalization of the farming structure here with the development of machinery. I mean, machines get bigger and bigger. You need bigger areas in the farms. That is a disaster for the biodiversity when you have the whole farm in one crop*." (Owner, Skurup)

Most of the participants expressed their willingness to improve their cropping systems but also relate it to the cost generated by making those improvements. In this case, they expressed doubts about who will pay for those ecosystem services.

> "*We need to have some kind of payment of what we do for the environment.*" (Owner, Ystad)

4.2.4 Development of the cropping systems

All respondents point out the dependency of fertilizers, agrochemicals and machinery in the whole farming sector. Many consider that the use of fertilizers and pesticides has decreased due not only to different regulations but also the use of technologies such as GPS and precision seeding. They also recognized that in practice it is very difficult to farm without the use of these inputs and stressed their concern on how agriculture will feed the growing population without the help of chemicals.

Several participants highlighted that although certain practices such as conservation agriculture, no-till farming and strip tillage have been practiced for several years in different parts of the world, these practices have recently been implemented in the agricultural sector in the region. They also believe that these practices are the new way of farming here in the region but it is necessary to acquire more knowledge and develop these practices to make them more suited to local conditions.

Another topic brought by participants during the interviews was the use of crops for the biogas production. The vast majority explained the lack of economic viability of this production, as well as the soil damage due to the heavy machinery used in harvesting. Only three participants agreed on the production of biogas essentially because they are part of the project of a new biogas plant (Jordberga) located in Trelleborg municipality. According to the consultant, farmers have a yield gap for the simple reason of a bad approach to the production management. One of the reasons is that they do not use all the biological potential within their farming system.

> "*Farmers have to prepare their land much better. The crop rotation needs to be better. The pressure on the land by machinery has to be reduced. We have a yield gap and we are not using at all the biological potential and why is that? It's mainly because for bad management.*" (Consultant)

4.3 Research question 2. Perception on climate change

This section will explain the various views that participants have about climate change, how aware they are on climate variability and how familiar they are with respect to different terms, such as climate change, adaptability, mitigation and resilience.

4.3.1 Climate variability

All participants expressed changes in weather patterns. The most common patterns cited by participants were: heavy rain, mild winters and longer periods of drought or with a lot of rain. At the same time, several of the participants attributed these changes to natural conditions rather than to climate change. One third of respondents, it was difficult to distinguish whether it is part of the natural processes or if the changes in climatic patterns are part of the climate change attributed to mismanagement of natural resources by the human being. Participants recognized that this climatic variability caused damage to their crops, but not yet on a large scale. Participants pointed out some years in which they have been most affected. Several expressed their concern over the difficulty to predict the climate in the future especially when they, as farmers depend on weather conditions.

"*The worst whether we have had was 2001 and 2006. Because 2006 it was pretty much raining all the time and the seed started growing in the fields, in the heads of the grain, so it was worthless.*" (Manager, Lund)

"*We had a major rain five years ago, with 150 mm in seven hours. In that time I lost 10% of the fields up there because it was rotting in the fields.*" (Owner, Skurup)

"*2011 we had an amazingly wet August. It cost a lot of money to get the harvest and made a lot of structural damage to the soil for years after.*" (Manager, Skurup)

4.3.2 Awareness on Climate change

The majority of participants argue being aware on climate change but it is not a topic that is discussed among farmers. They consider that farmers talk about differences in weather patterns but not actually climate change. About half of the participants, referred to climate change and global warming as an issue that should be discussed by politicians, and not as a matter affecting farmers because there is too little or nothing that they can do to address climate change.

"*What I can do as a single individual is a good question. That's something for the politicians and for the big guys in the G8.*" (Owner, Skurup)

All participants described the benefits and disadvantages of climate change and specifically regarding the cropping systems. The main benefit mentioned by participants was the longer growing seasons. Farmers have been able to plant earlier in the spring and seed and harvest later in the fall. Another advantage discussed by respondents was the possibility of introducing new crops or new varieties due to warmer climate. Several participants pointed out the increased infestations of pests, diseases and weeds as a disadvantage of climate change and it was ascribed to the mild winters. Quite a few participants mentioned impacts of climate change on the soil.

"*We already see that there are some benefits with the weather especially in the autumn where it is much warmer. Longer growing season so crops are going very long.*" (Manager, Eslöv)

"*Det enda dåliga med milda vintrar är att man inte har en naturlig fiende mot svamp och insekter.*" (Owner, Eslöv)

— "*The only disadvantage with mild winters is that you don't have a natural enemy for fungus and insects.*" (Owner, Eslöv) —

The consultant argued that the lack of awareness on climate change does not make the agricultural systems sufficiently resilient. Despite the opportunities posed by climate change for the agricultural sector in the region, these systems may face some threats such as increased infestations of pests and diseases, affecting significantly the production and perhaps increasing the use of chemical controls.

4.3.3 Mitigation strategies

None of the participants mentioned differences between mitigation and adaptation. The information was sorted according to the various practices that participants have implemented in recent years and some of which are related to climate change. Almost all of the participants claimed the on-farm reduction of GHG emissions. They considered being free from fossil fuel energy because they can produce their own electricity. The energy produced is used in heating housing, facilities and grain drying and mainly comes from straw, woodchips and solar energy. All participants stated being aware of their fuel consumption. They are trying to reduce their fuel consumption and improve soil quality through different agricultural practices. One participant mentioned using conservation agriculture; another said that they have converted to a no-till system and several have implemented strip tillage. Only two respondents affirmed using biodiesel, the remaining participants simply use diesel.

"*If the whole world used cover crops or conservation agriculture then we could have fixed the climate change. There is so much carbon dioxide that we could take out from the air and fix it in more stable carbon.*" (Manager, Eslöv)

"*I'm aware about our fuel consumption. This is my whole idea to stop ploughing and intercrop cover crops. That will lower our fuel consumption a lot.*" (Manager, Staffanstorp)

4.3.4 Resilience

For many participants it was hard to explain how resilient they consider their farming system to be. Some did not know the concept of resilience and quite a few respondents mistook it for resistance. Furthermore, participants argued enhancing of their adaptive capacity[6] for future climate change impacts. All participants agreed that the key to achieving resilience, is improving the soil health. All pointed out that they are increasing the organic matter in the soil. They explained how valuable it is to leave the straw and crop residues in the soil. Moreover, the majority stressed the importance of the use of soil amendments like manure. Others (about a third) supplemented this practice with cover crops and green manures.

6. Adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. (IPCC, 2001a)

"*I think we will be more resilient if we work with the soil and have a good rotation, at least the fields will be better.*" (Manager, Staffanstorp)

[Resilient] "*it's hard to answer. One of my purposes of developing the soils with more organic matter is to be more resilient against the droughts and the dry weather.*" (Owner, Svedala)

"*I think with this no-till system, we are better prepared for handling the big variations with a lot of rain and a long period of drought or whatever because there is much more better structure on the soil now compared to before when we were tilling the soil.*" (Manager, Skurup)

Many participants also noted to have made improvements in the drainage systems. They have realized that in recent years the frequency of heavy rainfall has increased, for that reason they consider that their fields would be greatly affected. Participants also discussed the increase in biodiversity to enhance ecosystem services. Some consider having increased some biodiversity because they have started to plant different species that are good for bees and other insects around water sources or around the fields; two indicated having fields especially for birds like larks. One participant mentioned the creation of dams, which have helped cleaning the water through the drainage system in order to reduce N loads and improve the environment of the lake near the farm.

"*Nowadays you talk more and more with the advisers about that you have to look after your draining systems and keep them updated and keep the old ones in good shape. So I think we are preparing slowly for climate change.*" (Owner, Trelleborg)

Finally, many respondents reflected on the future outlook of cropping systems in the region describing the possibility of introducing new varieties and crops and also changing the time in which various agricultural practices are performed such as seeding, harvesting and others.

"*One way to handle it is to have many different crops so that you harvest one early, one in the middle and one late. Then you cover the whole season because if you have all your crops in one time maybe all of them will get spoiled if the weather conditions are bad.*" (Owner, Trelleborg)

According to the consultant, farmers should focus on improving biological production. In other words, working with nature. That could maintain enormous improvement in production. Some technologies can kill common sense thinking. Care must be taken with the technology because it can affect the production. Another problem that arises in the region is the small amount of animal production systems; this is because they have been pushed away by the cereal production. It is not good because we need natural fertilizers such as manure to increase the organic matter in the soil.

"*The only thing is improving the biological production in the best way. We have to work with the nature. It can easily sustain huge improvement in production. Some of the technology can kill the common sense thinking. We have to be careful with the technology. It can destroy good production.*" (Consultant)

4.4 Research question 3. Impressions regarding diversification

4.4.1 Introduction of new/alternative crops

With regard to the introduction of new or alternative crops in the cropping systems, participants responded using catch/cover crops in the crop rotation. The most common practice is to grow the cover crops after wheat and before sugar beets. But also they can be grown after early potatoes or between peas and wheat. Oil radish was one of the most common cover crop used. However, some participants concluded that it is much more beneficial to use a mixture of cover crops, including phacelia, clover and other legumes. Several respondents also highlighted to have undersown these cover crops in the wheat and barley.

> "*[This field has] oil radish, hairy vetch, lupines and buckwheat, they are together. This is diversity.*" (Manager, Eslöv)

Another practice that has increased among participants is the introduction of grasses in the crop rotation as cover crops. Most respondents reported the use of grasses such as ryegrass and red fescue. Participants have realized the advantages of grasses for enhancing soil quality. Regarding climate change and global warming, most participants agreed that one of the crops that best fits the conditions in a near future are grain legumes, especially field beans. Other participants pointed out corn as a maturity crop or bioenergy crop. Two indicated the introduction of sunflower and hemp. All participants expressed their interest in growing soybeans but stressed that currently there are no varieties that are adapted to the conditions of the region. Additionally, two of the participants also showed interest in the production of vegetables.

