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Developing a market for organic lentils: qualitative insights from a farmer led producer group in Germany

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Developing a market for organic lentils: qualitative insights from a farmer led producer group in Germany

Marknadsutveckling för ekologiska linser: kvalitativa erfarenheter från en lantbrukarledd producentgrupp i Tyskland

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Foreword

During my studies in Forestry I learned about the diverse components that comprise an ecosystem and about the manifold interactions that make the entire system work. I became aware of how fragile ecosystems can be and also how much humanity depends on functioning ecosystems. I also became aware of that agriculture, something else we are dependent on, is one of the main drivers behind the degradation of ecosystems like forests. I realised that we need a comprehensive understanding of the complex interactions between the socio-economic system and the ecosystem in order to find a solution to this dilemma. This is how I came to Agroecolgy.

Agroecology is not the solution, but it provides the thinking that can help us to understand the problem. When I heard the first time the term 'systems thinking', it took me a while until I realised how important this way of thinking is in order understand problems in their full complexity.

Today scientists often look at problems in isolation. Moreover, they spend only little time with looking at the problem, but spend most of their time with the attempt to find a solution to a problem they do not understand. During the Agroecology programme I became even more aware of that everything is interconnected and I have learned that we often have to find local solutions in order to tackle global problems. I have also learned that if we want to find solutions to complex problems, diverse people with different backgrounds have to work together.

This study is applied agroecolgy, because it is about a local initiative of committed farmers and it is about the collaborations between a wide range of actors that developed a solution to a complex problem of global importance.

Summary

The growing of grain legumes has many benefits and can increase the sustainability of farming systems. Grain legumes have the ability to fix nitrogen from the atmosphere and need less or no nitrogen fertilizers, and produce nutritious seeds high in protein. In addition, grain legumes can diversify and enhance cereal based cropping systems by improving soil structure, reducing disease pressure and provide nitrogen for following crops. Although, the benefits provided by grain legumes in agriculture have been known for a long time, the cultivation of these crops in Europe decreased within the last decades due to a wide range of challenges. An increase in grain legume cultivation is seen as an opportunity to reduce the negative impact of European agriculture on the environment, but this would require strategies that can stimulate the cultivation of grain legumes despite the complex challenges. This thesis is a qualitative study focussing on a producer group which developed a production system for organic lentils on the Swabian Alb, a low mountain range in south-west Germany. The main aim of this thesis is to explore which factors, actors and collaborations have supported the development of organic lentil production on the Swabian Alb. The objectives are: (1) to understand what motivates farmers to grow lentils, (2) to understand which challenges farmers face when they grow lentils (3) to understand how farmers accessed and organised the required knowledge to develop the lentil production system, and (4) to evaluate roles and contributions of actors and organisations that interact with the producer group, in order to understand how these interactions enhanced the development of organic lentil production.
In order to develop this understanding an innovation systems approach was chosen to guide the analysis, which was based on semi-structured interviews conducted with the initiator of the producer group, his son the production manager, and 14 lentil growers of the producer group. The results showed that farmers started growing lentils mainly for two reasons: out of curiosity to try out something new, and to diversify and improve their crop rotation. The profitability of the crop and the broad acceptance for it were major reasons to continue the cultivation. As major challenges the farmers stated weed infestation which was highly influenced by local conditions, crop rotation and weather conditions. The access to knowledge on lentil cultivation was very limited in the beginning and farmers had to develop the cultivation systems through experimentation. The study revealed a comprehensive network of actors that collaborated with the producer group in manifold ways over the last years, which helped to develop the lentil production and increased awareness of the producer group and their products. The commitment and communication skills of the initiator, institutional changes in the wider surroundings of the producer group, and positive attitudes of the diverse actors towards collaboration were identified as major factors that supported the development of organic lentil production in the region. A promising strategy aimed at stimulating organic lentil production may include: (1) enhancing institutional change and thus creating an enabling environment; (2) providing targeted support for lentil grower initiatives focused on actual needs, (3) and facilitating the collaboration between farmers, researchers, food processors, local authorities and the media, in order to enhance the capacity for innovation of involved actors.

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1 Introduction

1.1 Problem background

In order to meet the rapidly growing demand for energy, fresh water, food, timber and other raw materials for a growing population, humans have changed Earth's ecosystems over the last 60 years faster and more substantial as in any other period of human history before (Millennium Ecosystem Assessment, 2005, p.1). There is now increasing awareness that this development caused dramatic challenges for humanity, like climate change, rapid loss of biodiversity and water pollution, which could have drastic consequences for current and future generations if not reduced to the Earth's regulatory capacity (Rockstrom *et al.*, 2009). Today agriculture is seen as one of the main contributors to this development and in view of a growing population which faces depleting resources, the call for a shift to more sustainable systems of food production, processing and distribution is becoming louder among scientists and the concerned society (Godfray *et al.*, 2010).

The rise of organic agriculture in Europe and other parts of the world, with less intensive and more environmentally friendly production systems, addresses those concerns. One strategy to manage some of the challenges mentioned above, is currently discussed in Europe, and concerns the promotion of domestic production of grain legumes in organic farming (Voisin *et al.*, 2014). This strategy has three main aims: to reduce the dependence of European agriculture on legume grain imports (mainly in terms of feed for the meat industry), reduce the impact of agriculture on the environment, and increase the productivity and sustainability of European farming systems. An increase in grain legumes cultivation in Europe has the potential to reduce the impact on the environment and to increase the sustainability of agriculture in manifold ways: (1) with their ability to fix nitrogen from the atmosphere, cultivation systems with legume grains would need less nitrogen fertilizer, thus requiring less energy for the production of nitrogen fertilizer, resulting in decreased emissions of green house gases. A reduced application of nitrogen fertilisers could also reduce the risk of water pollution through nitrogen leaching; (2) legume grains contain high amounts of protein and increased acceptance for this type of food could enhance the shift from a current highly resource intensive meat diet to a healthier and more balanced diet, which would further reduce the pressure on ecosystems; (3) intercropping (mixed cultivation of two or more crops on the same land) of grain legumes with cereals has demonstrated several benefits, amongst them increased land ratio efficiency (LER), more stable yields and increased on-farm wild biodiversity (Voisin *et al.*, 2014; Jensen *et al.*, 2012; Malézieux *et al.*, 2009).

Even though the benefits provided by grain legumes in agriculture have been known for a long time, and even though extensive efforts have been made by scientists, policy makers and concerned groups of stakeholders, the success of approaches to increase the area cultivated with grain legumes in Europe was very limited (Bues *et al.*, 2013). The relative area of arable land cultivated with grain legumes in the European Union (EU) has declined within the last 50 years from 4.7% to 1.8%, while the major part of the domestically produced grain legumes like pea and faba bean is used as fodder and only about 13% is used for human consumption (Bues *et al*., 2013).

One basic explanation for the decline in the area cultivated with these crops are the low and often unstable yields of grain legumes when compared with other crops like wheat, which makes the cultivation of grain legumes less profitable and more risky (Bues *et al*., 2013). Furthermore, cultivation of grain legumes can be challenging and problems with weed infestation and diseases are common. These issues caused a shift among European farmers to the cultivation of more competitive and profitable crops in more input intensive cultivation systems, which was further driven by availability of cheap nitrogen fertilizers and the insufficient support for legume crops under previous European Common Agricultural Policies (CAP) (Voisin *et al*., 2014). This was partly due to the fact that the chosen policy instruments and development approaches where not appropriate, and not sustainable in terms of creating structures that would provide incentives in the long term (Bues *et al*., 2013). There is increasing awareness among scientists and policy makers that the development towards more sustainable agriculture will not yield the desired outcome or create the necessary impact as long as it is based on consolidated rule-sets and top-down approaches, but requires the adoption of new paradigms and systemic approaches that enhance the creation of structures that provide incentives in the long term, taking into consideration the importance of all relevant actors in the agricultural sector and the institutions that influence them (Knickel *et al.*, 2009; Röling, 2009).

Connecting bottom-up and top-down approaches to agricultural development is today in view of many scientists necessary to create the required impact towards more sustainable agriculture (Elzen *et al.*, 2012). One promising approach, which is assumed to be particularly helpful when it comes to novel crops, products or practices, is to analyse and support innovative farmer-led initiatives, and to enhance linkages between initiatives and scientists and other relevant actors in the food sector in order to enhance reflexive learning about sustainability aspects and practical applicability (Moschitz & Home, 2014; Elzen *et al.*, 2012). Above all, this involves learning about innovative farmer initiatives and the surrounding system of actors, linkages and institutions that may have an influence on its development (Elzen *et al*., 2012). The concept of agricultural innovation systems (AIS), can be used as a framework to guide

the analysis of innovative initiatives by focusing on supportive or hindering structures, the roles and attitudes of actors involved, linkages between the initiative and other actors or organisations, and knowledge generation and exchange (Klerkx *et al.*, 2012).

The focus of this study is on domestic legume grain production for human consumption. This decision was taken for three reasons: (1) there is evidence that direct consumption of legume grains needs less resources and is more environmentally friendly as utilisation of these crops to produce food in form of meat (Marlow *et al.*, 2009; Pimentel & Pimentel, 2003); (2) production of grain legumes for food can differ considerably from the production of fodder. This is in particular true in terms of requirements regarding the final quality of the seeds, which is presumably higher for food and requires more elaborate processing; (3) it is assumed that the stimulation of grain legume cultivation for food is more challenging than for fodder. Fodder, for instance, can be used by the farmer to feed own livestock, food has to be marketed.

This thesis is an analysis of an innovative initiative in south-west Germany, where a group of organic farmers, the "Alb-Leisa" producer group, developed a lentil production system including cultivation, processing and marketing. The cultivation of lentil was common in Germany in the 19th century, particularly in the region where the producer group is located, but disappeared in the 1960s (Horneburg, 2000). Lentil cultivation is challenging, particularly under temperate climate in organic farming and stays in competition with other crops like cereals which are commonly viewed as more profitable and less risky. The initiator of the producer group started growing lentils in the 1980s on a small piece of land and founded the lentil producer group in 2001 with a few other farmers. Today the producer group has about 70 members who produce lentils on 240 hectares and sell their products to 600 retailers and 250 restaurants (L. Mammel, 2015, personal communication). This thesis will analyse how the agricultural innovation of organic lentil growing developed in the Swabian Alb region and which factors supported or hindered this development. The focus is in particular on the motivations and attitudes of the involved farmers, interactions with supportive actors or organisations, the nature and effect of these interactions, and knowledge generation and exchange. The analysis is guided by the AIS concept and is based on literature reviews and in-depth semi-structured interviews with farmers from Alb-Leisa.

1.2 Purpose and objectives

This study aims to deepen understanding about opportunities to increase the domestic production of grain legumes for human consumption. This is done through a systemic analysis of the development of an innovative farmer-led initiative of organic lentil growers in Germany. The analysis focuses on enhancing and hindering structures, the roles of key actors and organisations and the interactions between them, activities and places of knowledge generation and

exchange, and the institutional conditions of the agricultural system that enabled or hindered the development of the farmer-led innovation. The analysis is guided by the framework of agricultural innovation systems (AIS), and is based on semi-structured interviews conducted with the "Alb-Leisa" lentil producers in the mountain region Swabian Alb in south-west Germany.

The objectives are: (1) to understand why these farmers cultivate lentils, (2) to understand which challenges farmers face when they grow lentils (3) to understand how farmers accessed and organised the required knowledge to develop the lentil production system, and (4) to evaluate roles and contributions of actors and organisations that interact with the producer group and to understand how these interactions enhanced the development of the producer group.

The results of this study can provide implementers and initiators of participatory innovation projects with useful knowledge, when it comes to indicate and facilitate supportive measures to enhance and facilitate farmer-led or science-led initiatives aimed at enhancing domestic grain legume cultivation in Europe. Furthermore, the outcome of the study can add knowledge to the discussion about effective and promising approaches, incentives and interventions aimed at supporting innovative initiatives towards a more sustainable agriculture.

1.3 Research questions

The overarching research question for the thesis is: *Which factors have supported or hindered the development of the farmer-led initiative "Alb-Leisa" and the innovation of organic lentil growing in the Schwäbische Alb region?*

The overarching question has been subdivided into the five questions below:

1) What motivated farmers to start cultivating lentils and to participate in the producer group, and what is their motivation to continue? This question aims to explore the reasons why farmers grow lentils and what factors and conditions have influenced their decision.

2) Which challenges did the farmers face when they started to grow lentils and as how difficult do they consider lentil cultivation? The aim of this question is to identify challenges and obstacles that could prevent farmers from cultivating lentils.

3) What local and formal knowledge was available, how was it accessed and what role did formal and informal networks of knowledge exchange play? This question aims to analyse which kind of knowledge needs to be available to overcome barriers and to manage challenges in agricultural innovation processes, and how this knowledge needs to be provided and exchanged for successful development of similar initiatives.

4) What collaborations between the producer group and actors in the agri-food sector exist, or existed in the past and what role played these collaborations in the development of the producer group and the innovation of organic lentil production? The aim of this question is to identify key actors in the agricultural innovation system and to understand how the interaction between them and the producer group influenced the development of organic lentil production.

1.4 Thesis structure

The first part of the thesis points out how the cultivation of grain legumes can contribute to increase the sustainability of agriculture and provides an overview of the benefits that the cultivation of grain legumes can bring to farmers. The following part highlights what agronomic challenges farmers are likely to face when they start growing lentils and explores what the basic reasons for these challenges are. This is followed by an illustration of the reasons for the current low use in Europe, including agronomic and policy considerations. In the next part the practice of intercropping is introduced as a strategy to reduce challenges and increase benefits. In the following sections the particular focus is on difficulties and challenges in lentil cultivation and on the development as well as on the characteristics of the producer group. The next section provides a short overview of the region where the producer group is located.

The content of the sections mentioned above, provides an outline of the current situation concerning grain legume production in general and lentil production in particular, and is aimed at enabling a sufficient basis for assessing the situation of the producer group.

In the following sections a short explanation of why a systemic approach to agricultural development is viewed as appropriate for the analysis is presented. This is followed by the introduction of the concept of agricultural innovation systems (AIS), and the explanation of how this concept was used to guide the analysis. The following sections contain the results and the discussion according to the respective research question. This is followed by a discussion on limitations and the conclusion, including recommendations for further research.

1.5 Grain legumes - possibilities and challenges

This section aims to provide and overview of the possible benefits that the cultivation of grain legumes can deliver, presents some of the challenges related to its production and highlights reasons for the current low use of this crop.

1.5.1 Benefits provided by grain legume cultivation

The major advantage of grain legumes compared to other crops is their ability to fix atmospheric nitrogen through biological nitrogen fixation (BNF), which the plants achieve through a symbiosis with a certain type of bacteria living in their roots. Through this mechanism, the crop requires no or only little nitrogen fertilizer. Thus, the increase of grain legume production in Europe would result in reduced application of nitrogen fertilisers. In a literature review Crews & Peoples (2004) compared the sustainability of the application of synthetic nitrogen from industrial sources with nitrogen obtained by legumes and concluded that the latter is more sustainable in terms of ecological integrity. The main reason for this is that legumes use solar energy to produce nitrogen, while synthetic nitrogen production requires large amounts of energy commonly from non-renewable sources like fossil fuels (Crews & Peoples, 2004).