> "*We have been asking around about soy beans, but there's no good variety for this climate yet.*" (Manager, Ystad)

4.4.2 Motivations and interest

Most participants related diversity especially to the inclusion of cover crops in the crop rotation system. Many respondents explained the reasons behind growing cover crops; they consider that cover crops increase the yields of subsequent crops. They also noted that these cover crops not only benefit the nutrients in the soil producing significant percentage of N, but also help to recycle the excess of nutrient preventing leach out. Another point discussed by almost all participants was focused on the importance of keeping the soil covered throughout the year in order to increase the organic matter, and improving the soil environment for microorganisms and earthworms. Several respondents also said that the introduction of new crops could be very interesting and challenging. One of the participants was interested in intercropping, but stated that the farming systems are far from having 2-crop systems per year in the region.

> "*I believe that it's important to have diversity within the different crops just as you have different crops in your crop rotation.*" (Manager, Staffanstorp)

[Cover crop] "*that is where my thinking of diversity comes in. It's not in the primary crops because we are going to grow what the market demands (wheat, canola, barley and sugar beets).*" (Manager, Lund)

4.5 Research question 4. Socio-economic and environment influences on diversification

This section contains the views of the participants on opportunities and constraints when it comes to diversifying cropping systems from a social, economic and environmental context.

4.5.1 Issues

One of the main issues limiting the introduction of new crops in cropping systems is entirely related to the market. All participants agreed on the need for a consolidated market to make the production of a new crop possible. The participants expressed their concern on who might be the buyers of the products and which would be the target market. They clearly showed their interest in food production rather than products for animal feed or bioenergy. Some pointed to the beans as a product with very low profit because it is primarily for animal feed. Alfalfa was another example mentioned by one of the participants. He believes that the market for alfalfa is very narrow and maybe the potential of this crop is better suitable for the biogas production. To a lesser extent, investment in new machinery for the production of new crops was brought up. Quite a few respondents argued the cost of investing in the adaptation of machinery for the management of a new crop. Another issue that could have a great significance in crop diversification is the age of farmers. One of the participants mentioned that most of the farmers in the region are old and for this reason they may be deterred from implementing new ways of farming. In conclusion, the respondents emphasized the importance of growing crops that have good revenues.

"*I think the obstacle is the market but I also think that farmers just need to try new ways of farming.*" (Manager, Eslöv)

"*Grass is very important for the carbon sequestration. If you can make money on the grass you'll have it. The only way to grow grass is for seeds and the seeds aren't that good or profitable either.*" (Manager, Staffanstorp)

"*In some places they are too old for new crops. I mean if they were one generation younger like you, they would have a different view on things.*" (Owner, Skurup)

Regarding cover crops as a strategy to enhance the diversity of farming systems, several respondents pointed out the limited space between the crops in the rotation, e.g. sugar beets are harvested very late at the end of the year; consequently there is no opportunity to grow a cover crop. The only possible option is after wheat. One participant also mentioned the difficulty of managing the catch/cover crops due to heavy workload during the seeding of these crops because the main crop is harvested at the same time. Another point that was discussed by respondents was the effect of cutting payments to cover crops. They commented that many of the farmers abstained growing cover crops that are no longer subsidized.

"*Vi kör ju fånggrödor fastän vi inte får betalt för dem nu de senaste 2 åren. Många har ju därför valt att inte ha dem.*" (Owner, Eslöv)

— "*We have cover crops even though they stopped paying us for them, 2 years ago. That's why many farmers don't have them anymore.*" (Owner, Eslöv) —

"*Many farmers don't see the practical use of catch/cover crops. It's easier to have black soils for longer periods, take out weeds simply. It's tough to change your farming system. It takes time.*" (Owner, Svedala)

4.5.2 Opportunities

There were different views on the opportunities to diversify cropping systems among the respondents. In the case of organic producers, the diversification of cropping systems through cover crops allow them to reduce the use of fertilizers, which are very expensive in the organic production. They also argued that success in organic production requires diversity in the rotation system. This allows them to improve their income and also lower the risk of disease, pests and weeds.

"*I mean you put money in these cover crops but they really give you a lot back. When the diversity is increasing you can reduce your inputs of nitrogen and phosphorus.*" (Manager, Eslöv)

"*The cover crop is the most important crop of the crop rotation because it gives your field a great diversity with all the different roots and they draw different things to them and different animals, microbes and fungi and everything.*" (Manager, Staffanstorp)

Overall, most participants assumed that one of the opportunities to implement new crops in the region is undoubtedly climate change. They agreed that the increase in temperature would allow the expansion of the range of crops that could possibly adapt to the conditions of the region. Most participants stated the importance of cover crops as a strategy to sequestrate a lot of carbon, improve soil structure and mitigate the effects of climate change. Quite a few participants also added the importance of including perennial species in the crop rotation, which improves the quality and soil fertility.

"*We will be able to grow new kind of crops and have new varieties.*" (Manager, Skurup)

"*[Grass] It's very good for the soil structure which we have problem with down there for the high clay content in some fields. We can say that the grass seed can replace sugar beets.*" (Manager, Lund)

4.5.3 Enhancing more sustainable farming systems

The vision that participants have regarding the enhancement of sustainable farming systems is primarily linked to soil improvement. But for some it goes further. They commented that it is also important to improve water management and increase biodiversity. For instance, many consider fundamentally improving their cropping systems so that they become more environmentally friendly. However they are concerned about profitability. One participant mentioned the importance of understanding the ecosystems services, particularly creating environments for the nature to be part of the production systems. Around one third of participants argued the need of establishing either a long crop rotation or a

short rotation but with a wide variety of crops, in brief, harvesting twice a year. Another important point discussed by the respondents was the debate about which cropping system is better when it comes to meeting the needs of a growing world population; organic or conventional. For some, especially organic producers, they see a chance to open minds and change farming behaviors. They stated that growing organically has allowed them to be more creative when it comes to implementing new farming practices. According to some respondents, conventional systems are often so conservative that they hinder possibilities to expand and implement new ways of doing agriculture. Moreover, these respondents see that the future of farming systems should not be either organic or convectional but take the best of each system to improve the sustainability of farming systems. Some respondents from convectional systems also agreed with this statement.

"*I think in the future the answer is not either organic or conventional. I think they must meet each other and it'll be a compromise from both sides.*" (Manager, Eslöv)

"*Today you have these conventional systems, which I use and on the other hand you have organic farming systems. I think in the future there will be more hybrid systems to use the best from both worlds.*" (Owner, Eslöv)

4.6 Research question 5. Conditions and guarantees

The results presented in this section are an overview of the necessary conditions for the implementation of new crops from participants' perspective.

4.6.1 Implementations

Knowledge was one of the mentioned aspects for the implementation of more diversified cropping systems. According to respondents, it is necessary to develop more knowledge on how and when to establish the new crops, which kind of crops are suitable for the local conditions and which kind agricultural techniques are required for the development of these new cropping systems. Additionally, there is a need to have test fields in small and large scales that demonstrates the benefits of these crops in reality. Some respondents argued that there is too little development about cover crops for the conditions of the region. Many of the techniques implemented come from abroad and very few are known locally. The same goes for machinery.

[New ways of farming] "*We have to learn more about that.*" (Manager, Ystad)

"*Knowledge. So we know more about it so we feel confident.*" (Manager, Eslöv)

4.6.2 Hinders

The obstacles that participants considered limiting crop diversification is related to the regulations at national and EU level. Most respondents argued that the regulations do not allow them to improve the diversity of cropping systems because those regulations do not meet the needs that they have.

"*If you were allowed to have a cover crop there in mid November, then it wouldn't be a problem. So the rules are setting some limits.*" (Manager, Skurup)

Moreover, quite a few participants highlighted that the change in cropping systems has to come from the farmer himself. He should not wait for it to be implemented by regulations or entities. In that way, farmers have to change their attitude regarding new challenges such as climate change. Considering this factor, for some participants it is essential to create confidence when making changes in cropping systems. For many it is easier to be on the safer side. Namely, wait until others have developed these new practices and when is fully established, it is safe to try.

"*The problem is also within the farmers because they are not willing to change and to do something else. Farmers get stuck in the old way of farming.*" (Manager, Staffanstorp)

"*I don't want to be number one, it's better to be number two. I look at the number one and see how works. Personally I think I'm quite early on new thing but I want to see first.*" (Manager, Eslöv)

4.6.3 Support

One third of the participants commented that it is crucial to receive support from the government, at least in the initial investment. For other respondents support must relay on the advisers. They argue that there is a lack of advisory in relation to effective strategies to adapt to climate change. Furthermore there is very little promotion of new agricultural practices like no-tillage systems and conservation agriculture. Some also commented that the advice today is mostly focused on observing farmers to follow the rules rather than promoting innovation among farmers. One participant mentioned that large companies should invest into the development of new crops that are adapted to local conditions.

"*Things have changed in the advising. "Lantbruksnämnden" were helping farmers better 30-40 years ago. They were encouraging farmers to try new crops and techniques in a much larger scale than they do today.*" (Manager, Ystad)

The consultant explained that the advisory system has to change. Advisers often sell information only. In the future advisors should help farmers develop and implement necessary changes in their management. Farmers know more about what to do but the advisers need to guide farmers how to do it. It requires better understanding of transition processes.

4.7 Results from the workshop

15 people attended the workshop. Farmers who took part, but also some who did not participate in the interview study, advisers, students, researchers and one journalist participated in the event. Also, a MSc student who is part of the team of Climate-CAFE Denmark was attending as an observer.

Plan:

The plan of this workshop was to have a discussion about opportunities regarding diversification of cropping systems in Skåne to achieve better adaptability to climate change. Moreover, it sought to facilitate a participatory process with the intention of seeking appropriate solutions to farmers' demands and needs, and also collect data for this research study.

Procedure:

The workshop started with each participant making a short self-presentation with the purpose to familiarize participants with each other and have a general overview of participants' expectations for the day. Furthermore, a small introduction of the project Climate-CAFE was presented. During this presentation, participants discussed about the cropping systems most representative for the region. Participants were very active in this discussion. Another important point in this section was the definition of a collaborative group called adaptation pilot, which will be represented by the participants who attended the event but also those that could not attend the workshop but expressed willingness to be part of this project. As the next step, a presentation of predicted climate scenarios for Skåne in 2050 was showed using projections from the Swedish Meteorological and Hydrological Institute (SMHI). Participants also were very active during the presentation in which they had the opportunity to learn new information about climate change and resolve doubts about this phenomenon. Finally, concluding the introductory part of the workshop, the results of this research were presented to show the opinions and perceptions that farmers had on climate change and the possibilities to improve the climate change adaptability of cropping systems in the region. Farmers were able to validate the information. There was also space to explain the definition of diversification of cropping systems, the controversy surrounding the claim that farmers are often conservative or that somehow resist change. However, it was clarified that despite the younger farmers tend to do new things, older farmers can also come up with new ideas. Another point discussed was the opinion of farmers regarding the use of biotechnology as a strategy for climate change. It was explained that some farmers mentioned that option but pointed out that the understanding of the ecosystem services would be more appropriate to implement in the management of farming systems. After this introductory part to enable discussion among participants, three different posters were placed around the room for the participants to look at during the coffee break. One of the posters contained information about the extreme weather effects for 2006, which was identified as one of the most critical years for the region. The second poster showed information on world market prices over the last 20 years in products such as wheat, oil, nitrogen and phosphorus, this was intended to remind participants about the context of recent, and sometimes unpredictable, market fluctuations and illustrate potential links with extreme weather events. The third poster exhibited information on climate projections for 2050 in relation to temperature, precipitation and length of the growing season.

Observations:

Before starting the discussion, participants had the opportunity to ask questions, propose changes and add information to the posters with the aim of making the process more interactive and enable participants to adjust or agree with the information that was proposed. The group was divided into two smaller groups considering that the groups were made up of participants from different sectors. The small group discussion was held mainly to propose actions that could improve cropping systems to

adapt to climate change based on the information provided on the posters. This discussion also tried to address the following questions:

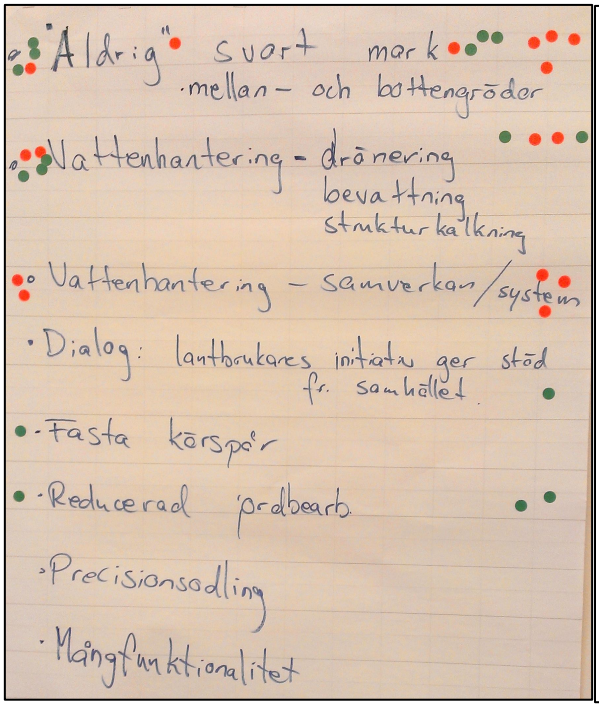
- What were the opinions within the group about agriculture needs to change to adapt to a changing and more uncertain climate?
- What were the groups' proposals on adaptation measures?
- How effective did the group consider the different measures to be?
- How did the group consider the measures in terms of feasibility for implementation?

After the discussion, the groups were asked to present their suggested measures. One group based its discussion in the problem of leaving the black soils particularly during the winter because it affects soil structure as well as losses of nutrients and soil carbon. They also discussed about which cover/catch crops could be included in the crop rotation. They emphasized the need for more knowledge about these crops. A comment that was highlighted during the discussion was the farmers' bad approach in the management of cover crops that might have influenced the creation of new regulations regarding these crops. Another point brought up by this group was how it could influence society, especially in consumption; and finally, the inclusion of water management as an important strategy to cope with the effects of climate change. The other group based its discussion on the use of new crops for the production of bioenergy such as alfalfa and corn. Also the practice of controlled traffic farming as an alternative but also mentioned that it might be difficult to implement in certain crops. Additionally, they pointed out the use of crops with different harvest times. Another important point was the use of precision agriculture to decrease inputs and also to prevent nutrients losses. Finally, they discussed the need for political support and the implementation of approaches such as multifunctionality and systems thinking.

Reflection:

A list of options that were discussed by the groups was summarized. Participants had the opportunity to reflect on the choices made and also assess them according to their effectiveness and feasibility for implementation. The result of individual participants' ranking of the different options for adapting to climate change is shown in Figure 4. The most effective and feasible options to be implemented were: 1) the use of cover crops to avoid black soils and 2) water management. Participants were able to discuss adaptation drivers and barriers that may arise in the implementation of these adaptation options. One of the main points discussed was the research. Participants were discussing about how much research is needed to show the advantages of these crops, but the participants also remarked on the need to know which new crops that could be introduced, when to establish these crops and how the management would be. The water management strategy was seen as just as important as improving the soil health. The participants pointed out the lack of participants from government institutions because many of the actions regarding this management are subject to regulations. As last activity of the event, a summary of the workshop was presented. Several proposals for future activities were considered to perform during 2016. It was also discussed whether the group should be larger or remain with the same number of participants. Some participants recognized that this small group gave the opportunity to have a more comfortable and deep discussion. Furthermore, participants stressed the importance of including other institutions and the government as well. The creation of a collaboration to develop cropping systems with "whole-year ground cover" was also suggested. Participants agreed to make a field visit to one or a few of the participant's farm to show and discuss practices of soil covering dur-

ing the winter, using diverse cover crops. Besides, the financial resources available for the project Climate-CAFE were discussed. Due to these resources being limited, it was suggested to send proposals to other institutions such as Partnership Alnarp to apply for more economic recourses. Lastly, naming the group of "adaptation pilot Skåne" was agreed.



- Never black soil
  - Cover crops and under-sown crops
- Water management:
  - Drainage
  - Irrigation
  - Structure / liming
- Water management: Collaboration Systems
- Dialogue: farmers' initiatives for support from the community
- Controlled traffic farming
- Reduced tillage
- Precision agriculture
- Multifunctionality

Figure 4. Summary and ranking of the options for adapting to climate change. Red dots correspond to the effectiveness of adaptation and green dots for feasibility.

4.8 Reflections on the participatory process

The workshop was very positive in general. The participants were pleased to have been involved in this activity. They stressed the lack of inclusion of farmers in decision-making for the creation of regulations that primarily affect them. Although the team that organized the workshop was new in the use of participatory approaches, good structure of the workshop allowed filling up all the expectations and addressing the questions that were being sought. It is noteworthy that all the participants had space to participate. However, it was evidenced that researchers and consultants by the nature of their role in the work they perform, somehow led the discussion. As a researcher, this participatory process was very useful to expand my knowledge but also provided me with new ideas, which were included in the discussion and the conclusion of this study.

5 Discussion

A variety of approaches, strategies and methodologies have been presented in this study to facilitate the discussion about the diverse factors that have influenced farming systems in recent years. The possibility of understanding how a system works from a social, economic and environmental context served to get a holistic view of the system. The integration of farmers advancing issues related to adaptation to climate change and achieving the goals of sustainable development views play an important role. In this section, insights, concerns and actions on the perception of farmers on climate change and the diversification of farming systems as a strategy to increase the adaptive capacity of these systems to address climate change will be discussed.

5.1 A rich picture of the current agriculture in the region

Current cropping systems have been influenced by different factors in recent years. It is clear that the specialization of farming systems has been promoted by agricultural policies and price regulation, forcing the farm structure development towards a model of more industrialized agriculture (Björklund *et al.*, 1999). The scientific and technological achievement of these intensive systems has been succeeded throughout the use of high yielding crop varieties, chemical fertilizers and pesticides, irrigation and mechanization (Matson *et al.*, 1997). Furthermore, under the legislation of the CAP reform, the amount of integrated crops, livestock and forestry systems has decreased, as well as the increase of environmentally detrimental practices and overproduction due to intensification of farming systems (Stoate *et al.*, 2001). Large-scale agriculture has established large fields and block cropping resulting in more uniform landscapes. Moreover, the adoption of simple rotations and crops managed with more mineral fertilizer and pesticides compared with the past, has allowed farmers to simplify the management of these agricultural systems. The result of this simplification has led to the reduction in crop diversity and loss of non-crop areas such as pastures, fields boundaries, watercourses and trees consequently resulting in the deterioration of soil structure and other off-farm impacts on biodiversity, water and air (ibid). Soil compaction is another problem, which has been generated by the use of heavy machinery. Regarding the soil, it is estimated that the annual decline of organic matter is about one million tones in Swedish soils (Lilliesköld and Nilsson, 1997 see Björklund *et al.*, 1999 p. 275) due to simplified systems of annual crops and lack of practices that stimulate the increase of organic matter in the soil.

Although the objectives of the CAP market intervention, in order to improve a fair standard of living among farmers increase productivity and support internal prices to consumers, it has created many social and economic problems in rural communities. The increase in land prices with subsidies as an important driver (Ciaian et al., 2014) has limited the expansion of agricultural businesses and limiting the access of land to younger farmers. In addition, the profitability of farming systems has decreased significantly in recent years, thus resulting in high debt of agricultural businesses causing losses to farmers. Another factor that emerges is the lack of competitiveness of agricultural systems reflecting the dependency on the subsidized mechanism. Notwithstanding, the efforts of the CAP comply with aspects of multifunctionality; this reform has still not overcome many of the problems associated with

inequality in socio economic structure of farms in the EU, which restricts long-term development of rural areas (Papadopoulos, 2015).

The recent CAP reforms have started to promote agro-environmental schemes that reduce impacts on the environment by agricultural practices. At a national level, the targets set by the government to improve the environment towards a more sustainable way, have significantly diminished the negative impacts of agricultural production to the environment, regulating the use of chemicals to prevent contamination of water sources, increasing biodiversity around water basins and fields and also promoting high standards in the fair working conditions and animal welfare. However, these strict regulations have reduced the amount of agricultural businesses in the Skåne region especially in animal production due to high costs involved with complying with these standards in this type of production. The implementation of these regulations creates confusion among farmers. Papadopoulos (2015) stated that there is inequality of regulation and the direct payment among member countries of the EU and also that the production-oriented reforms have resulted in damage on the environment.