Studies conducted in Germany, France, Switzerland and Spain have shown that the introduction of grain legumes in cereal based cropping systems can reduce global warming potential, energy use, acidification and ozone formation, and thus can increase the sustainability of farming systems (Nemecek *et al.*, 2008). The main reason for these positive effects was reduced application of nitrogen fertilisers, not only for the grain legumes, but also for the following cereal crops because of the availability of nitrogen that remained in the soil after the grain legumes were harvested (Nemecek *et al*., 2008). In addition to reduced impact on the environment, farmers can benefit from this effect through considerable cost savings for nitrogen fertilisers (Preissel *et al.*, 2015). Another effect of grain legumes that can improve growing conditions of cereals was assessed by Preissel *et al*. (2015, p. 67) and is the so called 'break crop effect' which includes reduced pressure from diseases, enhanced phosphorus mobilisation and benefits to soil organic matter and structure. This effect often increased yields of the first and second subsequent crop substantially (Preissel *et al*., 2015). The introduction of grain legumes in crop rotations can also have a positive impact on the local biodiversity, by providing nectar and pollen particularly to wild and domestic bees (Bues *et al*., 2013). In a global perspective, replacing the amount of imported legume grain (particularly soya) through domestic production can also reduce the pressure on international land use change caused by extensive soya production (Bues *et al*., 2013).

Despite the positive effects mentioned above, there are also some possible trade-offs when it comes to legume production. Some authors found an increased potential of nitrogen leaching in cropping systems with grain legumes compared to other cropping systems (Nemecek *et al.*, 2008; Crews & Peoples, 2004). This was mainly caused by mineralisation of grain legume residues which lead to high amounts of nitrogen in the soil, and was influenced by the ineffective uptake of nitrogen by the following crops (Crews & Peoples, 2004; Nemecek *et al*., 2008). The impact of this effect depends on soil type, rainfall patterns and farming practices, and can be reduced by introducing catch crops in the rotation and by incorporating straw into the soil after the harvest (Crews & Peoples, 2004; Nemecek *et al*., 2008).

1.5.2 Agronomic challenges and reasons for low use

The yield of grain legumes is often much lower when compared with other crops like cereals and has not increased as fast within the last decades as the yield of wheat for instance, which is now around twice that of grain legumes (Bues *et al*., 2013). Preissel *et al.* (2015) revealed in their study that in Europe the crop gross margin of grain legumes is usually much lower compared to profitable crops like wheat, rapeseed or sunflower, which is mainly a result of the lower yields achieved by grain legumes. Thus, the low yields make the crop less profitable when compared to other crops, which is one of the main reasons for its decline and current low use (Bues *et al*., 2013). One explanation for the low yields is probably a trade-off related to the ability of legumes to fix nitrogen, because the process of biological nitrogen fixation, which is also the basis for the high protein content of the crop, needs high amounts of energy which limits the potential of the plant to produce high yields (Bues *et al.*, 2013).

Several authors pointed out that the yields of grain legumes are often unstable and can vary considerably from year to year (Bues *et al*., 2013; Cernay *et al*., 2015; Preissel *et al*., 2015). Cernay *et al*. (2015) have analysed the yield variability of the major legume and non-legume crops in Europe and America over the last 50 years, and revealed that the yields of legume crops are generally less stable than non-legumes, and can be several times more variable than yields of cereals. The authors argue that this issue is very likely one of the major reasons that prevents farmers from growing grain legumes (Cernay *et al.*, 2015).

Most grain legumes are poor competitors to weeds, which is particularly true for peas and lentils (Fernandez *et al.*, 2012). Weed infestation in grain legume cultivation can reduce yields considerably, this is especially a problem in organic farming where weed control heavily relies on mechanical methods (Fernandez *et al*., 2012). Some grain legumes like lentils and peas are also susceptible to lodging (collapse of stems so that the crops lie on the soil - particularly after heavy rainfall) which increases the risk of rotting and makes it difficult to harvest the entire crop (Bues *et al*., 2013). Another problem is the indeterminate or continuous growth of some grain legumes, which means that the plants grow and produce flowers as long as the

conditions are favourable, and which causes the seeds to ripen irregularely so that ideal harvest dates are difficult to determine (Bues *et al*., 2013). Many grain legumes are particularly affected by various diseases, mainly soil-born fungi and viruses, which requires long breaks of several years between the cultivation on the same field (Chen *et al.*, 2009).

The characteristic mentioned in this section limit the potential of grain legumes in terms of possible production quantity, profitability and overall impact of provided benefits. The main reasons which can prevent farmers from growing grain legumes are summarised in the following key points:

- low yields of grain legumes cause low profitability when compared to other crops
- unstable yields cause increased risk of economic loss
- weed and disease management is challenging (particularly in organic farming) and increases risk of economic loss

1.5.3 Intercropping - advantages and challenges

Intercropping or mixed cropping is a cultivation practice where two or more crops are grown on the same field at the same time, and is considered as a "practical application of ecological principles based on biodiversity, plant interactions and other natural regulation mechanisms" (Malézieux *et al.*, 2009, p. 43). Intercropping of grain legumes with cereals or other crops has demonstrated to be a promising practice to increase use efficiency of resources like land, water, soil, nutrients and solar radiation, while at the same time reducing risks in terms of unstable yields and thus increasing the productivity and profitability of the farming system (Bedoussac *et al.*, 2015; Gaba *et al.*, 2015; Hauggaard-Nielsen *et al.*, 2009). Grain legumes intercropped with cereals can also help suppress weeds and reduce the potential of lodging by providing physical structure (Bedoussac *et al*., 2015).

Even though intercropping of grain legumes has demonstrated clear advantages compared to sole cropping, it is also considered to be more difficult to manage, because utilisation of the potential positive effects depends on a diverse set of factors, which can make it challenging to design an appropriate intercropping system that generates the desired outcome (Malézieux *et al.*, 2009).

1.6 The lentil - Ecology and production

The lentil is a bushy annual legume crop, between 20-45 cm tall, that produces small pods containing one or two lens-shaped seeds well known as nutritious food, which is rich in protein, minerals and vitamin (Saxena, 2009). Lentils belong to the earliest crops domesticated by humans and are today cultivated across the world under cool or temperate climatic conditions (Saxena, 2009). The current four major lentil producing countries are India, Canada, Turkey and the USA (FAOSTAT, 2013). Lentils are tolerant of low soil fertility, but do not tolerate waterlogging or extreme cold, and in most of the production regions lentils are sown in the winter season or in early spring, with rather dry growing conditions during the vegetation period (Materne & Siddique, 2009). The lentil as a grain legume can play an important role as rotation crop, particularly in cereal based cropping systems by enhancing soil fertility and interrupting pest cycles (Erskine, 2009). Despite its value as a protein rich and nutritious food and its potential to enhance the sustainability of farming systems, the quantity of lentils produced within the European Union in 2012 was about four times lower than the imported quantity, while the major part of European lentil production was concentrated in only two countries, in France and Spain (FAOSTAT, 2012a).

In principle, the growing conditions in Germany are favourable for lentil cultivation and lentils where a common crop until the beginning or the last century, traditionally grown on poor, calcareous soils (Horneburg & Becker, 2008). According to Fruwirth (1914, cited in Horneburg 2000, p.49), at the end of the 19th century lentils were grown on about 40,000 hectares in Germany, but lentil production nearly disappeared until the 1960s (Horneburg, 2000, p.49). Gruber *et al*. (2012, p. 366) stated three main reasons for abandoning lentil cultivation: (1) the use of mineral fertilizer made it profitable to grow cereals on poorer soils, (2) the high expenditure of work and the associated costs made lentil production increasingly unattractive, and (3) the earnings level was compared to other crops very low. According to FAOSTAT (2012b), in 2012 Germany imported 27,000 tonnes of lentils, without any recorded domestic production. This situation is also common in several other European countries.

This section has illustrated that there is at least in theory a high potential demand for domestically produced lentils in Germany and other parts of Europe. However, lentil production can be challenging as will be illustrated below.

1.7 Lentil production - issues and challenges

1.7.1 Weed control

Among grain legumes the lentil is a particularly poor competitor against weeds and one of the major challenges in lentil cultivation is weed infestation which can reduce yields considerably (Fernandez *et al.*, 2012; Yenish *et al.*, 2009). One reason for this poor competitive ability is that the seedlings grow slowly early in the growth period, which reduces their ability to compete with weeds for water, light and nutrients (Nleya *et al.*, 2004). This is particularly a problem when lentils are grown in a temperate climate, where cool weather after sowing can further slow down the growth of seedlings so that weeds can overgrow the crop (Nleya *et al*., 2004). Later in the growth phase, the competitive ability of the lentil remains poor due to its rather short stature and open plant habit (Knott & Halila, 1988). These characteristics limit the ability of the lentils to suppress weeds and to prevent weeds from establishment later in the growing period (Knott & Halila, 1988).

In the literature several strategies for weed control in lentil cultivation are frequently mentioned, such as diversified crop rotation to reduce weeds in the field, different tillage practices, the burning of weeds, soil solarisation and chemical weed control with herbicides before and after seedlings emerged (Yenish *et al.*, 2009; Nleya *et al.*, 2004; Muehlbauer *et al.*, 1995; Knott & Halila, 1988). Nleya et al. (2004) did not recommend any mechanical post-emergence weed control like harrowing as it could damage the seedlings and could increase incidence of diseases. Muehlbauer *et al*. (1995) stated that most of the weed problems can be solved by applying herbicides, while Yenish *et al*. (2009) complained about the limited number of herbicides registered for the use in lentil cultivation in order to control weed effectively.

The reviewed literature illustrates that weed control in lentil cultivation can be challenging in conventional agriculture and is very likely even more challenging in organic farming, where farmers do not have the option of using herbicides in addition to mechanical practices. Thus, the high potential for weed infestation in organic lentil cultivation is likely to be one of the reasons that prevent farmers from growing this crop.

Gruber *et al*. (2012) mentioned that lentil production is currently experiencing a renaissance in Germany, Switzerland and Austria, as regional niche product with high added value. However, since the lentil disappeared from Central European agriculture 50 years ago, no breeding activities or development of cultivation practices have been undertaken in this region, which caused a lack of appropriate knowledge about lentil cultivation under Central European growing conditions (Gruber *et al*., 2012). However, it is known that intercropping of lentils with oat or rye was a traditional cultivation practice in Germany, mainly aimed at providing the lentil with a physical structure to prevent it from lodging in the event of heavy rains, which

can make the harvest difficult and can increase the risk of rotting. Wang et al. (2012) tested lentil intercropping systems with different companion crops and differing seed rates under temperate climate in Germany. Their results have clearly shown that intercropping of lentils with cereals can not only prevent lentils from lodging, it also suppressed weed effectively and increased the land ratio efficiency. Early sowing of lentils (before April/May) has been tested by Wang et al., (2013) as a method to increase yields and as indirect method of weed control, because it provides more time for crop growth and ground cover. The results have indicated that early sowing has the potential to increase yields and reduce weed infestation, but the effect can vary from year to year and is highly dependent on local conditions and the respective weather conditions. In order to reveal options to develop effective strategies for weed control in Central European organic farming, Gruber *et al.* (2012) reviewed strategies for weed control in lentil cultivation from many parts of the world. The authors recommended the following promising strategies:

1) Introduction of root and tuber crops in the crop rotation as preceding crops to reduce the weed in the fields for the following lentils.

2) Increased share of companion crops in mixed cropping systems to suppress weeds.

3) Applying the false seedbed practice to stimulate weed germination in combination with sowing the lentils in late spring.

4) Deep sowing of lentils in combination with blind harrowing.

5) Increased row spacing in combination with harrowing.

Even though these practices are considered to be promising, the authors stated that those strategies may not suited to all farm conditions and that farmers need to select the practice appropriate to their farming system.

1.7.2 Diseases

Lentils are affected by many diseases, mainly caused by different fungi, viruses and bacteria, while diseases caused by fungi seem to be the most widespread and most serious (Chen *et al.*, 2009; Nleya *et al.*, 2004). Major diseases caused by fungi are wilt, root rot, rust, seedling rot, blight as well as stem and pod rot (Chen *et al.*, 2009; Nleya *et al.*, 2004). Some of these diseases can reduce yield and quality of seeds drastically, but their relative importance depends on geographical location and the particular growing conditions (Chen *et al.*, 2009; Nleya *et al.*, 2004). Many diseases caused by fungi are soil born and can remain dormant for several

years in the soil (Chen *et al.*, 2009; Muehlbauer *et al.*, 1995). The most common management strategies are based on application of fungicides and diversified crop rotations, to reduce levels of fungi in the soil (Chen *et al.*, 2009; Nleya *et al.*, 2004).

In organic agriculture the use of fungicides is prohibited and diversified crop rotations with breaks in lentil cultivation of several years may be the only option to manage diseases. However, some authors mentioned that several lentil genotypes have been identified that are resistant to specific diseases and are now used in breeding programmes (Kumar *et al.*, 2013; Muehlbauer *et al.*, 1995). Due to limited literature about organic lentil cultivation it is not clear if these resistant varieties are suitable for organic farming in temperate climate.

1.7.3 Implications of the literature review for this thesis

The literature reviewed in the previous sections has shown that an increase in grain legume cultivation bears great potential for the development towards a more sustainable agriculture. The literature review has, however, also clearly illustrated that cultivation of grain legumes in general, and lentil cultivation in organic farming in particular, is a challenging task. Thus, the question arises: why would a farmer start to cultivate lentils if it is so difficult? As the literature has revealed, farmers are in general confronted with potentially low and unstable yields when they decide to grow lentils, which could basically mean to lose money. If there is the political will and the societal need for utilizing the potential opportunities provided by increased grain legume cultivation, then the realities and motivations of farmers who face these challenges, but still decide to cultivate lentils, need to be understood, which is one aim of this study. There are not many examples of organic lentil cultivation in central or northern Europe, which makes the possible insights provided by the farmers of the Alb-Leisa producer group very useful. For those reasons, 14 lentil growers of Alb-Leisa were asked:

- What was your motivation to start growing lentils?
- What was your motivation to continue growing lentils?
- What challenges did you face when you started cultivating lentils?
- As how difficult or laborious would you describe lentil cultivation compared to other crops?

The fact that the producer group and the production output has grown considerably in recent years, gives rise to the question: what has made that development possible, despite the challenges described in the literature? In order to answer that question the agricultural innovation systems (AIS) approach was applied, which assumes that this type of development comprises an innovation which is the outcome of knowledge exchange and collaborations between a

wide range of actors. Following this assumption, it would be helpful for the development of approaches aimed at stimulating grain legume cultivation, to understand how this system of actors functioned and what kind of collaborations have supported the development of the producer group. In order to generate this understanding, W. Mammel the initiator of the producer group, L. Mammel the head of the company that processes and sells the lentils, as well as the 14 lentil growers were asked:

- What knowledge was available when you started to cultivate lentils and how was it exchanged?

- What actors collaborated with the producer group and what is the nature of those collaborations?

The two section below will provide some facts about the region where the producer group is located, and presents a brief overview of some facts about the development of the producer group.

1.8 The setting

1.8.1 The Swabian Alb

The Swabian Alb is a low mountain range with an average altitude of 700-800 m, located in south-west Germany, which is relatively sparsely populated and one of the largest karst regions in central Europe covering an area of about 6000 square kilometres (MUKEBW, 2004). The climate of the Swabian Alb is comparable to other low mountain ranges in central Europe, with an average annual temperature on the plateaus (main area of agricultural activity) of about 7°C, and an average annual precipitation of 800 mm (MUKEBW, 2010). The soils on the Swabian Alb are commonly poor, shallow, chalky and stony, but there are also areas were loess soils and deep loamy soils can be found (MUKEBW, 2004). Because of the short vegetation period and the poor soils, the area used as grassland is relatively large (above 50 percent) compared to the area used as crop land, which is mostly cultivated with cereals (LEL, 2013).

Most of the arable land in the region is conventionally farmed, but the percentage that is farmed organically has increased by 2.5 percent within the last 10 years and is now at 8 percent (SLBW, 2014). This development was supported by the agricultural policy of the federal state of Baden-Württemberg where the producer group is situated, which emphasise the role of organic agriculture in the region. In 2012 the Federal State Ministry of Rural Areas and Consumer Protection Baden-Württemberg started a comprehensive initiative, the "Aktion-

splan Bio" (action plan organic), aimed at stimulating and supporting organic farming in the federal state (MRLVBW, 2014). This initiative includes several funding programmes focussed at: (1) increased financial support for ecosystem services provided by organic farming; (2) extension of research, education and advisory services focussed on organic farming; (3) improvement of marketing structures and promotion of increased consumer trust and acceptance for organic products (MRLVBW, 2014).

Between 2001 and 2013 the region was a project area of PLENUM, a federal state programme for nature conservation and rural development. The basic principle of the programme is a bottom-up approach that is based on enhancing self-initiative of rural actors, and on supporting the collaboration between these actors (ifls, 2013). In particular local initiatives active in the field of regional production, processing and marketing of food and forestry products, as well as in the field of renewable energy and gentle tourism, can apply for funding of services or the purchase of investment goods (ifls. 2013).

1.8.2 The Alb-Leisa producer group

Farmer W. Mammel was one of the first organic farmers in the region of the Swabian Alb when he started farming in the early 1980s. The idea of growing lentils was inspired by discussions with old farmers from the region in the 1980s, who told him about the traditional lentil growing (intercropped with barley) in the past (W. Mammel, personal communication, 2015). Lentil growing had a long tradition in the region of the Swabian Alb, but disappeared in the 1960s. W. Mammel's interest in the topic was partly driven by his interest in self-sufficient farming and partly by the fact that lentils are one of his favourite foods (W. Mammel, personal communication, 2015). He started to grow different varieties on small plots and sold the harvest to friends and neighbours. His interest in the topic increased over the time and he started to search for lentil varieties traditionally grown in the region, but he soon realised that those were impossible to find. In 1985 he got a French lentil variety, the Le Puy lentil, which turned out to be suitable for the local conditions (W. Mammel, personal communication, 2015). In addition it was considered by consumers to be very tasty and had good cooking qualities. From then on W. Mammel concentrated on the cultivation of this variety on a few hectares of land.

During the next 15 years the initiator W. Mammel and his son M. Mammel improved their lentil production system, including cultivation practices, processing facilities and marketing strategy, until they considered lentil quality and business profitability as acceptable (W. Mammel, personal communication, 2015). Due to the increasingly high demand for their lentils in the region and underutilised machine capacities, they decided to ask friendly farmers whether they would cultivate lentils for them. In 2001 a few other organic farmers started to grow lentils and the Alb-Leisa-producer-group was founded (Lauteracher Alb-Feld-Früchte, 2014).

From then on those organic farmers delivered their harvest to the central processing and marketing company established by the initiator. From this time on the producer group grew slowly but steadily by several farmers a year. After years of searching for traditional lentil varieties, a friend of W. Mammel discovered in 2006 two traditional varieties from the Swabian Alb in a seed bank in the Vavilov Institute of Plant Industry in Saint Petersburg (Slow Food Deutschland, 2012). In 2007 the initiator got some hundred seeds from the seed bank and started with the support of the University of Hohenheim, the University of Nürtingen and a specialised seed producer, a complex and protracted seed multiplication (Mammel & Stephan, 2013). It took 4 years until the first harvest of the old varieties could be sold in 2011. In 2008 the extension of the processing facilities was funded with 60,000 € by the Federal State Ministry of Rural Areas and Consumer Protection Baden-Württemberg via the rural development programme PLENUM (ifls, 2013). In 2009 L. Mammel, the son of W. Mammel, took over the management of the company and the organisation of the producer group, which had already 34 producer members.

All lentils are intercropped, mainly with a dwarf variety of oat and naked barley, but also with camelina sativa, malting barley and black malting barley. The main reason for this practice is to provide the lentils with a structure to grow on. Lentils cultivated without a companion crop under temperate conditions, are difficult to harvest because of the low height, and are susceptible to logging, which increases the risk of diseases and rotting (Mammel & Stephan, 2013). Lentil cultivation in temperate climate is difficult and the processing is laborious, because after the harvest lentils need to be dried, separated from the companion crop and cleaned from stones, residues and other particles. Therefore, the producer group is contentiously searching for companion crops that are suitable as companion crops to lentil and have at the same time a high market value, in order to increase the profitability of lentil cultivation.

All parts of the production system, from cultivation to processing and packaging to marketing are entirely operated by the producer group and L. Mammel's company. The major part of the drying and a large part of the separating is operated on four farms spread in the region, while the cleaning, packaging and selling is entirely operated by L. Mammel's company. In 2014 the producer group had 75 members, who are located within a radius of approximately 20 km around the municipality of Münsingen. L. Mammel's lentil production company delivered in the same year via direct selling lentils to 600 retailers and 250 restaurants (L. Mammel, personal communication, 2015). In the same year the Mammels opened a local shop and an internet shop for organic food. So far the lentil production created 4 full-time and 4 half time jobs in the office of the company, the shop, as well as in the processing and packaging facility (L. Mammel, personal communication, 2015). The present demand is much larger than the current production capacities and seasonal production is often already sold out in spring, even though the retail price for one kilo lentils is about 11 €.

2 Theoretical Framework

This chapter starts with a short critique of common approaches to agricultural development and explains why a systemic approach is needed in order to understand the drivers of agricultural innovation and development. It follows a short introduction to the concept of innovation and innovations systems. Finally, the concept of agricultural innovation systems (AIS) is explained and the way how this concept is applied in this study is defined.

2.1 Agricultural development paradigms

This thesis aims to understand how innovations towards a more sustainable agriculture, such as organic lentil production systems in Central Europe, can be stimulated and supported. This is done by taking an innovation systems perspective and by analysing the factors that lead to the agricultural innovation of organic lentil production on the Swabian Alb. In order to make clear why the innovation systems approach is seen as particularly helpful to support sustainable agricultural development, it was compared with common approaches to agricultural development.

The approaches shown in table 1 are a selection of common pathways for agricultural development. The first two pathways are a common part of agricultural development and policy in both industrialised countries as well as in developing countries, while the latter three are so far mostly applied within national or international development projects in developing countries. As these approaches illustrate, strategies to agricultural development are manifold and new approaches have emerged over time as adaptation to specific contexts and as response to changes in institutions and socio-economic realities, as well as emerging environmental challenges. Even though these approaches follow different development paradigms, they may overlap in certain characteristics or may be a component part of another, and generally have one goal in common: to improve the performance of the agricultural sector and the livelihood of farmers. Innovations are immanent in these attempts to improve conditions and performance, and comprise new technologies and techniques, new ways to organise business, and new models to organise learning. However, past experience has shown that the application of top-down approaches like technology-supply push or purely market-oriented thinking and actions such as marked propelled innovation, that consider innovation and development as the outcome of a science driven linear process, often failed to generate the desired development (Röling, 2009). This was partly due to the fact that those approaches were often based on wrong assumptions regarding actual needs and demands of the stakeholders in focus (Pretty,

1995). Further, these approaches underestimated the complexity of innovation processes and ignored the diverse set of actors along the food chain that play a role in these processes (Röling, 2009).

Table 1: Different approaches to agricultural development. Based on Röling (2009).

Approach	**Description**
Technology supply push	Focus is on agricultural research and technology development. Agricultural development is achieved through science based technologies, which are delivered to users who are expected to adopt the technique and diffuse it among them (the underlying model is often referred to as *the linear model, the pipeline model or the technology transfer model*).
Market propelled or induced innovation	Innovation is expected to increase competitiveness of early adopters, through increased productivity and price advantages. With the result that less innovative producers leave business, while innovative producers remain in business and need to grow (scale enlargement) and to adopt more innovations in order to stay competitive (approach is also known under the term *the agricultural treadmill*).
Farmer driven innovation	Farmers experiential knowledge is used as a starting point for agricultural research. Farmers innovations are identified and in collaboration with research institutes further developed and promoted.
Participatory development	Development and improvement of practices and techniques in participation with farmers. Knowledge hold by farmers is recognised as very valuable, because: (1) it provides insight to institutional settings as well as to skills and practices adopted to local conditions, and (2) it provides information about what kind of support is actually needed and which techniques and practices are feasible under local conditions.
Innovation systems	Innovation is not viewed as the pure outcome of science or markets, but as emergent property of interactions among stakeholders in opportunities for development. Innovation is seen as opportunity to push sustainable development of agriculture, but requires institutional change and targeted support from key actors and the state.

The recognition of these shortcomings and increasing awareness that development under participation of relevant stakeholders would yield better results, which led to the development of participatory approaches, like participatory development or farmer driven innovation (Röling, 2009; Pretty, 1995). These approaches emphasise the importance of farmers knowledge, context specific circumstances and the importance of institutional change (Röling, 2009). A rather new concept that shares many similarities with participatory development, has recently drawn attention of scientists and policy makers, the concept of agricultural innovation systems (AIS). This concept puts strong emphasis on the innovative capacity of farmers and other actors in the food chain, and focuses on the roles and interactions between diverse actors and or-

ganisations in enhancing innovation, influenced by institutional settings. The approach comprises a new thinking of how innovation in agriculture can be enhanced, or as (Röling, 2009, p. 84) pointed it out:

> *"In the new thinking, the key challenge is not so much to transfer technology to users, but to enhance the innovative capacity of key stakeholders in an opportunity. Innovation is seen to emerge from the synergistic interaction of such stakeholders"*

This systemic view on how innovation occurs in the agricultural sector was used as theoretical framework for this study. It follows a short explanation of the basic assumptions which constitute the concept.

2.2 Innovation

As already mentioned earlier, this thesis aims to understand the development of the innovation of organic lentil production in Germany and tries to understand the function of the actors and collaborations that played a role in this development. To be clear about what is meant by the term *innovation* and how it differs from *invention,* Fagerberg (2004, p. 4) pointed out "Invention is the first occurrence of an idea for a new product or process while innovation is the first attempt to carry it out into practice". So in other words, an innovation creates impact while an invention does not (Mars *et al.*, 2013). Therefore, the focus here lies on innovation, because only if a novelty is noticed and recognised by others, it will have the ability to induce change. Innovation can be defined as the doing of new things or the doing of things that are already done in a new way (Dodgson & Gann, 2010). Thus, innovation refers not only to "new products", but also to "new methods of production, new sources of supply, the exploitation of new markets, and new ways to organise business" (Fagerberg, 2004, p. 6).

However innovation is often viewed as the outcome of a rather linear process which is referred to as *the linear model*, without much interactions and feedbacks between the innovators and other actors involved in the process, without much influence of the surrounding systems of institutions, and where consumers are believed to "absorb whatever new innovation is brought to them by entrepreneurs or firms" (Lundvall, 2010, p. 324). Moreover, the model ignores that learning is an essential part of innovation processes, including learning about the shortcomings and failures induced through feedbacks from the demand side (Kline & Rosenberg, 1986, p. 286). Furthermore, as Mars *et al*. (2013, p. 5) pointed out "Invention and innovation are both directly and indirectly influenced by cultural, economic, organisational, political, social, and technological conditions". For these reasons the linear model is viewed as particularly not very helpful when it comes to practical assistance for the development of innovation policies, because it does not indicate which intervention is required, nor where it is

needed most or how it can generate the largest impact (Edquist & Hommen, 1999). The shortcomings of the linear model lead to the development of complex systemic innovation concepts.

2.3 Innovation systems

In order to understand why innovation occurs and how it develops, systems concepts were developed which consider innovation as the outcome of interactions between actors within a certain system. A comprehensive definition of the term *system* which is in line with the authors view, is presented by Ackoff (1971, p. 662): "...a system is an entity which is composed of at least two elements and a relation that holds between each of its elements and at least one other element in the set. Each of a system's elements is connected to every other element, directly or indirectly. Furthermore, no subset of elements is unrelated to any other subset."

The idea of an *innovation system* goes back to the German economist Friedrich List and his concept of "The National System of Political Economy", published in 1841 (Freeman, 1995). List developed this concept to explain the differences in innovation capacity and economic performance between Germany (lagged behind) and England. He already recognised the importance of innovation and learning in terms of knowledge generation and knowledge exchange for the development of a nations economy:

> *"The present state of the nations is the result of the accumulation of all discoveries, inventions, improvements, perfections and exertions of all generations which have lived before us: they form the intellectual capital of the present human race, and every separate nation is productive only in the proportion in which it has known how to appropriate those attainments of former generations and to increase them by its own acquirements."* (List 1841, p. 113, cited in Freeman 1995, p. 6)

In his concept List recommended to connect actors and organisation from science, education and industry in order to enhance the development of new products and processes, supported by the state through long-term policies and by providing assistance, advice, and subventions to inventors (Freeman, 1995). Even though the work of List inspired many scholars to further develop the concept and to make considerable improvements in the design of supportive policies for innovation since then, policy makers and scientist have often shown a lack of understanding of the concept and have applied it in a too narrow sense, for instance by focusing primarily on science-based innovation in high technology sectors (Lundvall, 2010).

2.3.1 Innovation systems - approaches in agricultural development

The concept of innovation systems is not new as illustrated in the previous chapter and has also raised attention within the agricultural sector some decades ago (The World Bank, 2006). The evolution of the concept is shown in table 2, from early approaches with still linear characteristics, over to more comprehensive models, up to the agricultural innovation systems (AIS) concept. All presented concepts imply a systemic view on the agricultural sector and have in common to recognise the important role of learning in the development process, but differ in their recognition of the role of institutions and civic and private organisations in the innovation process. (The World Bank, 2006).

Table 2: Approaches for supporting agricultural innovation (Adapted from The World Bank (2006) and integrated with Klerkx et al. (2012).