From a systems thinking theory point of view, the farm is viewed in its entireness and in which the interaction of its components generates great complexity of the system (Badwen, 1995). One of the main components is the farmer whose choices are influenced by values, traditions and skills, but also by different structures and social norms, technologies and environment (Darnhofer *et al.*, 2010). For this reason, each farmer can adapt practices regarding the solution that is most valid and useful to their priorities and agricultural context (ibid). Understanding this, many farmers in the region can be characterized of having conservative values and attitudes, assuming that farmers are conservative because they avoid taking risks and to carefully take small steps of progress. Shucksmith (1993) described conservative farmers showing a traditional perspective and conservative technique with a strong resistance to change. This behavior is attributed mainly from "*subconscious and cumulative assimilation of an established ethos of being a farmer"*. It seems that young farmers tend to take a more open position towards new agricultural practices and that they see risk-taking as a positive side to gain experience while older farmers prefer to be on a safer side. A part of the risk-avoiding behavior or conservatism might be related to the achievement of a relatively stable level in the farm enterprise or to the fact that the techniques that these farmers are using were acquired from previous generations and also remain useful to them.

Despite all the factors that have influenced farming systems in the region in recent years, farmers have begun to realize the importance of caring for natural resources in agricultural production. Some farmers have focused on the implementation of technology as part of the development of a more sustainable production such as the use of precision technology such as GPS-aided application of seeds, pesticides and fertilizers. Some go a step further, focusing on improving soil health. Hence, practices such as conservation agriculture, no tillage systems and strip tillage have emerged. However, this change in the use of resource-saving or soil improving practices is being implemented very slowly. Furthermore, the lack of innovative advice constrains the diffusion of these new practices. Knowledge spreads mostly by the experience of farmers, researchers and advisory companies and the old model of technology transfer from researchers to farmers sometimes appears as old-fashioned and inefficient. Therefore, it is necessary to support a participatory and interactive model of networking where production of

knowledge is made up of different stakeholders, and where there is also room to promote adaptation, advising and education (EU SCAR, 2012).

Farmers will be further pressured by factors such as new environmental regulations, the effect of climate change and the economy. It is important to consider the role of farmers as stewards of the land and also to highlight or strengthen the role of the agricultural sector in the national economy. Therefore, it is important to clarify the long-term goal of agriculture in the region. Likewise, better communication strategies are needed regarding the implementation of new legislation and the impacts of climate change to the agricultural sector using a clearer and more comprehensive language to be understood by the wider community.

5.2 Farmers perceptions on climate change

Farmers interviewed in this thesis seem to believe that climate variability is attributed mainly to changes in weather patterns, identifying various extreme weather events such as heavy rainfall, mild winters and long periods of drought. Other authors have similar views about changes in the climate, like Peltonen-Sainio (2012) who argued that greater abundance and irregular rainfall in the future could cause lodging, delayed ripening of plant stands and consequences in deterioration of quality. Moreover, the increased temperature could increase the soil organic matter turnover rate, particularly in winter causing the building up of inorganic N and therefore the risk of nitrate leaching (Olesen & Bindi, 2002). This study found that many farmers believe that climate change is a result of a natural condition rather than anthropogenic-induced. The impacts of climate change are still not seen as a threat to the cropping systems. Although farmers have observed small damage to their crops, these extreme weather events have not been frequent enough to encourage taking action to counteract these effects. OECD (2010) argued that it is possible finding uncertainty on how society responds to climate change and also how its capacity to respond to projected changes would be.

The fact that some extreme weather events occurred in 2006 and 2011 seems to have increased the awareness of farmers regarding the climate change issue. However, farmers are skeptical about the long-term projections that the government and the scientific community have presented on climate change and they do not see particular vulnerability of farming systems in the region. Furthermore they may have a low sense of the perceived risks that the climate change could cause (Hyland *et al.*, 2015). Different factors such as personal experiences (Arbuckle *et al.*, 2015), feelings, information from the media (Asplund, 2014) and regulations (Holloway & Ilbery, 1996) could be influencing the awareness and understanding of these effects and decisions towards a possible response. Climate change is not part of the daily discussion among farmers but is rather related to climate shift. Therefore, for farmers, climate change is a question that should be discussed by politicians and emphasized especially as a social problem involving the community in general rather than an individual issue for farmers. Arbuckle *et al.* (2015) stated on the importance of accepting that climate change is caused by human activity and collective action is necessary to initiate and promote change in behavior. However, farmers were able to identify advantages and disadvantages that the climate change produces in their agricultural production. They are aware that the growing seasons are noticeably longer. Furthermore, the introduction of new crops as a consequence of increased temperature might cause the change in the

landscape. They are also aware of the effects that generate mild winters and the increased risk for infestation of pests, diseases and weeds and even impacts on the soil. Olesen and Bindi (2002) affirmed that warmer winters could allow pest to hibernate causing an early infestation during the following growing season.

Farmers have made remarkable progress in reducing GHG emissions through the scope of self-sufficiency in energy production with greener alternatives reducing the consumption of fossil fuel energy. These actions have been mainly motivated to reduce costs. Profit is an important factor for farmers. Hence, any changes or action plan to cope with climate change must be seen from an economic perspective. Fleming and Vanclay (2010) concluded that the capacity for action by farmers is obstructed by high costs and furthermore the action is appreciated to be negative to the competitive ability. Whereas farmers are not convinced that changes are occurring in the climate and the agriculture is itself responsible for one third of climate change (FAO, 2009), it will be difficult to establish adaptation strategies to reduce the long-term impact of climate change on agriculture. Farmers tend to take short-term actions in response to insights that they have for these variations in the weather. It is important to recognize that it is not only significant to reduce the effects of climate change but to develop a system that is able to take advantage of the opportunities of climate change and at the same time build up resilience to withstand the on-going changes in the future (FAO, 2013; Folke *et al.*, 2003). Darnhofer *et al.* (2010) suggested the integration of perceptions from complex adaptive systems and adaptive management as a tool to enhance the understanding of adaptability, resilience and persistence of agricultural systems. Still, adaptation is a slow and continuously ongoing process; which in some aspects is occurring even though the farmers are not actively aware of it.

Although action responses are different among farmers, it is important to highlight that some farmers have taken initiatives in improving their production systems. Particularly, improving the soil health as a key for enhancing climate change adaptability. Farmers acknowledge the importance of increasing organic matter in the soil. Many of the practices implemented in agricultural systems are mostly linked to the use of straw and crop residues to improve the soil organic matter. Furthermore, the use of manure, green manure and cover crops to improve soil structure, water holding capacity and restore the environment for soil biota. Matson *et al.* (1997) also agreed on how organic matter is an essential component in the ecosystem, because it plays an important role in maintaining the soil structure and reducing erosion. Another development recognized on adaptation is the improvement in drainage systems as a strategy for water management promoted by the advisers. Increased biodiversity is also a strategy that has been strongly promoted by the national government as a result of the implementation of environmental goals. Rosenzweig and Tubiello (2007) concluded that knowledge should be applied to 'real world' agricultural practices and sustainability could be increased under the pressure of climate change, through seeking the better synergies between adaptation and mitigation strategies.

As part of this study, the participation of farmers and other stakeholders in the agricultural sector in the discussion of alternatives for climate change adaptation opened a dialogue to discuss adaptation strategies most suitable to the agricultural sector from farmers' insights to meet their needs and demands. Such dialogue- or participation-oriented initiatives are an important in order to create a process of joint decision-making (Ison, 2008) that are more accurate for the region. Moreover, farmers have

the opportunity to learn new ways of interpreting facts, which can lead to change in understandings and practices (Darnhofer *et al.*, 2010).

5.3 Diversification of cropping systems

Farmers see the replacement of common crops grown in the region as a distant action. However, they recognize that there are opportunities in the introduction of new crops; it is attributed to different factors. On one hand, the effect of climate change will influence the choice of crops that are more adaptable to the new conditions. On the other hand, diversification is an important strategy in organic production because it reduces the cost of fertilizers, improves income and streamlines the management of these systems by suppressing weeds and breaking pests and diseases cycles. The introduction of N_2-fixing legumes in the cropping systems reduces the application of costly and energy-consuming fertilizers while promoting sustainability (Lichtfouse *et al.*, 2009). Many farmers understand diversification in cropping systems as the use of cover crops in the crop rotation. There are several reasons that motivated farmers to diversify their cropping systems by introducing cover crops. One of them is ascribed to the production of N and increasing yields for the subsequent crop. Farmers also perceive cover crops as an instrument to keep the soil covered throughout the year, which will prevent fertilizer runoff, improve soil organic matter and promote carbon sequestration – thus mitigating climatic change. Kremen and Miles (2012) described how diversified cropping system practices promote uptake of nutrients into crop biomass and soils, improving the efficiency of fertilizer use and thus lessening the loss of nutrients in to air and water. The diversification of cropping systems in time and space (e.g. crop rotation and intercropping) reduces the risk of crop failure (Tengo & Belfrage, 2004) and also serves as a strategy to increase resilience with respect to climate change (FAO, 2013; Kremen & Miles, 2012; Lin, 2011). Power and Kenmore (2001) remarked about how diversified cropping systems may show higher yield stability and also tend to be more resistant to environmental disturbances.

Although farmers recognize the positive effects of diversifying cropping systems, they remain reluctant to implement this strategy. One of the major problems is associated with the lack of a stable market for these new crops. One reason that could explain this situation is the consolidated cereals market that has prevailed for many years and the policy framework on market protection by the EU. It is evident that there is an overproduction of cereals in the EU, but apparently it is not a drawback, as the remaining production is sold to other countries outside the EU. This policy has generated international controversy due to the creation of social problems in these countries that cannot compete with subsidized production (ODI, 2011). Thus, to enable diversification, it is necessary to have a dialogue with buyer companies to promote the diffusion of these new crops such as beans, corn, sunflower, hemp and grass. For farmers, particularly producers of seeds, mixed products are not acceptable for buyers. Or conversely, farmers should encourage themselves to cooperate with other farmers to make easier the establishment of a more continuous market. Another issue that may limit the diversification of cropping systems is the investment in machinery and the increase of workload of establishing and maintaining these crops. Bommarco *et al.* (2013) argued that it is necessary to provide farmers and farm managers with tangible alternatives on how to approach the yield gap with a clear understanding of ecosystem services and functions taking economic opportunities and consequences into account. This implies that it requires extending the knowledge to understand how the complex farming systems

work instead of focusing on sole cropping. It is also important that advisory companies encourage farmers in the implementation of innovative practices for farming systems in the region. Social institutions play an important role in the dynamic process of diversification of farming systems motivating the transformation or preventing the inclusion of these diversified systems (Bacon *et al.*, 2012).

Further cuts in subsidies of cover crops and the change in the CAP reform, has discouraged farmers to implement this practice. Farmers consider that a more appropriate and clear support from the EU and the national government regarding the implementation of more sustainable practices but also encounter the needs of farmers and local conditions is necessary. Østergård *et al.* (2009) suggested that national and European agricultural policies should support the enhancement of crop management having as a focus the diversification of crop rotation, increase of organic matter and reducing tillage. Lithourgidis *et al.* (2011) assume that diversification of cropping systems should not simply rely on the policy support but it is also important to build up tools and technology in line with principles of diversity using a transdisciplinary collaboration within soil management, plant breeding, soil use based on the objectives of sustainable development and with the help of participatory approaches. Finally, an important factor to consider is the age of farmers and attitude towards diversification. Much of the agricultural production in the region is run by farmers over the age of 50. The continuity of their farming business is uncertain to many of the older farmers. For this reason, the willingness of farmers to diversify cropping systems is limited due to the time and investment that is required and the acquisition of new knowledge.

5.4 Sustainable production systems

The enhancement of sustainable agriculture is certainly the primary goal of the world community in general. Farmers recognize the importance of increasing sustainable production. However, farmers are still forced to make decisions based on economic realities rather than on ecological principles (Gliessman, 1998). Governments impose regulations using subsidies in order to reduce the pressure of the market in setting food prices. However, these political mechanisms are not in line with ecological practices (ibid). Despite that the EU has embraced environmental issues, the strategy in supporting agroecology and sustainable agriculture is still unclear. Moreover, the inclusion of agro-ecological practices in the national action plans remains marginal (Wezel *et al.*, 2014). Farmers, despite identifying the importance of maintaining healthy soils, conserve water and increase biodiversity continue to insist on the profitability. In that sense, it is important to bring the community closer to the agricultural sector. Consumers should be educated to understand the process of food production (Francis *et al.*, 2003). This knowledge could lead to better criticism when choosing foods but also assuming the joint payment of ecosystems services. Some farmers are still debating on what kind of production is more sustainable, whether organic or conventional. Furthermore, policies are remaining in the discourse of objectives and strategies for sustainable development but without much progress toward the action. In conclusion, it is not easy to promote these changes due to the complexity of the agricultural sector and where many social, economic, cultural and environmental aspects influence the balance of mechanisms of action. For this reason, it is important to continue emphasizing the joint participation by various actors in the search for solutions that promote the sustainability of agricultural systems (IAASTD, 2009).

6 Conclusions and recommendations

The use of systems thinking theory and the application of different approaches and methodologies allows clarification and understanding of the various factors affecting farming systems in the region. The development of these systems has evolved largely through the use of technology. In the same way, EU regulations have influenced the structure of these systems making them especially intensive. It is important to highlight that recent reforms in these regulations have made room for considering aspects of environmental conservation. However, it is unclear which approach is the most viable option for the implementation of these regulations.

Farmers' values and attitudes are influenced by economic, social norms and cultural factors and thus affected the choice of their farming approach. Farmers' conservative behavior is characterized by the simple fact that they can be reluctant to change the way they farm. However, various factors such as regulations, climate change and their own initiatives have emerged in order to improve production systems towards more sustainable models. Nevertheless, these changes are happening very slowly and are restricted due not only to an economic perspective but also to the lack of knowledge about the various benefits that would bring good management of ecosystem services in the long run.

This study demonstrated that farmers' perceptions on climate change are basically ascribed to natural effects. Furthermore, farmers have made great improvements in the implementation of mitigation strategies that have been particularly influenced by the national government for their strong objectives on the environment in order to achieve a more sustainable development. With respect to adaptation actions, farmers have begun to realize the importance of improved soil quality and health, as well as water management. However, it is important to highlight that the lack of recognition of climate change is an issue that has been caused by the wrong approach on the management of farming systems and will also adversely affect the agricultural sector in the future. It might be a very difficult progress in the implementation of measures and strategies to minimize the effects of the climate change.

Crop diversification is an adaptation strategy that would be possible to implement to address climate change in the region. Farmers recognize that crop diversification is linked mainly to the use of cover crops for biomass production in order to increase the organic matter and improve the soils' physical properties. Although with much emphasis on the economy and the market set by farmers who considered the introduction of new crops unfeasible, they assume that the effects of climate change would bring possibilities to introduce new crops that withstand new climatic conditions. One of the requirements to enable diversification of cropping systems is the expansion of knowledge. It is necessary to know what kind of crops to introduce but also to learn how to manage more complex and diversified systems. Finally there is a need not only for a policy support but also support from various stakeholders such as scientists, buyers, advisers and consumers to build confidence in the whole process of production of these diversified systems.

The realization of the workshop allowed opening the discussion on climate change and understanding the views of all stakeholders, especially the farmers on this issue. Also this allowed advancement in identifying the most appropriate actions that could be implemented to adapt farming systems to ad-

dress climate change. However, the absence of stakeholders from the public sector, limited the clarity of some adaptation measures that are based on different regulations.

This study recognized that it is important to understand the perceptions that farmers have about climate change, and also what kind of choices they see as possible solutions. For this reason it is important to broaden the knowledge on the perceptions of these actors and also the possibility of promoting change in behavior. Surely, there are very few studies that relate to this topic in the country and little involvement of farmers in decision-making on regulations and approaches to adaptation to climate change. It is necessary to encourage farmer-led innovation but also processes of social learning (Steenwerth *et al.*, 2014), which is defined as "a change in understanding promoted within social units through social interactions between actors within social networks" (Reed *et al.*, 2010). Furthermore, the use of participatory processes including diverse stakeholders in the agricultural sector are needed in order to develop adaptation strategies in line with local needs and which also empower the sector and the rural community. Climate change will bring advantages and disadvantages to this sector, it is important to improve the resilience of these farming systems in order to take advantage of opportunities, but also face the challenges trough understanding of farming systems as a complex system that are based on multiple interactions and where social, economic and environmental factors are affecting these interactions.

This study pointed out the need to understand the complex farming systems. Further research should focus on understanding the complexity in diversified farming systems in order to provide support to farmers in the establishment and management of these systems. Besides showing innovative solutions that some farmers have implemented in their cropping systems in order to motivate and prove to other farmers that it is possible to implement new ways of farming.

With the objectives of sustainable development to promote a green economy, we must recognize the value of agriculture at regional and national level, not only as a food-producing sector but also as producer of other goods and services such as fiber, bioenergy and ecosystem services.

Another important recommendation for further action is the improvement in the communication and dissemination of approaches and strategies such as agroecology, climate-smart agriculture and intensification of sustainable production, to decrease the gap in the misunderstanding about how these strategies could be implemented. Also, understand that these approaches are not just useful in developing countries but can also be used in a variety of agricultural systems throughout the world.

Finally, EU and national regulations must include a clearer policy to tackle climate change, where mitigation and adaptation measures are consistent with the needs of the agricultural sector.

Personal reflections

"*Reflection is a process that looks inward at our thoughts and thought process and outward at the situation in which we find ourselves; when we consider the interaction of the internal and external, our reflection orients us for further thought and action*" (Kemmis, 1985 p. 141)

This research gave me the opportunity to understand how the role of a researcher in the field of agroecology is on constant scope of knowledge but also confronting many challenges. The agroecologists not only must understand the cropping system in itself but also the different driving forces influencing these systems, comprising the various environmental factors, economic contexts and most importantly, social relations.

With the theory of systems thinking and agroecological basis I realized that it is very important to get a rich picture of the problem and then enable the inquiry into the details that create this problem before declaring possible conclusions. This was a truly learning process. From when I started to convince farmers to participate in the project as well as how it would be possible to encourage these actors to think about the problem of climate change and make them realize how much these agricultural systems could be affected if the corresponding measures are not taken in time. Thus, how can we make change beliefs and behavior and take action. The inclusion of PAR methodology helped me to infer how the participation of various actors might promote social change. Kemmis and McTaggart (2005 p. 278-279) stated that the main *concern of a participatory action researcher is the changing practices in the "here and now"*. With these new tools I could start to rethink the issues, develop new insights and put them in a new context. However, it still remains for me to further understand these assumptions about social paradigms. There is very little that we know and understand why these farmers do what they do. The education we receive in the area of agriculture is always based on evidence from formulas and scientific experiments and have always ignored the thinking, values and attitudes that lead the decision-making and further developed these ideas in a community or social event as if they were entirely separate aspects of the concept of agriculture.

However, this personal journey has been a way of looking at things differently, to do research, to take action, to reflect but also consider my values and critical knowledge as a driver to lead this process. For future research it would be interesting to follow up on the participatory process in the project Climate-CAFE, how social learning process develops over time, the actions taken by participants and also the reflections of this process as an example for other projects but also in the inclusion of participatory processes within policies of the agricultural plan on a national and EU level.

Finally, I am aware that this research study took me quite some time to do it. For that reason, I think it is important to understand that a thesis of agroecology does not take only two months to do, it requires more time to understand the different processes affecting an issue. The thesis should be a commitment that begins at the same time as the master's program starts and a large part of the activities during the program should serve to fulfill this assessment. Furthermore, the activities carried out within the various courses should not only promote critical knowledge but also provoke change. It is necessary to change, starting with the smallest things in the community so it can become a real social change.

References

Altieri, M. (1983). *Agroecology, the Scientific Basis for Alternative Agriculture*. Berkeley, CA: U.C. Berkeley.