Approach	**Description**
National Agricultural Research System (NARS)	Concept emerged in the 1980s. Development efforts focused on strengthening the research and extension system at a national level, and by providing policy support, management, capacity, and infrastructure.
Agricultural Knowledge and Information System (AKIS)	Concept emerged in the 1990s as a critique towards linear technology transfer approaches. Science and research is not seen as the only means for knowledge generation. Gives more attention to identifying what farmers actually demand and focuses on links between education, extension and research.
Agricultural Innovation System (AIS)	Concept emerged within the last decade and is inspired by innovation systems research. Innovation is viewed as the outcome of learning and interaction between actors of private, public, scientific organisations and individuals, which is supported by enabling institutions. Strong focus on the demand side for research and technology, because supply of new knowledge and technology does not necessarily lead to its diffusion. Emphasis is on identifying opportunities and understanding bottlenecks for enhancing innovation.

While the approach of NARS emphasised the expansion and centralisation of the public research sector, the AKIS shifted emphasis on the development of pluralistic knowledge and information systems and the interaction between diverse actors, due to evident inefficiency in many public research organisations (The World Bank, 2006). The AIS concept values the par-

ticipatory elements of the AKIS, but goes further in recognising a wider set of actors, and emphasises that the creation of enabling environments (institutions and policies) is at least as important as knowledge generation and exchange (Klerkx *et al.*, 2012; The World Bank, 2006).

2.3.2 Agricultural Innovation Systems (AIS)

The International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD, 2009) strongly emphasised the role of knowledge exchange, learning and innovation for the sustainable development of the agricultural sector. Innovation is no longer only seen as a driver for economic development, but is increasingly considered as an opportunity to support the transition towards a more sustainable agriculture, by providing also ecological and social benefits (IAASTD, 2009). The concept of agricultural innovation systems (AIS) has emerged only recently, but has raised attention among scientists and policy makers as a comprehensive frame work for analysing and supporting agricultural development towards increased sustainability.

This was due to an increasing recognition that the many complex issues currently faced in the agricultural sector can only be solved by the involvement of all relevant actors with a strong focus on enhancing collaboration and learning (Hermans *et al.*, 2015). Furthermore, the role of agriculture and rural areas has changed, from previously almost exclusively focusing on food production, to multifunctional systems with an increasing diversity of actors and stakeholders (Knickel *et al.*, 2009). Dealing with this can not be achieved by applying traditional linear models, but requires systemic approaches and institutional changes (Röling, 2009). Knickel *et al*. (2009, p. 133) argued that "the pace and intensity of changes in agriculture and rural areas signal a *second order change*" which is "in fact refraiming agricultural and rural relations". To cope with theses changes, the authors argue it requires "second order innovation" which "implies the adoption of new paradigms and rule sets". The authors stated that organic farming in its early stage was an example of a second order innovation, because it demanded practices and views contrary to the conventional paradigm and emerged outside of the agricultural knowledge system (Knickel *et al*., 2009). Another example for second order innovation are "high quality, low quantity regionally specific foods", that are contrary to the dominant paradigm of scale enlargement and standardisation, and emerged mostly disconnected from that paradigm supported by rural networks (Knickel *et al*., 2009, p. 134).

Following this argumentation, in its early stage, organic production of lentils in intercropping systems on the Swabian Alb can be considered as a second order innovation at the local level. Furthermore, examples of economically viable production systems of grain legumes for human consumption in organic farming, may have the potential to increase acceptance for this type of crops and this type of food on a larger scale, and thus may contribute to a transition towards more sustainable systems of food production. Learning about how these innovations

developed, and which actors and organisations played a role in fostering the innovation will be crucial for the development towards an agriculture where grain legumes may play a viable role in the long term.

The AIS concept views second order change and innovation at the local or regional level as the starting point for the development towards more sustainable agriculture, and recognises that this type of innovation will only develop as long as it is supported by actors that are open to novel ideas and unusual approaches (Klerkx *et al.*, 2012). Further, "the AIS approach recognises that innovation is the outcome of an interactive and co-evolutionary process, where a wider network of actors are engaged, with the speed and direction of innovation processes affected by the institutional and policy environment." and which "combines not only technological but also social, organisational, economic and institutional changes" (Lamprinopoulou *et al.*, 2014, p. 40).

Figure 1 provides an overview of actors and institutions that can form an AIS and illustrates the interactions between them. In this perspective the agricultural innovation system is formed by different domains that comprise actors and institutions that have a potential influence on stimulating innovation and fulfil different roles in the development of an innovation (The World Bank, 2006). However, this typology should be rather understood as a structure that provides orientation, and not as something set in stone. Some actors may comprise more than one role or may fulfil a role that would not be expected from them. Further, the AIS is a dynamic system where roles can change over time. According to The World Bank (2006) the function of the different domains can be described as shown below.

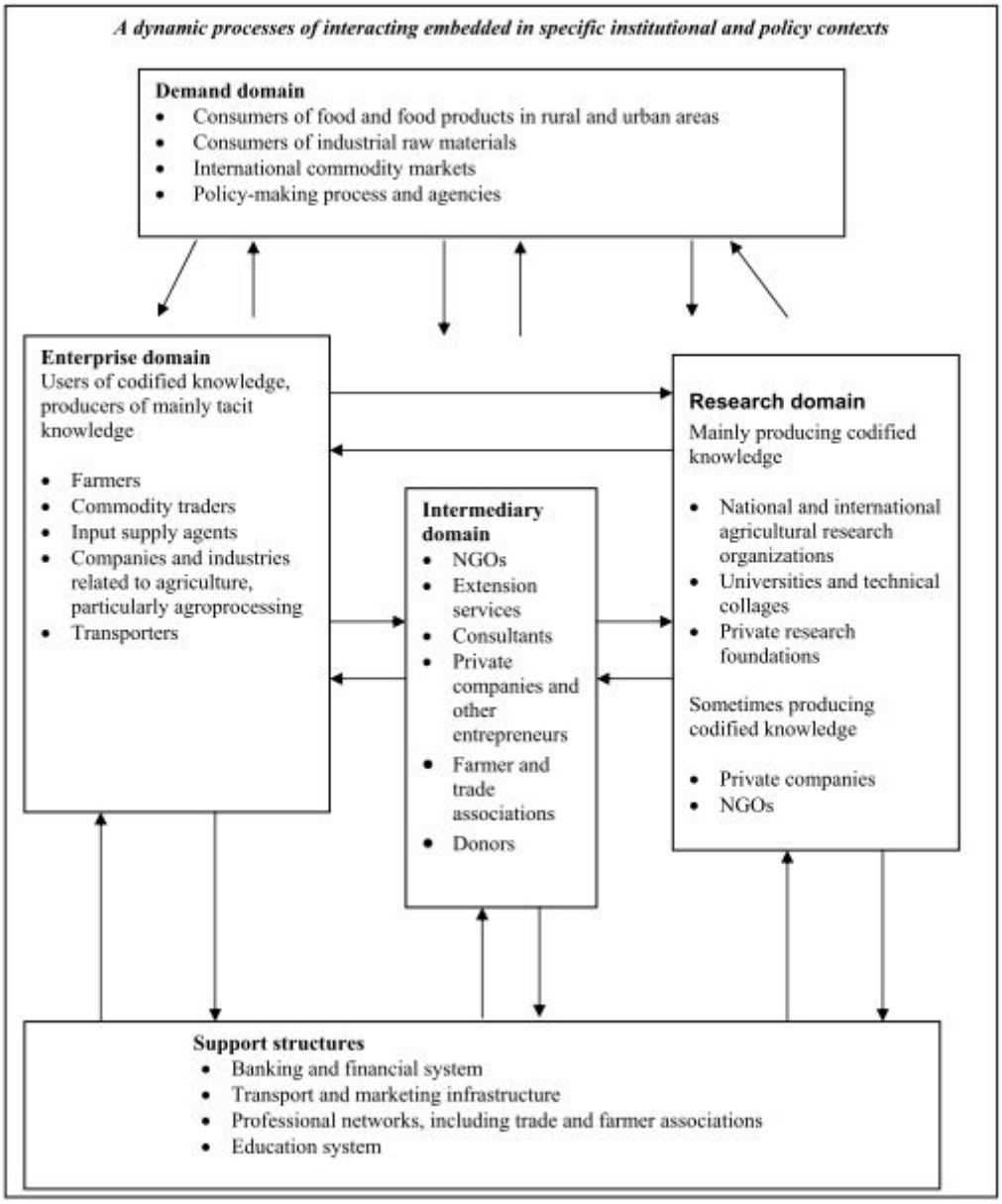

Figure 1: Elements of an agricultural innovation system (AIS). Source: The World Bank (2006), adapted from Arnold and Bell (2001).

Research domain: comprises actors and organisations that produce codified knowledge based on research, which means explicit knowledge that can be easily shared for instance in form of verbal advices or written guidelines and reports. These organisations can be public or private research institutes, that have the potential to support innovations by providing expertise and by conducting relevant research in collaboration with innovators.

Intermediary domain: comprises actors and organisations such as civic organisations or associations, that have the potential to create links between different actors in the AIS, and thus enable exchange of information and knowledge. Actors in this domain have also the potential to stimulate institutional change through networking and lobbing.

Enterprise domain: includes mainly actors such as farmers, rural entrepreneurs and different kinds of companies from the agri-food sector. Those actors can be innovators or actors that have business contacts with innovators. The interaction and collaboration between those actors has the potential to stimulate and support innovation on both sides, through exchange of experiences, knowledge exchange and feedbacks concerning viability, feasibility and desirability of inventions.

Demand domain: comprises mainly stakeholders that have a certain interest in the innovators activity, business or product, and contains groups of actors like consumers of food or other raw materials or policy makers and other interest groups. Consumers have the potential to support innovation, for instance through high consumer demand for an innovative product or service. Policy makers can stimulate innovation by promoting enabling institutional conditions, or by offering appropriate incentives or support to innovators.

Support structure: comprises physical (communication system, transport system etc.), financial (access to loans etc.) and education infrastructure (farmer schools, agricultural universities) that can enhance innovation if well established.

This structure was used to identify relevant actors and the roles they have played in the development of organic lentil production on the Swabian Alb.

The AIS concept has been applied in several ways, differing in scope and purpose. Klerkx *et al*. (2012) distinguish three different strands how the concept is interpreted and applied:

- **Infrastructural view of AIS**: focus is on presence, role and interaction of actors involved in the innovation process and on the institutions and infrastructure that governs their behaviour. The main question is: to what extent does the system support or hinder the innovation process. Available resource configuration like knowledge, finance and material is viewed as determining the potential for creative recombination of practices, technologies and knowledge.

- **Process view of AIS**: sees AIS as self-organising entities and growing networks of actors aiming to develop a novelty (product or process innovation), with the attempt to move towards an alternative to the dominant system. Focus is on how this network is embedded in the system and how it is supported. Focus can also lie on how the actors try to change their institutional and socio-technical environment.

- **Functional view of AIS**: focus is on specific functions of the AIS and whether they are fulfilled or not. The functions and the interactions between actors are mapped in order to identify functions that reinforce each other and have the potential to accelerate innovation processes and development.

The World Bank (2006) assessed the usefulness of the AIS concept in terms of guiding interventions to support agricultural development, based on the analysis of 8 case studies of sectoral and local scale in developing countries. The findings demonstrated that applying the concept can highlight the failures and opportunities in innovation processes. The study revealed some major obstacles to innovation. Actors from all domains showed frequently a lack of openness towards new ideas which hindered collaboration and learning. Authorities and researchers had often an ivory tower culture which caused decreasing motivation of farmers or other rural entrepreneurs to collaborate. In addition, these attitudes caused in some cases mistrust between farmers and researchers. Public and private organisations were often disconnected and mutual recognition of competencies and the capacity to innovate were often low. Further the goals or needs of rural entrepreneurs were often inconsistent with the goals of authorities or research organisations. In general, the attitudes and practices of actors often hindered interaction and prevented actors from taking supportive roles, which lead to a lack of interaction within groups and networks as well as with their wider environment.

Hermans *et al.* (2015) and Lamprinopoulou *et al.* (2014) applied the approach on a macro level (AIS of a country) and analysed based on interviews with key actors and reviews of policy documents in their studies the structural and functional performance of the AISs of several European countries. Their main findings emphasise the important role of farmers' and rural entrepreneurs' knowledge and motivation for the innovation process, and revealed lacking links between farmers and researchers, and the presence of overregulated innovation policies which made it difficult for promising innovation projects to receive support (Hermans *et al*. 2015). Lamprinopoulou *et al.* (2014) revealed several systemic failures, particularly the lack of public incentives appropriate to promote innovation and weak capabilities of researchers and farmers to collaborate in innovation processes.

Other authors focused on the micro level of AISs, which can be a single sector within agriculture or a single case or initiative of individual farmers or a group of farmers. Klerkx *et al.* (2010) conducted interviews, document reviews and reported innovation journeys of two innovative farmer-led initiatives in the Netherlands, aimed at analysing which strategies the farmers applied in order to change their institutional environment and evaluated how successful these strategies have been in achieving the desired change (public funding policies, attitudes etc.). Their results clearly illustrated that farmers have a limited ability to change institutional conditions, but that lobbying and building links to a diverse set of actors are promising strategies in order to improve their situation and to create opportunities. Further, the authors argue support instruments should focus on process facilitation and need to be able to ad-

apt to changing conditions. Tisenkopfs *et al.* (2015) analysed the learning and innovation processes of 17 initiatives and innovation networks in different European countries. The authors revealed the importance of key actors for the innovation process, who enhance or stimulate collaboration. These actors can be trusted researchers, civic activists or farmers, whose roles are based on trustful relations, merit and committed engagement.

The reviewed studies revealed some similar obstacles which are summarised to the following key findings that guided the analysis of this thesis:

- Attitudes and practices of actors can be major obstacles to innovation and are often the cause of the problems mentioned below.

- Lack of linkages between farmers and researchers, and lack of collaboration between other actors in the agri-food system.

- Incentives aimed at stimulating innovation are often inappropriate and innovation policy is often overregulated.

- Institutional conditions (policies, regulations, rules, paradigms of organisatios) have a strong influence on innovation and can be supportive or hindering.

- Farmers and other rural entrepreneurs have often limited access to knowledge.

The reviewed literature revealed that attitudes and common practices of actors and organisations have major implications on how organisations interact and which roles they can take. Particularly organisations such as advisory services, research institutes and public agricultural institutes have often shown hindering attitudes. These attitudes are often based on organisational cultures (ivory tower) that recognise only a small number of actors as possible partners, which hinders interaction with a diverse set of actors. Further, practices are often based on traditional approaches that prevent those organisations from responding quickly to changes in the agri-food sector. Organisations and actors that are not open-minded and show lack of trust in other actors capacities, hinder interaction and thus the development of innovations. Further, as long as the attitudes of actors are based on contrary paradigms, it may be difficult to stimulate interaction. Therefore institutions can play a major role in helping to overcome those differences, by increasing awareness and acceptance for alternative perspectives on agricultural innovation. Farmers and research institutes need to increase mutual understanding in order to enhance effective collaboration. Networking and lobbing seems to be, at least to a certain extend, a promising strategy for farmers in order to build linkages to supportive actors and in order to create funding opportunities.