Arbuckle, J.G., Jr., Morton, L.W. & Hobbs, J. (2015). Understanding Farmer Perspectives on Climate Change Adaptation and Mitigation: The Roles of Trust in Sources of Climate Information, Climate Change Beliefs, and Perceived Risk. *Environ Behav,* 47(2), pp. 205-234.

Asplund, T. (2014). Natural versus anthropogenic climate change: Swedish farmers' joint construction of climate perceptions. *Public Underst Sci*.

Bacon, C., Getz, C., Kraus, S., Montenegro, M. & Holland, K. (2012). The Social Dimensions of Sustainability and Change in Diversified Farming Systems. *Ecology and Society,* 17(4).

Bacon, C., Mendez, V.E. & Brown, M. (2005). *Participatory action research and support for community development and conservation: examples from shade coffee landscapes in Nicaragua and El Salvador*. (Center Research Brief #6. Santa Cruz, CA: Center for Agroecology and Sustainable Food Systems, University of California, Santa Cruz.

Badwen, R. (1995). On the systems dimension in Farming Systems Research. *Journal for Farming Systems Research Extension,* 5(2), pp. 1-18.

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), pp. 269-291.

Bommarco, R., Kleijn, D. & Potts, S.G. (2013). Ecological intensification: harnessing ecosystem services for food security. *Trends Ecol Evol,* 28(4), pp. 230-8.

Bossel, H. (1999). *Indicators for Sustainable Development: Theory, Method, Applications*. Canada: A Report to the Balaton Group, IISD.

Bradburn, C. (2014). *Thousands of Plant Breeders: Women Conserving in situ Crop Genetic Resources –A Case Study in the Medak District of Telangana, Southern India.* Diss. Alnarp: SLU, Swedish University of Agricultural Sciences.

Brydon-Miller, M., Greenwood, D. & Maguire, P. (2003). Why Action Research? *Action Research,* 1(1), pp. 9-28.

Bryman, A. (2012). *Social Research Methods*. 4th. ed. Oxford: Oxford University Press.

Cantore, N., Kennan, J. & Page, S. (2011). *CAP reform and development: Introduction, reform options and suggestions for further research*. London: Overseas Development Institute (ODI).

Carr, W. & Kemmis, S. (1986). *Becoming critical: Education, knowledge, and action research*. London: Falmer Press.

Ciaian, P., Kancs, D. & Swinnen, J. (2014). The Impact of the 2013 Reform of the Common Agricultural Policy on Land Capitalization in the European Union. *Applied Economic Perspectives and Policy,* 36(4), pp. 643-673.

Creswell, J.W. (2009). *Research design: qualitative, quantitative, and mixed methods approaches*. 3rd. ed. Thousand Oaks, CA: Sage Publications.

Dalgaard, T., Hutchings, N.J. & Porter, J.R. (2003). Agroecology, scaling and interdisciplinarity. *Agriculture, Ecosystems & Environment,* 100(1), pp. 39-51.

Dänhardt, J., Hedlund, K., Birkhofer, K., Bracht Jørgensen, H., Brady, M., Brönmark, C., Lindström, S., Nilsson, L., Olsson, O., Rundlöf, M., Stjernman, M. & Smith, H. (2013). *Ekosystemtjänster i det skånska jordbrukslandskapet (Ecosystem services in the Scanian agricultural landscape).*CEC Syntes Nr 01: Centrum för miljö- och klimatforskning, Lunds universitet.

Darnhofer, I., Bellon, S., Dedieu, B. & Milestad, R. (2010). Adaptiveness to enhance the sustainability of farming systems. A review. *Agronomy for Sustainable Development,* 30(3), pp. 545-555.

Egger, P. & Majeres, J. (1992). Local resource management and development: strategic dimensions of people's participation. In: Ghai, D. & Vivian, J. (eds) *Grassroots environmental action: people's participation in sustainable development.* London: Rotledge, pp. 304-324.

Eksvärd, K. (2009). *Exploring new ways: systemic research transitions for agricultural sustainability.* Diss. Uppsala: Swedish University of Agricultural Sciences.

Elbehri, A., Elliott, J. & Wheeler, T. (2015). Climate change, food security and trade: An overview of global assessments and policy insights. In: Elbehri, A. (ed). *Climate change and food systems: global assessments and implications for food security and trade*. Rome: Food Agriculture Organization of the United Nations (FAO), pp. 1-27.

EU SCAR (2012). *Agricultural knowledge and innovation systems in transition – a reflection paper*. Brussels.

European Commission (2013). *Overview of CAP Reform 2014–2020*. Agricultural Policy Perspectives Brief No. 5, December 2013: European Commission.

European Commission (17/09/2015). *Sustainable Development*. http://ec.europa.eu/environment/eussd/.

FAO (2009). *Coping with a Changing Climate: Considerations for Adaptation and Mitigation in Agriculture*. Rome: Food and Agriculture Organization of the United Nations.

FAO (2010). *"Climate-smart" agriculture: policies, practices and financing for food security, adaptation and mitigation*. Rome: Food and Agriculture Organization of the United Nations

FAO (2013). *Climate-Smart Agriculture Sourcebook*. Rome: Food and Agriculture Organization of the United Nations.

FAO (2014). *Agriculture, Forestry and Other Land Use Emissions by Sources and Removals by Sinks: 1990–2011 Analysis*. FAO Statistics Division Working Paper Series, 14/01. Roma: UN FAO.

Fleming, A. & Vanclay, F. (2010). Farmer responses to climate change and sustainable agriculture. A review. *Agronomy for Sustainable Development,* 30(1), pp. 11-19.

Folke, C., Carpenter, S.R., Walker, B., Scheffer, M., Chapin, T. & Rockstrom, J. (2010). Resilience Thinking: Integrating Resilience, Adaptability and Transformability. *Ecology and Society,* 15(4).

Folke, C., Colding, J. & Berkes, F. (2003). Synthesis: building resilience and adaptive capacity in social-ecological systems. In: Berkes, F., Colding, J. & Folke, C. (eds) *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*. Cambridge, UK: Cambridge University Press, pp. 352-387.

Francis, C., Lieblein, G., Gliessman, S., Breland, T.A., Creamer, N., Harwood, R., Salomonsson, L., Helenius, J., Rickerl, D., Salvador, R., Wiedenhoeft, M., Simmons, S., Allen, P., Altieri, M., Flora, C. & Poincelot, R. (2003). Agroecology: The Ecology of Food Systems. *Journal of Sustainable Agriculture,* 22(3), pp. 99-118.

Gliessman, S.R. (1998). *Agroecology: Ecological Processes in Sustainable Agriculture*. Chelsea, MI: Ann Arbor Press

Godfray, H.C. & Garnett, T. (2014). Food security and sustainable intensification. *Philos Trans R Soc Lond B Biol Sci,* 369(1639), p. 20120273.

Greenwood, D. & Levin, M. (1998). *Introduction to action research: Social research for social change*. Thousand Oaks, CA: Sage.

Guest, G., Namey, E. & Mitchell, M. (2013). Qualitative research: defining and designing. In: *Collecting qualitative data: a field manual for applied research*. Thousand Oaks: SAGE Publications, pp. 1-40.

Hall, M., Lund, E. & Rummukainen, M.r. (2015). *Klimatsäkrat Skåne (Climate Assured Skåne)*: CEC Rapport Nr 02. Centrum för miljö- och klimatforskning, Lunds universitet.

Heron, J. & Reason, P. (1997). A Participatory Inquiry Paradigm. *Qualitative Inquiry,* 3(3), pp. 274-294.

Holloway, L.E. & Ilbery, B.W. (1996). Farmers' attitudes towards environmental change, particularly global warming, and the adjustment of crop mix and farm management. *Applied Geography,* 16(2), pp. 159-171.

Howden, S.M., Soussana, J.-F., Tubiello, F.N., Chhetri, N., Dunlop, M. & Meinke, H. (2007). Adapting agriculture to climate change. *Proceedings of the National Academy of Sciences,* 104(50), pp. 19691-19696.

Hyland, J.J., Jones, D.L., Parkhill, K.A., Barnes, A.P. & Williams, A.P. (2015). Farmers' perceptions of climate change: identifying types. *Agriculture and Human Values*.

IAASTD (2009). *Synthesis report with executive summary: a synthesis of the global and sub-global IAASTD reports*. Washington: Island Press.

IPCC (2001a). *Climate Change 2001: Impacts, Adaptation Vulnerability*. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. J.J. McCarthy, O.F. Canziani, N.A. Leary, D.J. Dokken and K.S. White (eds). Cambridge University Press, Cambridge.

IPCC (2001b). *Climate Change 2001: Synthesis Report*. Contribution of Working Groups I,II, III to the Third Assessment Report of the Intergovernmental Panel on Climate Change. R.T. Watson and the Core Team (eds). Cambridge University Press, Cambridge and New York.

IPCC (2014). *Climate Change 2014: Synthesis Report*. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Core Writing Team, R.K. Pachauri and L.A. Meyer (eds). IPCC, Geneva, Switzerland.

Ison, R.L. (2008). Systems thinking and practice for action research. In: Reason, P.W. & Bradbury, H. (eds) *The Sage Handbook of Action Research Participative Inquiry and Practice* 2nd edition. London, UK: Sage Publications, pp. 139–158.

Johansson, G.A., Jonasson, L., Rosenqvist, H. & Yngwe, K. (2014). *Skånskt lantbruk: En blick in i framtiden till år 2025*: Hushållningssällskapet Skåne och Länsstyrelsen i Skåne län.

Jordbruksverket (2015-09-21). *Landsbygdsprogrammet 2014–2020*. http://www.jordbruksverket.se/amnesomraden/landsbygdsutveckling/programochvisioner/landsbygdsprogrammet20142020/vadarlandsbygdsprogrammet.4.1b8a384c144437186ea10a.html [2015-09-18].

Kemmis, S. (1985). Action research and the politics of reflection. In: Boud, D., Keogh, R. & Walker, D. (eds) *Reflection: Turning experience into learning*. London: Kogan Page, pp. 139-163.

Kemmis, S. & McTaggart, R. (2005). Participatory action research: Communicative action and the public sphere. In: Denzin, N. & Lincoln, Y. (eds) *The Sage handbook of qualitative research*. 3rd. ed. Thousand Oaks: Sage.