For the purpose of this study a partly functional and partly infrastructural view of the AIS is taken. Applying this view of the AIS approach is assumed to provide the required structure for the analysis, because it puts the focus on presence of enhancing or hindering institutions and on the roles and interactions of actors within the AIS. Considering the limited resources (time, finance) available for this study, it would not have been possible to analyse the entire AIS by interviewing all actors involved. Therefore the focus was on the core part of the system, the farmers and inventors who stay behind the initiative. It is clear that the focus on a single perspective on the AIS can not draw a comprehensive picture of the entire system and its development. However, it was clear from early conversations with the initiator as part of the prestudy, that the farmers and the initiator would be the only actors who have been constantly involved in the process. Therefore, they are assumed to be the key actors who are at the core of the AIS and who most likely have the ability to shed light on the other parts of the system, compared to other actors in the system.

3 Methodology and methods

Methodology can basically be described as "...the set of theoretical ideas that justifies the use of a particular method or methods" (Midgley, 2000, p. 105). Thus, methodology can be understood as the researchers reasoning, based on an underlying paradigm, why the chosen method is believed to be valid and appropriate to answer the research question. The reasoning for the chosen research design follows below.

3.1 Research design

This thesis is a qualitative study, using semi-structured interviews and focusing on the development of organic lentil production on the Swabian Alb in Germany. The main aim of the thesis was to understand:

(1) why the farmers started to grow lentils and what was their motivation

(2) what where the major obstacles and challenges faced by the farmers

(3) which knowledge was available and how was it accessed

(4) which actors and which interactions played a supportive role in the development of the producer group and the lentil cultivation system

Taking into account the challenges implied by lentil production in organic farming and in temperate climate, it is crucial to understand the motivation of farmers in order to assess which incentives may be viable and desired to stimulate lentil growing, and which not. For the same reason it is necessary to understand what challenges farmers may face when they start growing lentils and what solutions are available. In order to understand the development of the producer group, the study took a holistic and systemic view of the development. The underlying worldview for this thesis is influenced by the farming systems concept, which considers farms as complex socio-economic and ecological systems which are interconnected through relationships and processes, and which are embedded in larger systems of culture, economy, politics and geography (Darnhofer *et al.*, 2012). Further, the approach of this study was based on an agroecolgy worldview which involves the assumption that agriculture is not seen as a pure production activity, but rather as a system that includes the co-evolution of biological systems, social organisation, knowledge, values and technology (Norgaard & Sikor, 1995). Thus, the development of the producer group and the innovation of organic lentil production was not seen as a linear process, but as the outcome of dynamic interactions between a diverse set of actors and institutions, driven by ecological, social and economic challenges and opportunities. Viewing the development of the producer group and the innovation of organic lentil cultivation from a systemic perspective has allowed it to identify factors that influenced the development, key actors and organisations interacting with the producer group, and helped to understand the meaning of those factors and interactions.

The fact that the agroecolgy paradigm formed the basis for this study, required a holistic structure of the thesis that started with placing the problem in a wide environmental and political context, followed by zooming in on challenges, opportunities and connections of actors at the local level, to then zoom out again to identify the relevance of the outcomes on the wider level of policy intervention and intervention research, including implications for further research.

In order to answer the research questions and to achieve the stated objectives, an inductive qualitative approach was chosen. The research design of this study was rather inductive but partly also deductive. It was inductive because it did not start with a stated hypothesis and was not aimed at testing a theory, as common in deductive approaches (Bryman, 2012), but was rather aimed at making sense of situations and contexts, while ideas and theory derived from the collected data, as common in inductive approaches (Creswell, 2007). However, the study had also deductive characteristics, as it comprised for instance the assumption that innovations, like the lentil production system developed by the farmers, are not the outcome of a linear processes, but the result of complex and dynamic interactions. A qualitative approach was chosen because it is viewed as most appropriate if the focus is on understanding of contexts, situations and peoples behaviour (Bernard, 2006). Moreover, a qualitative approach is applic-

able if research is situated in a natural setting and focuses on the meaning of a phenomena, while the researcher is directly involved in the process of discovering (Taylor 2005), which was the intention of this study.

3.2 Selection of site and respondents

As common in qualitative research the approach of purposeful sampling was applied in order to select the site and the respondents that can "...purposefully inform an understanding of the research problem and central phenomenon in the study" (Creswell, 2007, p. 125). The overarching research problem which framed this research is, how can agricultural innovations and farmer-led initiatives be stimulated and supported in order to increase the cultivation of grain legumes for human consumption in Europe and in particular in Germany. Learning about innovative farmer-led initiatives that already contribute to the increase of legume grain cultivation, can help to identify promising supportive measures to stimulate or support initiatives elsewhere. Therefore, the producer group was selected, because it was initiated with the purpose to increase domestic grain legume production, represents an innovative system of grain legume production in temperate climate and has developed promisingly in recent years.

Following the recommendation of W. Mammel the initiator, the yearly producer group meeting in spring was attended and a short presentation of the planned research was given. This was done to increase acceptance for the project and to persuade a sufficient number of farmers to participate in the interviews. The initiator stated, when contacted earlier in the planning process, that due to the increasing number of requests to participate in degree projects, the producers have become more reluctant to participate when contacted via e-mail or telephone. Furthermore he stated that attendance on the producer group meeting would demonstrate seriousness of the project and commitment of the researcher, which would be rewarded with greater acceptance. This strategy provided to be successful and after the presentation 15 farmers agreed to participate. In the following weeks farmers were contacted and dates for interviews were agreed upon, except for on farmer who was not able to participate within the planned period.

Attending the producer group meeting was not only helpful to increase acceptance, it provided also a valuable insights regarding the way of knowledge exchange, communication of issues and evaluation of the last years results. Furthermore, a presentation given by L. Mammel on the meeting, provided access to important information about the development of the producer group, current problems, novel ideas and the yields of the last years.

3.3 Interviews

The main method of data collection were semi-structured interviews based on three interview guides that had a slightly different focus. One interview guide was prepared for W. Mammel, one for L. Mammel and one for the group members. The interview guide for W. Mammel focussed rather on interactions between the producer group and supportive actors of the AIS, while the interview guide for L. Mammel focused rather on interactions between the company and the demand side. The interview guide prepared for the lentil growers put a stronger emphasis on motivations, attitudes and perceived challenges. Even though the interview guides hat different foci, several questions were similar, for instance those concerning knowledge exchange. Bernard (2006) recommended semi-structured interviews as the method which will generate the best results, if the research is focussed on the understanding of complex situations, because it provides not only the flexibility to follow emerging issues or ideas by adding new questions, but also follows a given structure in form of an interview guide, a written list with topics and questions. Interviews were conducted face-to-face with W. Mammel the initiator, his son L. Mammel the head of the Alb-Leisa company and 14 producer group members, mostly at the homes of the respondents. The collected data was complemented through observations like visits of fields or facilities. The interviews with the group members lasted between one and two hours and the interviews with the Mammels lasted about two and a half hours each. Using an interview guide provided a red thread that ensured that all topics and questions were covered during the interviews, but it also ensured that the given time was used efficient (Bernard, 2006).

This research design was based on the recommendations provided by Bernard (2006), and (Kvale & Brinkmann, 2009), who argue that it enhances identification of attitudes and perspectives of the respondents and helps to generate theory and understanding of the situation. In the case of this study it also helped to identify relationships and interactions between the producer group and the AIS, and allowed it to understand the meaning of those interactions. Moreover, this approach provided the flexibility needed to develop the applied methods within the process of data collection and allowed adjustment to the specific situation and emerging issues, through continuous reflection on the findings (Creswell, 2007). After the first three interviews have been conducted, some questions were changed or deleted, as it became apparent that some questions were to broad, or that the farmers had no knowledge about certain topics. Further, some questions were added in order to follow interesting issues that had emerged during the interviews. All interviews were recorded and later completely transcribed.

3.4 Data analysis

After the audio records were transcribed a structured qualitative analyses was carried out that was focussed on content and meaning of given answers. The interviews with W. Mammel and L. Mammel where considered as expert interviews, where the focus has been rather on content that helped to explore the structure of the AIS and to understand the meaning of interactions. The analysis of answers concerning motivations and attitudes provided by the lentil growers, followed the design recommended by (Davis, 2007). In the beginning the data was organised in a useful way. Therefore, a table for each interview was created, with one column for the answers and one parallel column for own comments. The answers to each question were summarized to one short sentence and then classified with colours. Afterwards the summarized and classified answers were copied into tables, one for each question, to compare the answers. Then the actual process of analysing started and a detailed comment to each answer was entered that summarised and highlighted the meaning of the answer. Kvale & Brinkmann (2009) describe this process as, compressing the answers into a few words focused on the main content. In the next step the comments were coded, which means the quintessence or main ideas were further categorised, and summarised under emerging themes (Kvale & Brinkmann 2009). This process generated a number of themes, of which the less important have been rejected and the most important were defined until a manageable number was formulated (Davis, 2007). The finally selected themes were then reflectively interpreted to answer the research questions. However, the interpretation of meaning is a complex process and can be influenced by researchers bias and own opinions, also known as biased subjectivity (Kvale & Brinkmann 2009). The success of the entire research and finally the validity of the outcome, therefore basically depends on how accurate, intensive and reflective the data analysis is done (Davis, 2007). In the results part of the report, the outcome of the study is presented in a logical order and is supported by functional use of direct quotations from the interviews.

3.5 Validity, reliability and sources of error

First of all, both, in qualitative research and quantitative research, scientists attempt to keep objectivity and try to produce valid and comprehensive knowledge (Bernard, 2006). However, every researcher has his own background, worldview, values, attitudes, bias, skills, assumptions and agendas which affect the choice of the problem, the way of looking at it, the way of analysing it and the meaning given to the outcome of the research (Bernard, 2006; Midgley, 2000). Thus, complete objectivity can never be achieved and methods used in science will always intervene with the subject studied, and can never be absolutely comprehensive (Midgley, 2000). It is therefore particularly important to be clear about possible bias, the personal worldview and assumptions (which has been tried to do in the first section of the meth-

odology part), and to be ambitious in minimising influence on the research caused by personal attitudes or bias, in order to generate knowledge that is as valid and reliable as possible (Bernard, 2006; Taylor, 2005). Further, every research has its limitations and sources of error, in terms of availability of resources, unforeseen events or unexpected issues, that also affect the validity and reliability of the outcome. Transparency about these issues will increase credibility of the study, which will be in focus of the following paragraphs.

One possible weakness of this study is that the applied AIS approach is relatively new and experiences with this approach are still rather limited, which makes it difficult to choose the best research design. In general it is obvious that the best way to study the AIS would be to conduct interviews with all relevant actors of the system, but this has not been done in most of the literature reviewed and will probably not be possible in most of the cases considering the multitude of actors involved. However, this study explored only the farmers' perspective on the AIS, which limits the potential insights provided by the outcome of this study. As a result, only assumptions can be made concerning the incentives and motivations of other actors in the AIS. Apart from the limited resources available for this study, like time and finance, the decision to focus on the farmers perspective was driven by early conversations with the initiator, who stated that he his son and the other lentil growers would be the only actors who have been constantly involved in the innovation process. Therefore, it was assumed that they are the key actors who are at the core of the AIS and who most likely have the ability to shed light on the other parts of the system, compared to other actors in the system.

There are some potential sources of error and research bias in this study that need to be addressed here. One possible source of error is the way of analysing the development of the lentil production system, which was done in a retrospective way based on the experiences and memories of the respondents. Even though it is obvious that there is no better way of researching events and actions that lie in the past, as by asking those persons that have been involved, it bears the risk that the respondents remember only some certain issues and events, but others not. It is also conceivable that the respondents' attitudes and perceptions have changed over time, which may has affect the retrospective evaluation of those.

Another possible error that may have occurred is that those farmers who have agreed to participate in the interviews may not be representative of the whole producer group. It is for instance possible that only the highly motivated and committed farmers participated. This could have biased the results, particularly those dealing with questions about farmers motivation. In this context it is notable that the interviews revealed that four out of five of the first producer group members participated in the interviews, which may support the assumption stated above.

The fact that all quotations have been translated from German into English, bears the basic risk that some of the meaning got lost in the translation or that the translation may be affected by researchers bias. It was tried to reduce this risk by translating the statements as close as possible to the original and by adding short explanations if the meaning of certain words was not absolutely clear (given in square brackets).

4 Results

4.1 The interview participants

In addition to W. Mammel the initiator of the producer group and L. Mammel the head of the lentil processing and marketing company, 14 lentil producers were interviewed. Table 3 presents the characteristics of the farmers participating in the interviews. In order to ensure the anonymity of participating farmers, no specific characteristics like ages or locations are presented that would allow an identification. This was necessary considering the relatively small size of the producer group, and the fact that most of the farmers know each other very well. However, all direct quotations of farmers were provided with a number (which was used before to plan the interview route) in order to distinguish between quotations from different farmers. For a bit more than half of the respondents farming is the main occupation, while for the other respondents farming is a sideline activity. The respondents were asked what they consider as their production emphasis in terms of revenues. The statements are listed from the highest share of revenue, to the lowest. About half of the farmers stated that they generate the major part of their farming income from milk cows or suckler cows, while most of the other farmers generate their major income with cereals. Lentils are often only cultivated on small areas and thus play in most of the cases only a marginal role when it comes to income. However, for some farmers lentils are among the major crops, generating a considerable part of the farming revenues.

Table 3: Characteristics of participating lentil growers

Type of business	Production emphasis	Area of crop land (in ha)	Lentil area (in ha)	Cultivates lentil since:
primary	Suckler cows; clover grass; cereals	70	7	1999
primary	Milk cows; cereals	44	4	2007
primary	Milk cows; clover grass; cereals	50	7	2004
primary	Cereals and vegetables	30	1-2	2012
primary	Milk cows; lentil; clover grass; cereals	80	10	2012
primary	Milk cows; clover grass; cereals; lentil	30	5	2002
primary	Cereals; lentil; linseed	125	10	2009
primary	Laying hens; clover grass; milk cows; spelt; vegetables	44	6	2009
sideline	Spelt; malting barley; lentil; oat	16	1	2010
sideline	Cereals; vine	40	5	2007
sideline	Spelt; lentil; buckwheat; winter triticale-peas mixture	15	2	2007
sideline	Milk cows; cattle fattening; clover grass; spelt; lentil	50	6	2010
sideline	Suckler cows; spelt; lentil	12	1-2	2005
sideline	Cereals and lentil	50	6	2007

4.2 Research question 1. Motivation and attitudes

In order to analyse the reasons why and how the revival of lentil cultivation in the region has developed and how it was possible that the producer group has grown to its current size, it was explored why farmers decided to grow lentils and why they joined the producer group in the beginning. Furthermore, aiming to explain this development, the reasons were explored why farmers continue to cultivate lentils in the long term. Therefore farmers where asked:

1) "What did motivate you to grow lentils in the beginning?"

2) "What motivates you today to continue the cultivation of lentils?"

4.2.1 Original motivation to cultivate lentils

Almost half of the farmers mentioned curiosity and the will to try out something new as their main motivation for growing lentils in the beginning. It is mentionable that all of the farmers who stated that, belong to the early members of the producer group and started the cultivation of lentils around the time when the producer group was founded. What the farmers meant by "something new" differed among the farmers and ranged from trying out an uncommon and exotic crop, over doing something that people consider as impossible, to being part of a new and alternative approach to food production and marketing, compared with the common food sector.

> *"I have always been willing to start something new and to play a part in it. I actually always focus a bit on niche products. After I have tried the lentil, I started to grow buckwheat last year [...] and this year I want to try some cress."* (Farmer 3)

> *"Actually it was out of curiosity. To try out how that works.. My son has grown soy beans here once and that has worked too. So it is not the case that this doesn't work here on the Schwäbische Alb."* (Farmer 7)

> *"My motivation was, I just wanted to try out some other things for once. I find it somehow boring to grow always clover-grass, spelt, barley or something like that. And at that time the lentil sounded relatively exotic to me."* (Farmer 11)

> *"To try out something new and to grow something which stays in the region and where you know the marketer personally. Thus to not to have to produce for anyone you don't know, like any of those giant companies, which are common in the organic sector too by now. Yes just something with small structures and which is just around the corner."* (Farmer 9)

More than one third of the farmers expressed as their main motivation, that they where searching for a possibility to improve their crop rotation. The main reasons mentioned was to increase the nitrogen supply and to enhance the soil structure.

> *"[...] I've got no animals, this means I'm actually always at the lower level with the nitrogen supply, because I've got only some forage. Meanwhile I actually get quite a lot manure from a neighbour that I spread on the fields, but this just wasn't enough... And I haven't got a fertile location neither. Seen from that point of view the lentil suits me very well I would say."(*Farmer 5)

> *"It fits actually quite well into the crop rotation. Well it's actually the additional benefit, here with us everything is loaded with grain so to say, we had only our clover grass in principle and without animals it's even more difficult and the only thing you can do is incorporating the green manure into the soil. [...] so the lentil fits well in there. Now I have in my crop rotation: two years clover grass, than the spelt, and if it's well enough barley or oat in between, and then the lentil and af-*

terwards I can bring spelt, rye or barley again and then comes two years clover grass again. That just fits well and the lentil as a legume is good for the soil. Thus you have a very loose soil after the lentil and that's actually pretty good." (Farmer 10)

"[...] Than we said we have to have some kind of legume and that's how we came across the lentil. And with view on the crop rotation with pure grain cultivation and without animals it's generally very difficult." (Farmer 1)

"[...] I can just place the lentil at the last position [of the crop rotation]. I can sow the lentil on an organic field even when no barley or anything else would grow there anymore, because I have to little nitrogen in there, then I can still bring the lentil, because it's a legume and it produces nitrogen and doesn't need much. Thus the lentil fits into it." (Farmer 8)

Only one farmer mentioned explicitly financial incentives.

"[...] for us it was actually an alternative to oat, because you can't earn anything with oat." (Farmer 12)

Another farmer stated that he started to grow lentils for political reasons as a way of political activism.

"Because it was something else. At this time genetic engineering was already a topic and we went to events against GMO. And then we have thought we don't want to be always against something, we want to do something instead. And then this thing with the lentil suited us just well." (Farmer 15)

4.2.2 Motivation to continue with lentil cultivation

Even though only one farmer stated financial incentives as the reason why he started to grow lentils in the beginning, almost all Farmers mentioned it as one of the reasons why they continue the cultivation of lentils.

"Well it's also a fact that it's very good from a financial point of view. That's also an aspect. And then it fits of course very well into my crop rotation, because at first I have three years of clover grass, and then spelt and then comes the lentil and then there is still enough nitrogen in there so that I can sow it over." (Farmer 7)

"For financial reasons, absolutely clear." (Farmer 12)

"It's actually still the same. Well it's actually nothing new anymore. But it works well, so one can master it well. Also when it comes to weed control and crop rotation...so far. No idea how it will be in future [...] Well, and the money you earn

with the lentils is not too bad. If I grow barley I earn much less, that's clear. Or in particular oat...which nobody wants. Thus, lentil is similar to spelt, which is about 2000 € per hectare, as the case may be." (Farmer 9)

"[...] From an economical point of view it's similar to spelt, so from the profitability it's similar, that differs not much, but for the crop rotation it's interesting. The soil is easy to till afterwards, it is very loose, so it is well-rooted. [...]" (Farmer 10)

Most of the farmers compared the profitability of lentils with spelt, the most rewarding among the combine-harvested crops in the region. One farmer illustrated this notion by providing an example calculation.

"We get about 2.5 € per kilo from Lutz. If it's a poor harvest of 500 kilos than you get 1250 €. If it's a good harvest you get 2000 € or a bit more. With spelt we thresh 4 tonnes per hectare and we get 50 to 60 € per 100 kilos. Thus, a good year of lentils is all about the same as a good year of spelt." (Farmer14)

In addition to financial incentives, several farmers expressed that it motivates them that the lentils are highly demanded and that it enjoys a high level of acceptance in the region and beyond. The farmers stated that the feedback from customers, friends and even from conventional farmers is in most of the cases very positive.

"I think my main motivation is, firstly, that you produce a product that is highly demanded and that enjoys a high level of acceptance. Secondly, it was of course not a disadvantage that it was on average over the last years relatively profitable. And what I like best about the whole story, is that you eventually saddle a product the other way around. So that you consider, what do I need to get for the product so that I can work in an economically reasonable manner and that you put it on the market for that price and not the other way around, as we are accustomed to [...]" (Farmer 11)

"[...] And of course, lentil cultivation is a great thing, because there you...the lentils are famous throughout Baden-Württemberg [federal state] and beyond. So if you are somewhere else and you say Schwäbische Alb, people immediately say: Isn't that where the lentils grow? And then you say yes, I'm one of the producers and that's great from an emotional point of view. [...]" (Farmer 8)

4.2.3 Attitudes of lentil producers towards technical support

Several farmers considered the funding of machinery and facilities in the past as very helpful. It was expressed that this was particularly supportive to achieve the high quality of the final product, which the farmers considered as one of the major reasons for the sustained high consumer demand. It was brought up that the funding was mainly concentrated on the extension of facilities for drying and storage, and on the purchase of facilities for separating, cleaning

and packing. Thus, the measures were mainly focused on improving the lentil processing and not on improving machinery for soil preparation, cultivation or harvesting. Most of the farmers mentioned that there was and actually is no particular need for improvement or extension of the machines they use. One farmer mentioned that it would be great if they could equip their combine harvesters with a so called pick-up unit, which allows it to cut the lentil plants very low above the ground. However, it was brought up that this would not be worthwhile considering the rather small lentil fields cultivated by the majority of farmers.

> *"No. As long as you are not forced to separate the stuff. No. You need...actually nothing. You just need a wagon to transport the stuff and that's very well organised, almost all producers can deliver it somewhere and the really tricky tasks [like drying and separating] are always solved by other persons. [...]."* (Farmer 11)

> *"[...] If the money would be invested to conserve old varieties or to breed new varieties, which are adapted to our local conditions and work better, then the state should support that with money, then I'm in favour. [...]"* (Farmer 8)

> *If it comes to lentil varieties it is always interesting if someone researches or breeds, but the cultivation area is to small to be profitable for a professional breeder. So, if someone would start breeding he must be supported until it pays off."* (Farmer 10)

4.2.4 Attitudes of lentil growers towards state funding and subsidies

Aiming to identify which measures are perceived by the farmers as particularly helpful to stimulate the cultivation of lentils in the past and for the future, the interviews explored:

- The farmers attitudes towards subsidies and direct payments for lentil cultivation
- What the farmers consider as helpful measures in the past and for the future

Almost all farmers considered the lack of financial support in the past, in terms of direct payments for lentil cultivation, as not detrimental for the development of lentil production in the region. Many farmers pointed out that the producer group needed a slow and healthy growth to become as successful and competitive as it is now. It was brought up, that the slow development enabled a balanced growth of produced quantity and the demand for regionally produced lentils.

Moreover, most of the farmers expressed a critical view on future scenarios including direct payments or single area payments as measures to stimulate the cultivation of lentils. One argument brought forward by the producers was, that they have no need for financial support, because the lentil cultivation is profitable enough to compete with other crops. Therefore the

producers assume that current producer prices should attract enough interested farmers, without the prospect of additional funding. Some farmers expressed their concerns about subsidies for lentil cultivation. They pointed out that higher financial incentives could boost the production of lentils and could flood the market, which would result in decreasing prices.

> *"No. Well I think it's always a difficult matter if you push it too much. Then you have always a lot of the product on the market and then the price has to go down. That's always difficult. Thus, it has to develop slowly and healthy."* (Farmer 7)

> *"Well financially...I see no need for that. Well probably for the advice we give to universities or so, if that is paid for so that the producer group has no additional costs with that. That's okay, if that would be funded by the state or by the federal state[...]"* (Farmer 3)

Moreover, it was brought up that state funding programmes, as measures of political intervention to steer a certain development, have already let to many undesirable consequences and unwanted trends in the past. One given example was the stimulation of biomass production trough subsidies within the framework of the Renewable Energy Act (EEG) in Germany.

> *"No, for the cultivation certainly not. [...] I thing it's more healthy if something grows...with the demand instead from outside...thus where politics interfere, see biogas for instance or something like that, then it gets a completely different character or a completely different dimension. [...] That could create a glut where nobody knows where to sell the lentils. [...] Thus, the purchase of certain items within the frame of initiatives should be funded, but not the cultivation by itself."* (Farmer 14)

> *"As long as the plant [the lentil] eventually brings the yield and the profit as it does, I think it's not good. [...] to subsidise farmers eventually for something...that's always a difficult matter, because no matter where you look, you can see that with the renewable energies, where you can receive subsidies the industry will tap those subsidies by producing the products you finally need. Thus, personally I'm not in favour of it."* (Farmer 8)

> *"Well, I think it's not positive if the state interferes, rather that someone like Mammel wants to try something and then realises that this has potential and enlarges it...from the cradle. It's probably healthier...it's a healthy growth. [...] It is crazy how it changed since the EEG [Renewable Energy Act], how it [agriculture] has intensified...we already have been on a better path back in the 90s...particularly in terms of intensive fertilizing. When the EEG was passed, the original idea was certainly that you should produce biogas from the manure you had left...and the opposite happened. Finally we have biogas companies who have no animals at all...so much about subsidy programmes."* (Farmer 13)

Only two farmers expressed a positive attitude towards direct payments. One farmer viewed it as generally interesting but not necessary. Another farmer mentioned that the cultivation of protein plants in general should be supported through subsidy programmes, because production of theses types of crops often involves an additional risk for the producer, which is not compensated for so far.

> *"Yes why not, funding is always interesting. [...] Well it's not unprofitable. If I grow oat, I earn only half of the money in the end. So, in terms of money it's not absolutely necessary. [...]"* (Farmer 10)

> *"Well funding generally [...] if protein plants on the field would be supported EU-wide or at least through funding programmes in the region or in Baden-Württemberg, through FAKT or something like that, so that you get more subsidies for such kind of crops, not only for lentils, also for peas and soya, so that they would do more for that as they have done so far. Well, so far that's actually not honoured at all, through the single area payment or whatever, for the risk someone takes to develop a reasonable cultivation system."* (Farmer 4)

4.3 Research question 2. Challenges and difficulties

4.3.1 Problems faced by lentil growers

Aiming to identify obstacles faced by farmers when they started to cultivate lentils, which could prevent farmers from starting or continuing to grow this crop, the interviews explored:

- what problems did farmers face when they started cultivating lentils

Some farmers stated they had not much problems in the beginning when they started to grow lentils and that they are always wondering why particularly the new members in the producer group have the highest yields. One explanation expressed by a farmer was that most of the newcomers have converted to organic agriculture only recently before they started to cultivate lentils. Thus, it was brought up that it is likely that their fields were sprayed with pesticides only recently, which could still result in reduced weed infestation on their fields when they start lentil cultivation. However, this effect obviously lasts only for a short period of time.

> *"In the beginning we had no problems at all. We have had always excellent yields. It was also nice to look at and it actually has only become a problem over the years, so that it isn't that nice anymore. [...] I assume that it has to do with the fact that we had quite a lot converted land [most of the new producers have converted to organic only recently]. Thus, the weed infestation was just lower because of the spraying before the conversion. That's what I think."* (Farmer 11)

"And often it is like that, funny enough it is actually quite often... in the first year they have...so the newcomers, they always have top yields. There was this farmer, who isn't a member for that long...can you remember [to his wife]?...he has threshed 1.5 t lentils in his first year. He was the big hero. So in the fashion that the new Messiah is born. And then in the next year it wasn't that good neither... Thus there is no recipe." (Farmer 15)

Almost all farmers mentioned weed as the main problem when they started to cultivate lentils and it still remains one of the major issues. However, some farmers stated that they believe in no sufficient practice for active weed control and that one can only influence it by the design of the crop rotation. Some of the growers have had bad experiences with blind harrowing and others never tried it because they simply consider it as not practicable. However, other farmers mentioned that rolling and harrowing are functioning and appropriate practices.

One possible explanation for that is the diversity of the cultivation region, which holds also a high diversity of different growing conditions (soil types, altitude, average temperatures, length of the vegetation period). These different conditions determine which practices are adequate and effective, and which not. Thus, farmers perception on mechanical weed control is to a certain extend determined by the local conditions in their fields. However, farmers who have their fields spread over a large area, stated that mechanical weed control is particularly difficult on heavy and moist soils at high altitudes.

"The weed infestation. There is nothing you can do. Except perhaps you cut it by hand. To harrow it doesn't work and hoeing doesn't work neither. Spraying is not possible anyway, of course. Thus, weed infestation is the main problem. Well and the threshing is not that easy, to drive decent and slowly. Round here the hail is also a problem, but I have no influence on that anyway. Thus, we already had a year where we have grown lentils, but where we haven't threshed any." (Farmer 9)

"Last year I had problems with thistle and the thistles were exploding here in my lentil fields...if you're not careful. It was such a wet year, seems that it has pleased the thistles quite well. So it was wet from June to August and as I have noted the lentils rather like it dry. However, two years ago, where we had this dry summer, there I have sown it quite late and yet was the first who threshed it and it was fully ripen, it was fully dry. Otherwise, here we usually thresh the lentils when it is still a bit green at the top or when they are still blossoming, so to get the right moment and to thresh it before they fall out below and are yet a little bit green at the top. However, two years ago it was completely ripen." (Farmer 10)

"In the beginning we actually had some trouble, we just had to much weed. Partly extremely weedy fields. With thistle and... Thus at the very beginning you had to have a pioneering spirit to some extent. [...]...often we have done just too little and you have to do quite a lot after the sowing, some rolling, and once we have

tried to harrow it with a spike harrow. This time we have tried to harrow it when the lentils were already outside. However, you have the weed, because it is a delicate plant and it will always thin out a little bit." (Farmer 13)

"As a grower, it's probably where do I integrate the lentil in my crop rotation. Because the agronomic options are in principle limited and you can't do much more as to design the crop rotation. If the stuff is sown and the soil rolled than you can actually just watch it grow. Sown, watched, harvested. [...]" (Farmer 16)

"How do I do it right. How do I prepare the seedbed? When is the right time? Such things. And then of course the weed. How can I keep it in check? However, this year I didn't harrow it. This time I just have sown it and I will only come back to thresh it. If the thistles start to prevail, I will go in and cut their heads off by hand." (Farmer 3)

However it became obvious that farms with a focus of production on cows in their farming system, have less problems with weed infestation because they have more weed suppressing crops in their crop rotation.