Kremen, C. & Miles, A. (2012). Ecosystem Services in Biologically Diversified versus Conventional Farming Systems: Benefits, Externalities, and Trade-Offs. *Ecology and Society,* 17(4).

Kurukulasuriya, P. & Rosenthal, S. (2013). *Climate Change and Agriculture : A Review of Impacts and Adaptations*. Washington, DC. : World Bank.

Länsstyrelsen-Skåne *Jordbruksfastigheter*. http://www.lansstyrelsen.se/SKANE/SV/LANTBRUK-OCH-LANDSBYGD/LANTBRUK/Pages/default.aspx [23/02/15].

Lewin, K. (1946). Action Research and Minority Problems. *Journal of Social Issues,* 2(4), pp. 34-46.

Lichtfouse, E., Navarrete, M., Debaeke, P., Souchère, V., Alberola, C. & Ménassieu, J. (2009). Agronomy for sustainable agriculture. A review. *Agronomy for Sustainable Development,* 29(1), pp. 1-6.

Lin, B.B. (2011). Resilience in Agriculture through Crop Diversification: Adaptive Management for Environmental Change. *BioScience,* 61(3), pp. 183-193.

Lithourgidis, A.S., Dordas, C.A., Damalas, C.A. & Vlachostergios, D.N. (2011). Annual intercrops: an alternative pathway for sustainable agriculture. *Australian Journal of Crop Science,* 5(4), pp. 396-410.

Loewenson, R., Laurell, A.C., Hogstedt, C., D'Ambruoso, L. & Shroff, Z. (2014). *Participatory action research in health systems: a methods reader*. Harare, ZW: Regional Network for Equity in Health in East and Southern Africa (EQUINET).

Malézieux, E., Crozat, Y., Dupraz, C., Laurans, M., Makowski, D., Ozier-Lafontaine, H., Rapidel, B., Tourdonnet, S. & Valantin-Morison, M. (2009). Mixing plant species in cropping systems: concepts, tools and models. A review. *Agronomy for Sustainable Development,* 29(1), pp. 43-62.

Matson, P.A., Parton, W.J., Power, A.G. & Swift, M.J. (1997). Agricultural Intensification and Ecosystem Properties. *Science,* 277(5325), pp. 504-509.

McTaggart, R. (1994). Participatory Action Research: issues in theory and practice. *Educational Action Research,* 2(3), pp. 313-337.

McTaggart, R. (1998). Is validity really an issue for participatory action research? *Studies in Cultures, Organizations and Societies,* 4(2), pp. 211-236.

Méndez, V.E., Bacon, C.M. & Cohen, R. (2012). Agroecology as a Transdisciplinary, Participatory, and Action-Oriented Approach. *Agroecology and Sustainable Food Systems,* 37(1), pp. 3-18.

Millennium Ecosystem Assessment (2005). *Ecosystems and Human Well-being: Synthesis*. Washington, D.C.

National Research Council (2010). *Toward Sustainable Agricultural Systems in the 21st Century*. Washington, DC: National Academies.

Naturvårdsverket (2013-07-01). *Sveriges miljömål*. http://www.miljomal.se/sv/Miljomalen/ [2015-08-18].

Neely, C. & Fynn, A. (2012). *Critical choices for crop and livestock production systems that enhance productivity and build ecosystem resilience*. SOLAW Background Thematic Report -TR11. Rome: FAO.

Neufeldt, H., Jahn, M., Campbell, B.M., Beddington, J.R., DeClerck, F., De Pinto, A., Gulledge, J., Hellin, J., Herrero, M., Jarvis, A., LeZaks, D., Meinke, H., Rosenstock, T., Scholes, M., Scholes, R., Vermeulen, S., Wollenberg, E. & Zougmoré, R. (2013). Beyond climate-smart agriculture: toward safe operating spaces for global food systems. *Agriculture & Food Security,* 2(1), p. 12.

ODI (2011). Making the EU's Common Agricultural Policy coherent with development goals. *Briefing Paper 69*. Available from: http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/7279.pdf [2015-11-16].

OECD (2010). *Climate change and agriculture: impacts, adaptation and mitigation*. Paris.

Olesen, J.E. & Bindi, M. (2002). Consequences of climate change for European agricultural productivity, land use and policy. *European Journal of Agronomy,* 16(4), pp. 239-262.

Østergård, H., Finckh, M.R., Fontaine, L., Goldringer, I., Hoad, S.P., Kristensen, K., Lammerts van Bueren, E.T., Mascher, F., Munk, L. & Wolfe, M.S. (2009). Time for a shift in crop production: embracing complexity through diversity at all levels. *Journal of the Science of Food and Agriculture,* 89(9), pp. 1439-1445.

Papadopoulos, A.G. (2015). The Impact of the CAP on Agriculture and Rural Areas of EU Member States. *Agrarian South: Journal of Political Economy,* 4(1), pp. 22-53.

Peltonen-Sainio, P. Crop production in a northern climate. In: Meybeck, A., Lankoski, J., Redfern, S., Azzu, N. & Gitz, V. (eds) *Proceedings of FAO/OECD Workshop on Building Resilience for Adaptation to Climate Change in the Agriculture Sector* Rome, Italy, 23-24 April 2012: FAO/OECD, pp. 183-216.

Power, A. & Kenmore, P. (2001). Exploiting interactions between planned and unplanned diversity in agroecosystems: what do we need to know? In: Uphoff, N. & Altieri, M. (eds) *Agroecological Innovations: Increasing Food Production with Participatory Approaches*. London: Earthscan Publications.

Reed, M.S., Evely, A.C., Cundill, G., Fazey, I., Glass, J., Laing, A., Newig, J., Parrish, B., Prell, C., Raymond, C. & Stringer, L.C. (2010). What is social learning? *Ecology and Society*, 15(4). Available from: http://www.ecologyandsociety.org/vol15/iss4/resp1/ [2015-11-21].

Regionfakta (2015-12-15). *Skåne county - Facts and figures. Environment*. http://www.regionfakta.com/Skane-lan/IN-ENGLISH/Environment/ [2015-12-16].

Richmond, B. (1994). Systems thinking/system dynamics: Let's just get on with it. *System Dynamics Review,* 10(2-3), pp. 135-157.

Rickerl, D. & Francis, C. (2004). Multi-Dimensional Thinking: A Prerequisite to Agroecology. In: Rickerl, D. & Francis, C. (eds) *Agroecosystems Analysis*. Madison, WI: American Society of Agronomy, pp. 1-18.

Rockstrom, J., Steffen, W., Noone, K., Persson, A., Chapin, F.S., Lambin, E.F., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J., Nykvist, B., de Wit, C.A., Hughes, T., van der Leeuw, S., Rodhe, H., Sorlin, S., Snyder, P.K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R.W., Fabry, V.J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P. & Foley, J.A. (2009). A safe operating space for humanity. *Nature,* 461(7263), pp. 472-475.

Rosenzweig, C. & Tubiello, F.N. (2007). Adaptation and mitigation strategies in agriculture: an analysis of potential synergies. *Mitigation and Adaptation Strategies for Global Change,* 12(5), pp. 855-873.

SARE (2012). Diversifying Cropping Systems(2015-03-01). Available from: http://www.sare.org/Learning-Center/Bulletins/Diversifying-Cropping-Systems.

SCB (2012). *Hållbarhet i svenskt jordbruk 2012*. Statistics Sweden: Stockholm, Sweden.

SCB (2015). Jordbruksstatistisk sammanställning 2015 med data om livsmedel – tabeller (Agricultural statistics 2015 including food statistics – tables). Available from: http://www.scb.se/sv_/Hitta-statistik/Publiceringskalender/Visa-detaljerad-information/?publobjid=25884 [24-09-15].

Scherr, S.J. & McNeely, J.A. (2008). Biodiversity conservation and agricultural sustainability: towards a new paradigm of 'ecoagriculture' landscapes. *Philos Trans R Soc Lond B Biol Sci,* 363(1491), pp. 477-94.

Shucksmith, M. (1993). Farm household behaviour and the transition to post-productivism. *Journal of Agricultural Economics,* 44(3), pp. 466-478.

Sichoongwe, K., Mapemba, L., Ng'ong'ola, D. & Tembo, G. (2014). *The determinants and extent of crop diversification among smallholder farmers: A case study of Southern Province, Zambia*. (MaSSP Working Paper. Washington, D.C.

Smit, B. & Skinner, M.W. (2002). Adaptation options in agriculture to climate change: a typology. *Mitigation and Adaptation Strategies for Global Change,* 7(1), pp. 85-114.

Steenwerth, K.L., Hodson, A.K., Bloom, A.J., Carter, M.R., Cattaneo, A., Chartres, C.J., Hatfield, J.L., Henry, K., Hopmans, J.W., Horwath, W.R., Jenkins, B.M., Kebreab, E., Leemans, R., Lipper, L., Lubell, M.N., Msangi, S., Prabhu, R., Reynolds, M.P., Sandoval Solis, S., Sischo, W.M., Springborn, M., Tittonell, P., Wheeler, S.M., Vermeulen, S.J., Wollenberg, E.K., Jarvis, L.S. & Jackson, L.E. (2014). Climate-smart agriculture global research agenda: scientific basis for action. *Agriculture & Food Security,* 3(1), p. 11.

Stenmark, J. (2015). *Evaluation of Skåne County's Capacity to Be Self-Sufficient in Foodstuff Production: Now and for the Years 2030 and 2050.* Diss. Uppsala: Master thesis in Sustainable Development Uppsala University.

Stoate, C., Boatman, N.D., Borralho, R.J., Carvalho, C.R., Snoo, G.R.d. & Eden, P. (2001). Ecological impacts of arable intensification in Europe. *Journal of Environmental Management,* 63(4), pp. 337-365.

Tengo, M. & Belfrage, K. (2004). Local management practices for dealing with change and uncertainty: a cross-scale comparison of cases in Sweden and Tanzania. *Ecology and Society*, 9(3). Available from: http://www.ecologyandsociety.org/vol9/iss3/art4/.