"It has one disadvantage [...] the weed infestation. You bring in weed infestation [into the fields] in this year and for some farms it may be more difficult. I see it not as that big problem, because I always bring after the third or the forth year clover grass again, for my cows, and after three years clover grass you have no problems on your fields for the next two years, I mean no weed or something like that. Thus, from this point of view it fits quite well, and if I have some thistles on the field in the year I grow lentils, then that doesn't bother me. That doesn't really matter." (Farmer 8)

In addition to the problem of weed infestation, most farmers mentioned that it was very difficult to find the right sowing date and the optimal date for threshing.

"Well, the sowing date was a big issue. I don't like the early sowing so much. However, once I have sown it in May and the yield wasn't so good neither...and then...it was barley [the support crop]...which didn't ripen fully. Thus the sowing date is really important. What's also important is that you till the field in autumn properly, where you want to sow the lentils, and then only a little in spring. Thus let the weed germinate in autumn properly [...]" (Farmer 7)

Sowing at the wrong time can cause serious problems and can lower the yield considerably. Sowing the lentils to early can lead to high weed infestation. Sowing the lentils too late can lead to insufficient water supply for the seedlings due to dry spring periods common in the region. Furthermore, late sowing increases the risk that the support crop does not ripen at the same time as the lentil. This results in high moisture contents of the harvest and therefore increases time and energy is needed for drying. Moreover, it increases the risk that the harvest

starts to mould shortly after the threshing, which can reduce the quality of the lentils considerably. The optimal harvest date has also a large influence on lentil quality but also on the quantity harvested. That means to find a compromise between moisture content of the mixture, ripeness of the lentils, the potential risk of germinating lentil seeds during rainy seasons in late summer and bursting pods during the harvest. Some farmers mentioned that it was difficult in the beginning to find the right harvest date, but meanwhile it seems to be viewed as a minor problem as long as harvest and drying are well organised, which is usually the case. Today, the he drying is operated on four farms spread in the region to keep transport distances short. In order to coordinate the drying capacities, the harvest dates have to be agreed upon in advance with the nearby farmer who operates the drying.

> *"In the first year, the most difficult was actually to find the right moment to thresh it. Though we had a good year back then. There we have threshed it pretty dry. Since then, we have always threshed it rather moist. [...] That's a problem. Once we have threshed it with 25 % moisture content and in the first year it was only 17 %. So that was actually quite good. In terms of cultivation practices, you can't do much. Sowing and threshing."* (Farmer 12)

> *Then the threshing was a big issue. How to adjust the harvester. And then, do we have sufficient drying capacity? [...] And in the beginning, when do we actually have to thresh? Meanwhile we are more bold and we wait until it dried more off. In the beginning we threshed it much to early, when it was still moist, because we were afraid that it could germinate immediately. [...]"* (Farmer 16)

4.3.2 Perception on complexity and invested effort

Aiming to identify obstacles faced by farmers when they started to cultivate lentils which could prevent farmers from starting or continuing to grow this crop, the interviews explored:

- As how laborious and difficult do farmers perceive the cultivation of lentils compared with other crops?

All producer group members expressed that lentil cultivation is not more laborious than the cultivation of other combine-harvested crops like cereals. The sowing for instance differs not much from other crops and includes only one work step as usual, because lentils and support crop are sown simultaneously in a mixture. Rolling as a method to even the soil, was brought up by most of the farmers and was considered as essential if soils are stony. Soil and seedbed preparation in autumn and spring is obviously the major part of the work. In the event that thistles take over, several farmers stated that they try to stem it by going into the fields and cutting the thistles by hand. Many farmers mentioned that they usually do not much more as sowing and harvesting, but it was brought up that it needs skills and experience when it comes to harrowing and threshing.

"Well, with respect to soil preparation it is not much more, maybe one drives through it one more time because of the weed. One just has to make sure that it fits. Therefore one can harrow it, but one doesn't need to. We have never tried that so far. Thus, it isn't additional work. The additional work comes when you thresh it, the harvester needs to drive slowly and you have to be a bit more careful." (Farmer 10)

"It isn't more laborious than other things. That's not the problem I think." (Farmer 11)

"The other crops get more attention. With the lentil you just have to roll it if the soil is stony. The sowing is imaginable simple, because you sow it as a mixture, so no double sowing or re-seeding. One has to take the preceding crops into account, so that you keep a sufficient time lag between legumes. Apart from that it's imaginable simple." (Farmer 14)

"Actually not laborious. Well I do it meanwhile that way, I do nothing except to sow it early in spring, not as the first one but relatively quickly. And before, I drive through it if possible, so that the weed germinates a bit. I also have tried to harrow it...that was one year good and the other year it wasn't that great. It is just crucial how well you catch it [the weed] and how is the site. In any case...I don't make any big effort and I just sow and harvest it eventually." (Farmer 5)

"As rather small. Only if there are a lot of thistles in there, than I do hand work. Then I have cut it with a sickle before, so that it doesn't look to glaring. That's actually more kind of an optical matter." (Farmer 7)

"Little. You actually do not that much. You sow the lentil mixture, you roll it and then you watch it (laughs). And you hope that the weather plays along. And of course the harvest yes...I think the harvest is actually...here you have to be careful again." (Farmer 13)

"Actually not much more laborious as grain. If I sow it and only come back again to harvest it, then it differs not much from grain." (Farmer 3)

"Actually it's not necessarily laborious. I prepare the seedbed, I sow, I roll and then I come back again to thresh it. Of course, if the thistles take over then I try to stem it by hand." (Farmer 9)

4.4 Research question 3. Access to knowledge and knowledge exchange

4.4.1 Access to knowledge in the beginning

W. Mammel stressed that even though he was searching for a long time, there was almost no information available when he started to grow lentils in 1980s, with the exception of one or two old books in English with rather basic information. The only source of information on cultivation practices were the stories of elderly resident farmers, who had worked on lentil farms when they were children. Those farmers stressed that lentils had always been cultivated intercropped with oat or barley, in order to provide a structure that should prevent them from being pushed down and from starting to rot after heavy rain. However, in the traditional cultivation systems almost no machinery was used and most of the work was done by manual labour. Further, no concrete information on cultivation practices were available and the reported yields were quite low. W. Mammel pointed out that he decided to develop his own cultivation system mainly based on trials and adjustments. W. Mammel mentioned that it took about 15 years until the cultivation system worked well enough and until the production increased.

The early members who joined the producer group around the time when the producer group was founded (2001), stated that there was not much information on lentil cultivation available, particularly at the very beginning in the early 2000s. Farmers expressed, at this time there was neither easily accessible literature on lentil cultivation nor much on the topic in the internet. Public or private advisory services with focus on the organic sector had not yet been common, or did not play a role. It was brought up, that at this time the main source of information was the advices and tips provided by W. Mammel, mostly based on his own practical experiences and enquiries. In addition most of the farmers mentioned that they just tried out different practices in order to improve their cultivation systems.

> *"Everything from Woldemar. At that time I've tried to browse in some books, but there wasn't much in there."* (Farmer 11)

> *"In the beginning most of the information came from Mammel. [...] In the beginning, Mammel had this advantage and all the others just tagged along with him. A little like free-riders. You just have asked Woldemar, how do you do this and how do you do that...[...]"* (Farmer 16)

> *"From Woldemar, he has already known a bit, and then we have tried out quite a lot. We have done some testing with more seeds, fertilization, have tried one strip with hey and manure...we have just made some experiments."* (Farmer 15)

Other farmers mentioned that they did research on the internet, but found only little information, especially when it came to detailed practical recommendations regarding sowing dates, seed rates and weed control. Several farmers mentioned that they received advices from other farmers in their neighbourhood who already had some experience with lentil cultivation. None of the farmers mentioned public or scientific institutions as source of lentil specific information.

> *"From Mammel, and then I have researched a bit on the internet. And then I was looking around and have asked those who had already cultivated lentils, how do they do this and that... And there was this Demeter farm close by, they had already cultivated lentils much earlier and I have asked them several times how they do it and so on. [...]"* (Farmer 7)

> *"I already had some experience trough the work at another farm where they had lentils. There I had already adopted some of their practices, how they do it. I also have tried some things out on my own [...]"* (Farmer 13)

> *"I would say a lot of trying...well you actually had to collect the information on your own and you have asked others how they do it. There simply wasn't any information. Some said you can harrow it and the others said never do that. [...]"* (Farmer 1)

4.4.2 Places of knowledge exchange within the producer group

As already indicated in the previous chapter, several farmers considered the information provided by the initiator rather as a starting point for further improvement, than practices set in stone. For those farmers, experimentation with different practices was a common strategy in order to get a grip on the various problems. This local knowledge which is based on experiences and generated within the producer group, is shared among the farmers via different formal and informal places of exchange. These networks differ in their characteristics and in their importance for knowledge exchange. Five of these networks could be identified:

1. Monthly Bioland group meetings (Bioland is the largest organic farmer association in Germany; 90 % of the lentil growers are members)

2. Yearly producer group meeting (the majority of members regularly participate)

3. Informal occasional meetings among employees at the Landratsamt Münsingen (Agricultural Office in the district)

4. Occasional meetings among farmers belonging to a group delivering to the same farmer with drying and separating facilities

5. Occasional meetings among farmers belonging to the same machinery cooperative

6. Alb-Lentil-Pig producer group meetings

The only examples with rather formal network character are the first two in the list. The majority of farmers stressed that particularly the Bioland group meetings are important opportunities to exchange experiences on cultivation practices and to get informations about how the other farmers' cultivation systems work in the respective year. The vast majority of lentil producers are members of Bioland and lentil cultivation was mentioned to be a regular topic. The groups are organised due to the area in the region the farmers belong to. In the case of the Swabian Alb, the region is divided into three areas with one group each, a north-western, north-eastern, and southern area. Farmers meet particularly during the growing season every month at changing locations, mostly at the farm of one of the members. During the visits the farmer explain their farming system and certain topics are discussed.

> *"[...] Thus if you would actually invite all producer group members and all Bioland members, then you probably would have 80 % analogy. [...] So when we had the meetings during last summer, we had in any case...as a rule, the farmer also had lentils and then you have of course a look. It is in your own interest to have a look and then you ask as well how did you do this and how did you do that. So far I actually found it sufficient have an exchange at this level."* (Farmer 4)

> *"Well we also have our regular Bioland meetings. So in the Bioland group Reutlinger Alb [north-western area] there the majority of the producers in the region actually participates, and there we of course exchanges our thoughts and experiences. [...]"* (Farmer 10)

The yearly producer group meeting is the only place or event where almost all lentil producers participate and where they have the opportunity to exchange experiences with lentil growers from other parts of the production area. However, the meeting is mainly used by W. Mammel and L. Mammel in order to communicate changes and novel ideas, as well as to discuss issues and to recruit interested farmers.

> *"Well L. Mammel normally organises the producer group meeting, which you have attended in Dapfen [Village where the meeting has taken place]. There we actually discuss how it was the last year, and who is going to grow what and where. Which lentil, the small or the big one and so on... And then he usually tells us what else he needs, like camelina [as support crop] for instance which was added recently and where he already had some farmers who have grown it, but where he probably needs a bit more now. [...]"* (Farmer 13)

At least four members of the producer group work part time or full time at the districts' Agricultural Department as advisers. One of these farmers, who participated in the interviews and worked there until recently, stated that he exchanged regularly ideas and experiences regarding lentil cultivation with his colleagues at work.

> *"Well my former principal occupation was advisor for plant protection at the Agricultural Office of the district [...] there several of my colleagues have lentils too. And there we have of course exchanged experiences and thoughts. [...]"* (Farmer 5)

As already mentioned in the introduction, the drying and separating is organised around four facilities spread in the region. For organisational reasons farmers are assigned to one of the facilities near by, where they are supposed to deliver their harvest. All farmers belonging to one group have agreed to grow the same lentil variety and certain support crops. It became apparent that these groups represent groups in the group, certain communities of practice with similar concerns and problems. One farmer stated that there where 6 other farmers in his village last year who have grown the same lentil variety as he, with whom he exchanged information regarding cultivation practices and yields. Several farmers stated that they discuss sowing dates and harvest dates with the farmer who operates the drying in their area, and that this farmer also communicates related thoughts and ideas of other farmers in the same group.

> *"[...] Or when I deliver it to Anton [one of the farmers who operates the drying], who I visit from time to time. He is actually always open to discuss certain things and tells how it is at other farms. How it worked there."* (Farmer 10)

Some farmers who share their machinery with other farmers, mentioned they have gained experiences regarding lentil cultivation through their work on farms from group members. On those occasions they discussed related issues with the farmers, like seed bed preparation, seed rates and weed infestation.

> *"Well you have always contact to the farmers nearby. So also through the machinery cooperatives and so on, where you discuss such topics. We also make regularly field-walks at each others farms to have a look how it actually works there."* (Farmer 1)

> *"Well, as far as I know my neighbour was one of the first who has started to cultivate lentils [...] and there was always a connection, so that you have talked about it. And she had no suitable machines, so that she has asked: I need someone who rolls my seed bed and so on. And then I have done that for her and therefore I actually have been involved right from the beginning."* (Farmer 8)

The presented types of networks and places illustrate that the knowledge exchange among the farmers is not particularly organised by W. Mammel, L. Mammel or other actors of the producer group, and happens mostly on the Bioland group meetings, or in informal networks on a rather casual basis. For instance when neighbours or colleagues meet during their daily work and discuss current topics. The only place of exchange organised by the initiator is the yearly producer group meeting, which had been attended in preparation for the interviews. There the main focus lies on the evaluation of the last year and the communication of novelties, changes and issues, and there is not much time for the exchange of experiences and knowledge between farmers. Nevertheless, two farmers had the opportunity to present their ideas and a short discussion evolved. One discussion concerned the experiences of a farmer with the cultivation of camelina sativa as a companion crop to lentils. Another discussion concerned the issue whether inoculation of the fields with rhizobia may has the potential to increase lentil yields or not. The meeting provides also the opportunity for researchers to present their research and to encourage farmers to participate in studies. However, in terms of knowledge exchange, most farmers expressed that the Bioland group meetings are the place where the major exchange of experiences regarding lentil cultivation happens.