The Montpellier Statement (2015). Climate-smart agriculture: Towards sustainable landscapes and food systems. *Climate-smart agriculture: Global Science Conference, 16-18 March 2015*. Available from: http://csa2015.cirad.fr/var/csa2015/storage/fckeditor/file/Montpellier Statement CSA 2015 comp.pdf [2015-10-02].

Tubiello, F. (2012). *Climate change adaptation and mitigation: challenges and opportunities in the food sector*. Prepared for the High-level conference on world food security: the challenges of climate change and bioenergy. Rome, 3-5 June 2008: Natural Resources Management and Environment Department, FAO, Rome.

UNEP (2011). Food and Ecological Security: Identifying synergy and trade-offs. UNEP Policy series. Ecosystem Management.

United Nations secretary-General's high-level panel on Global sustainability (2012). *Resilient People, Resilient Planet: A future worth choosing*. New york: United Nations.

Wezel, A., Bellon, S., Doré, 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), pp. 503-515.

Wezel, A., David, C., Ferrer, A., Letort, A., Féret, S., Peigné, J., Vian, J.F. & Celette, F. (2014). *Agroecological practices supporting the provision of goods and services in agriculture: Examples from France and Europe*. France: ISARA-Lyon.

Whyte, W.F. (1989). Advancing Scientific Knowledge Through Participatory Action Research. *Sociological Forum,* 4(3), pp. 367-385.

World Commission on Environment Development (1987). *Our common future*. Oxford; New York: Oxford University Press.

Acknowledgments

This thesis is the outcome of a personal and academic experience that was only possible with the enormous support of many people, friends, professors, family and the sacrifice of my little daughter. The participation in this program allowed me to gain invaluable knowledge and continue a process of learning from a viewpoint of reflection and self-criticism and also opened my mind to perceive things in another way. I hope that the program continues to develop and the agroecology approach extends outside the classroom to be shared with the rest of the community.

I want to thank Georg and Mozhgan for their priceless support in the formulation of this document and their critical and positive guidance.

I also want to extend my gratitude to all farmers participating in this study and to share what they think, for the opportunity they gave me to show me the work they do, for their honesty and candor in discussing complex issues to understand.

The Climate-CAFE project for letting me be part of a participatory process and open space to discuss with other actors issues that concern us all.

To all the lecturers of the Agroecology master programme for sharing their precious knowledge.

My fellow agroecologists, Johanna and Christopher for their friendship, support and sharing the same dream for agroecology.

Also to other students in the program that made this experience very enriching and shared plentiful discussions.

My family for their perseverance, motivation and help in the real realization this dream.

My family in Colombia for keeping me motivated and especially my mom for their constant prayers and words of encouragement.

Appendix 1. Data collection

a) Interview Guides

Farmers Interview Guide

Farmer's name: Farm: Date:

I. Background

1. Can you give me a brief description of yourself? Age? Profession? Studies? Family?
2. How long have you been farming?
3. What are your main goals for your farming system?
4. What kinds of motivations lead you to be a farmer?
5. In your opinion, what are the challenges you face as a farmer in the Skåne region?
6. What is your vision for your farming system in the future?

II. Cropping system

1. How many hectares is the area of arable land? If there is pasture, graze land, forest. How many hectares?
2. What are the main crops on your farm?
3. What is the target market for the crops grown in your farming system? Human consumption, animal food, bioenergy or others.
4. What are the approximate yields per hectare for the major crops raised?
5. Can you explain the crop rotation system that you manage in your farming system? Including cover crops, catch crops and fallow periods.
6. What are the major purchased inputs used in the management of your cropping system?
7. How is the management of pests, diseases and weeds in your cropping system?
8. Are you satisfied with the way you handle these problems?
9. What kind of soil are characteristic in the cropped land?
10. Are there any limitations for the soil management? e.g. compaction, are the soils erodible, etc.
11. How is the nutrient management plan in your crop production?
12. Do you apply manure or some other type of waste to your cropping system?
13. What types of tillage practices are included in the management of your cropping system?
14. Have you implemented any innovative solution or done any significant change in your cropping system during the last five years?

III. Environmental aspect

1. How do you think your cropping system impacts the environment?
2. Are you aware of the greenhouse gas emissions produced by your cropping system?
3. How has the health and fertility of the soil been affected with the way you are farming?
4. Do you have any problem with leaching due to fertilizers use?
5. Have you seen any changes in the biodiversity of the surroundings due to the established cropping system?

6. Do you have any plans to improve the quality of your soils?
7. How have you been affected by the Swedish rules regarding the GHG emission and the environment?
8. What do you think is the future outlook of your farming system becoming a sustainable system?

IV. Economy aspects

1. What are your approximate gross annual sales of farm products?
2. Do you have another source of income?
3. Has your income increased over the last five years?
4. Do you receive any kind of subsidies?
5. Has your enterprise made any profit without taking the subsidies into account?
6. What is your opinion about subsidies? Are you satisfied with them?
7. If you didn't receive subsidies? How would you improve the competitiveness of your enterprise?
8. Do you consider it risky to make any changes in the way you are farming? If so what kind of risks?
9. How many workers are assisting you on the farm?
10. Do they have any opinion on decisions on crop production?
11. What kind of actions have you implemented to ensure an environment of fair work?
12. Do you have any crop insurance?
13. How have the CAP's rules impacted your farming system?

V. Social Aspects

1. What kind of driving forces influenced you to choose your farming approach?
2. How does buyers/consumers impact the way you produce and the selection of crops in your farming system?
3. Do you receive technical assistance from government agencies or private consultations? Has the advice been useful? Are there any plans or programs hosted by these entities for adaptation of climate change in the region?
4. Are you involved in any group of farmers?
5. Do you share information with other farmers in the region about the management of your farming system?
6. Have you participated in making decisions concerning agricultural policies? If so ... how?
7. Have you worked with others farmers in participatory processes in order to implement joint solutions in adapting to climate change and crop diversification?
8. How do you encourage other farmers to participate in joint solutions to achieve productivity of farming systems and simultaneously adapt these systems to climate change?
9. What are you most proud about when you think of how you manage your farming system?

VI. Climate Change

1. Have there been weather events such as floods, storms or others events that have impacted your cropping system in the last years?
2. How has your cropping system been affected by the global warming and climate change?
3. How do you think your cropping system will be affected by climate change in the future?
4. How resilient do you consider your farming system to be?

5. What are the farmer's perceptions about climate change?
6. What kind of governmental policy that you know of, is mentioning adaptation of farming systems to climate change?

VII. Diversification Cropping systems

1. Do you know if there are plans or initiatives to diversify farming systems in the region?
2. How feasible might it be to introduce new crops in your cropping system? What crops do you think could be introduced?
3. What are the greatest obstacles to strengthen the diversification of your cropping systems?
4. What kind of support do you think is necessary for the farmers when they decide to diversify their cropping systems? By the government, the EU, the advisory companies?

Consultant interview Guide

Respondent name and position: Company name:

1. Can you give me a brief description of your role and responsibilities as an advisor?
2. How do you define the following terms: sustainable Development, intensification of sustainable production, diversification of cropping systems
3. What cropping systems are common among farmers in the region of Skåne today?
4. Do you know what is the main reason for the predominance of cereal and rapeseed in the agricultural sector in Skåne?
5. Based on your experience, could you explain how resilient farming systems are in the region?
6. What are the impacts that current farming systems have on the environment, the economy and in the social context of farmers?
7. What are the farmer's perceptions about climate change?
8. What kind of governmental policy do you know is mentioning adaptation of farming systems to climate change?
9. What kinds of technologies are being implemented in farming systems to adapt to climate change?
10. What kind of strategies are the advisory companies using to adapt cropping systems to climate change? And what are they doing to promote biodiversity and ecosystem systems management?
11. Are there plans or initiatives to diversify farming systems in the region?
12. How feasible might it be to introduce new crops in the farming systems in the region? What crops?
13. What are the greatest impediments to strengthen the diversification of cropping systems?
14. What are the impressions of farmers regarding the integration of new crops in cropping systems? e.g. Introduction of legumes, catch crops, cover crops.
15. What kind of support could the farmers who decide to diversify their cropping systems receive? By the government, the EU, the advisory companies?
16. How is the participation of advisors in the design and planning of innovative solutions in crop diversification?
17. How do you encourage farmers to participate in joint solutions to achieve productivity of farming systems and simultaneously adapt these systems to climate change?

b) Written Consent Form

Written consent for participation in the interview for the Master thesis in Agroecology at SLU Alnarp

Researcher: Carolina Rodriguez

Phone: Email: Address:

Research information

Research study about diversification of farming systems as a strategy to achieve sustainability and adapt to climate change. The research will be developed in the region of Skåne.

Research questions

- What types of cropping systems are common among farmers today?
- What are the perceptions of farmers in relation to climate change and how resilient their current cropping systems are?
- What is the impression that farmers have regarding the diversification of cropping systems?
- How to increase the participation of stakeholders in the design, planning and evaluation of systems of alternative crops in order to reduce the risk to climate change, achieve productivity and rebuild agroecosystems?
- What could be the impact on social, environmental and economic level in diversifying cropping systems?
- What kind of conditions and guarantees do farmers require regarding the integration of new crops in cropping systems?

Part of the work is to interview selected people who have a connection to these issues and can provide valuable information. The study will hopefully provide an exchange back to the farmer/respondent by comparing the various participants as well as through the final results of the work presented in the form of a report.

Expectations of the participant's contribution

The researcher conducts an interview with the participant who is expected to take about 2 hours. Participants will also take part of the outcome of the interview to confirm that this is something they can stand for and approve. Each participant has the right to withdraw from the project at any time, if they not longer want to participate.

Management of the data

- The interview will be recorded in the form of a sound recording. Then the researcher will make a transcription of the interview, which will be sent back to the participant for approval.
- After possible amendments and approval of the contents of the transcript, it will possibly be attached as raw data in the final report that will be available in Epsilon on SLU's website.
- The participant will decide if he/she wants to be anonymous or his/her name can be cited in the final report.

Anonymous □ Use my name □

I understand the above information and agree to participate in the project:

_____ The _____ / _____ /2015

Signature and printed name

_____ The _____ / _____ /2015

Researcher's signature and printed name