4.5 Research question 4. Interaction within the AIS

4.5.1 Supportive interactions and knowledge exchange

The following sections illustrate which actors and organisations constitute the AIS around the producer group and is based on the information provided by interviewees. The focus is on actors and organisations that played a supportive role in the development of organic lentil production on the Swabian Alb, and does not consider actors or organisations that are part of the agricultural sector of the region, but had no influence on the development of the producer group or the lentil production.

The interviews have revealed that interaction between the producer group and actors in the AIS is mainly organised and managed by the initiator W. Mammel and his son L. Mammel. This includes establishing and maintaining contacts to research institutes, non-governmental organisations, food processors, policy makers, the media and other individual actors, while W. Mammel is organising most of the exchange with research institutes, non-governmental organisations and the media and L. Mammel maintains most of the contacts of the demand side. In addition there is a small number of very active group members who offer help and assistance to researchers and students if needed, or who give interviews to the press in case the Mammels have no time. Several of these contacts to actors in the AIS came about through W. Mammels involvement in farmers' associations and networks and initiatives focusing on or-

ganic farming, preservation of agrobiodiversity and GMO-free agriculture. Some contacts are based on long-standing friendships to persons who came later into key positions at organisations in the AIS.

W. Mammel emphasised that particularly research institutes often contacted him and asked for cooperation, and not the other way around. He stated that the interest of actors to cooperate with the producer group increased substantially after the media reported on his discovery of the traditional lentil varieties in the Vavilov Research Institute of Plant Industry in Russia. After the extensive and positive reporting in the media on the topic, several new contacts to actors in the AIS were initiated and several intensive collaborations with research institutes and other organisations started.

The following sections provide an overview of conditions, organisations and actors that supported the development of the farmer-led initiative and organic lentil production on the Swabian Alb. The used structure is based on the AIS framework presented in figure 1 in chapter 2.3.2.

4.5.2 Support structure and demand domain

This section focusses mainly on structural conditions or trends that supported the development of the producer group, but deals also with supportive financial measures like the funding of services or purchase of investment goods.

Access to knowledge and machinery: W. Mammel the initiator stated that it was very difficult in the beginning to get access to literature on lentil cultivation, so he had to try out what works and what not. He stated, however, that it was in the beginning in general difficult to get access to information on organic farming too. He pointed out that it was also difficult to find machines and facilities for lentil processing like separating and cleaning that where suitable and affordable. He mentioned that he finally got used machines for separating and cleaning from nearby farmers that went out of business. He pointed out that the number of farms in the region as declined considerably within the last decades. A trend which is of course apparent in most other regions in the EU too. So, it is assumable that this trend made it easier to access the desired machines. However, he stressed that he and his second son M. Mammel had to rebuild and extend the facilities over the years, in order to improve the quality of the final lentil product.

Federal State Ministry of Rural Areas and Consumer Protection Baden-Württemberg: The Mammels emphasised the importance of the financial support for the professionalisation of the lentil processing via the PLENUM programme, which was established in 2001 by the Federal State Ministry of Rural Areas and Consumer Protection Baden-Württemberg. In 2008 the purchase of several storage and drying facilities as well as an optical table separator for

lentil cleaning was subsidised via the programme with about 60.000 €. The Mammels mentioned that they were not able to purchase theses facilities at this time (the optical table separator alone costed 80.000€) and that it would not have been possible to expand the lentil production without the funding of these machines. Before they got the facilities, their drying and storage facilities had been utilised to the limit and they had to transport the lentils to a grain mill for cleaning 40 kilometres away. They pointed out that this was very time consuming and that the cleaning did not yield the desired quality. The Ministry also financed the early part of the seed multiplication of the two traditional lentil varieties in green houses, which was done in collaboration with the Nürtingen-Geislingen University of Applied Sciences and a nearby nursery. Later in the process of seed multiplication, the Ministry provided an anti-hail net for the first sowing in open land.

It is notable that W. Mammel mentioned that he had visited the ministry several times because of his involvement in a regional initiative for GMO-free agriculture. He stated that he also had personal contact to the former minister and still has contacts to actors in the ministry. In 2014 the current minister visited his farm together with representatives of the press, which was later reported in several regional newspapers.

Consumer demand: All farmers stated that there was always a high demand for the lentils even in the very beginning when the initiative was still unknown in the region. Almost all farmers pointed out that the reason for this high consumer demand is most likely the fact that lentils are a traditional food in the region, and part of the very popular dish "Linsen mit Spätzle", which is lentils with egg pasta. Consumers came mostly from nearby villages and demand increased only by word-of-mouth advertising from consumer to consumer. The initiator also expressed that the demand regularly exceeded supply which encouraged him to grow more lentils and to search for more farmers who could be persuaded to start cultivating lentils. Most of the farmers stated that with increasing popularity, also driven by supportive reports in the media, the demand in the region grew fast in recent years and is expected to continue to grow.

Marketing philosophy: L. Mammel stated that he sells the lentils and the other products in direct selling and exclusively to small retailers and restaurants in Baden-Württemberg. That means he principally does not sell the lentils to supermarket chains or wholesalers, and never sells very large amounts to the food industry. He pointed out that his marketing philosophy is based on two major beliefs. First, the selling to a large number of retailers and restaurants spreads the risk of dependency on single customers. This has also the effect that the single retailer or restaurant has no bargain power, and thus can not cause pressure on the lentil price. This strategy also allows him to set the price at a high level, which makes it in turn possible to buy the lentils from the producer group members at a price that makes it profitable for the len-

til producer to grow the crop. As the second reason L. Mammel stated, that he wants to support small businesses, because he is again the trend that small businesses go out of business and leave the country side due to competitive pressure from supermarket chains.

Lentil varieties and quality: Many farmers mentioned they believe that the taste of the Le Puy lentil was one of the major reasons for the high consumer demand in the beginning. They consider it as a fortunate coincidence that they started to grow the green French Le Puy lentil in the beginning instead of another variety, because some consider it as one of the most tasteful varieties in the world. All farmers who have farm shops or visit markets to sell their products, stated that most of the customers buy the lentils first of all because of its taste, followed by the regionality and the overall quality of the product. In addition, most of the farmers consider the Le Puy lentil as more tasty than the two traditional varieties. The demand for this variety is still unbroken and normally exceeds the demand for both traditional varieties taken together.

Number of farmers and size of area converted to organic: The initiator stated that he wanted the lentils to be organic and he emphasised that he was dependent on the few organic farmers spread in the region. Further, the potential cultivation area on the organic farms was very limited due to the necessary breaks in lentil cultivation on the same field to control diseases. Therefore, he stated that the precondition for an increase in lentil production was an increase in the number of organic farms. However, uncultivated farm land was limited in the region and so there was not much potential for farmers who wanted to start an organic farm from scratch. Therefore, the only opportunity for the initiator to increase the lentil production was an increasing number of conventional farmers situated in the region who were willing to convert to organic farming.

4.5.3 Research domain

Georg-August University Göttingen: W. Mammel stated that he had been in contact for a long time with an expert for organic plant breeding who had already in the 1990s carried out research on lentil cultivars. The expert works at the Section of Genetic Resources and Organic Breeding at the Georg-August University Göttingen. W. Mammel mentioned that this expert had offered his help in the seed multiplication when he heard about the discovery of the two traditional lentil cultivars in Russia. The expert carried out the very first part of the seed multiplication during the winter in green house of his institute. W. Mammel emphasised that this was very helpful to accelerate the multiplication process, because he had received only some hundred seeds from the seed bank.

Nürtingen-Geislingen University of Applied Sciences: The seed multiplication was also the starting point of an extensive cooperation with the Nürtingen-Geislingen University of Applied Sciences. W. Mammel stated that the cooperation was initiated by a friend who is com-

mitted to Slow Food and who is also professor at this University. This professor also initiated contacts to other researchers at the same University over the time. W. Mammel emphasised the important role of the collaboration which yielded very relevant results. Further, he stated that the involved researchers were very committed and that the collaboration was based on mutual respect. Researchers of the University cooperated with the producer group over the years in several ways: (1) in 2009 researchers planned and organised the first sowing of the traditional lentil cultivars in open land on an experimental farm; (2) researchers carried out comprehensive field trails aimed to compare the growth characteristics of the two traditional cultivars with other lentil varieties; (3) a student conducted in collaboration with another research institute a genotype screening of the traditional cultivars aimed at assessing the characteristics and the quality and (4) several students planned and conducted a comprehensive public taste test aimed at assessing the acceptance of the old cultivars.

The Agricultural Technology Center Augustenberg (LTZ): The genotype screening of the traditional lentil cultivars, mentioned in the paragraph above, was carried out in cooperation with **t**he Agricultural Technology Center Augustenberg (LTZ), a research institute belonging to the Federal State Ministry of Rural Areas and Consumer Protection Baden-Württemberg. One researcher of the institute, a specialist for electrophoresis, developed in cooperation with the student mentioned in the paragraph above, especially for the producer group a procedure that allows it to analyse the protein of a lentil cultivar in order to assess whether the cultivar is homogeneous or not. This procedure already existed for most other crops, but M. Mammel stated that no such standard procedure had existed for lentils before. The contact was initiated by an advisor of the regional Office of Agriculture, and was further extended through the collaboration with the Nürtingen-Geislingen University of Applied Sciences. W. Mammel pointed out that he is still in contact with the expert and sends now and then lentil cultivars to him that he got from seed banks, to get them assessed. W. Mammel pointed out that the genotype screening was very helpful in order to assess whether the traditional lentils are homogeneous cultivars and whether they are of high quality in terms of their qualitative characteristics. W. Mammel stated that the results have revealed that the cultivars are of excellent quality and comparable to other commercial varieties. Another section of the same institute has recently launched a project aimed at increasing the cultivation of grain legumes in Baden-Württemberg. W. Mammel stated that he was asked for cooperation and provided extensive information on cultivation practices based on the experiences made by him and the producer group. The outcome of the cooperation is a guide to lentil cultivation for farmers, which is published on the institute web page. W. Mammel mentioned that in addition several group members cooperate with the institute and offer demonstration days where interested farmers can visit their farms and can inform themselves about difficulties and opportunities in lentil cultivation.

University of Hohenheim: In 2008 W. Mammel was contacted by two researchers, a professor and a PhD student from the Institute of General Crop Farming at The University of Hohenheim who stated that they would like to conduct research on lentil cultivation. The researchers asked him about the most urgent challenges he is facing and what practical problems need to be solved. W. Mammel stated that at this time he and the other lentil producers had difficulties to find the optimal seed rates for the companion crops in order to suppress weeds effectively. Another problem was to find the optimal sowing date for the same reason, but also to increase the yields. One of the researchers decided to write her doctoral thesis on it. In the following years the researchers carried out several studies in cooperation with the producer group, on effects of seed rates with different companion crops and different sowing dates on weed infestation. The results of the research were published in form of three papers in international journals (see the publications of Wang et al.). W. Mammel stated that the cooperation comprised extensive exchange of knowledge and that he got in particular access to current international publications on lentil cultivation and breeding. Further, he pointed out, the collaboration helped the producer group to improve the lentil cultivation system and to develop it to its current state.

Agroscope: W. Mammel mentioned that he **s**tays in close collaboration to Agroscope, an **a**gricultural research institute in Switzerland that carries out a project aimed at promoting the increase of lentil cultivation in Swiss agriculture, including field trails with different lentil cultivars. W. Mammel emphasised the close contact and the intense knowledge exchange in both directions with the institute and pointed out that researcher of the institute have visited the producer group several times to get insight into their production system. W. Mammel mentioned that he and some other group members have also visited the institute, where they discussed problems, inspected the field trails and provided advice on practical issues.

Keyserlingk-Institut: According to W. Mammel there is a close cooperation with the Keyserlingk-Institut, which is an association with the focus on research and breeding of locally adapted crop varieties for organic farming, and is situated in the same federal state. The contact to the institute was initiated by L. Mammel who had studied together with on of the contributors of the association. W. Mammel stated that to the best of his knowledge this institute is the only breeder organisation who is currently breeding lentil varieties for organic farming in Germany. The cooperation between the producer group and the association is focussed on improving current varieties and on identifying varieties that are potentially adapted to the conditions of the region. W. Mammel mentioned that the institute carried out field trails with the two traditional cultivars, that confirmed their good growth characteristics.

4.5.4 Intermediary domain

The interviews revealed that the producer group had been in contact, and still is in contact with a multitude of actors who played often an indirect role in supporting regional lentil production by establishing contacts to other actors in the AIS, often resulting in comprehenisve collaborations, or by increasing the popularity of the Alb-Leisa-producer-group. Some of these actors have thereby pushed the demand for lentils produced by Alb-Leisa, and have most likely positively influenced attitudes towards organic lentil production in the region.

Consulting agency Ökonsult: W. Mammel pointed out that he has a good relationship to a person working at the consulting agency Ökonsult in Stuttgart, who plan campaigns and press work for ministries, political parties and amongst others the Bioland association. This person is also an active member of Slow Food and was one of the two persons who identified the traditional lentil cultivars in a Russian seed bank. W. Mammel and one of the lentil growers pointed out that Ökonsult has planned and organised the travel of producer group members to the Vavilov Institute in Russia and invited the press to attend the travel. One producer group member stated that Ökonsult also initiated contacts to the Federal State Ministry of Rural Areas and Consumer Protection Baden-Württemberg which became later the main supporter of the producer group in financial terms.

Slow Food: W. Mammel emphasised the important role of the Slow Food movement for the development of the producer group. He pointed out that his contact to Slow Food and the resulting cooperation was a crucial factor for the current high popularity of the producer group and their products. W. Mammel stated that Slow Food promoted their lentils for instance by adding their traditional lentil varieties to the list "Ark of Taste", a list of endangered heritage foods, or by inviting them to the Slow Food fair, which pushed sales substantially. Several farmers emphasised the important role of the Slow Food movement for the development of the producer group as the following statements illustrate:

> *"And there is of course this gigantic story with St. Petersburg* [where the Vavilov Institute is located]. *You have to recognise that this was perfectly prepared and organised by actors of Slow Food and others to get communicated through the media... well there were just the right people at the right time at work."* (Farmer 16)

> *"*[...] *and of course now it gets really pushed, like in the last years through the Slow Food fairs and so on...there it's getting popularised more and more and that works pretty well."* (Farmer 1)

> *"I've been at the fair* [Slow Food fair] *last year and that was really phenomenal when you have seen how great the interest was... L. Mammel was staying there at the stand and was saying to the traders all day long: no I can't sell so much lentils to you, I haven't enough. ...you won't see something like that again."* (Farmer 8)

The media: Beside the support through Slow Food, several farmers emphasised the crucial role of different media in increasing the popularity of the Alb-Leisa-producer-group. In particular the ongoing reporting about lentil cultivation and the producer group in the press on local, regional and federal sate level, was considered by all farmers as very helpful to increase acceptance for their lentils and to push the demand. Many farmers stated that they believe that the medial attention, which was particularly high in the years after 2006 when the traditional cultivars had been discovered, was also responsible for the high acceptance among farmers in the region towards lentil cultivation. Some farmers also pointed out that two television stations, a regional (SWR) and an international (Arte), produced documentaries about the producer group and lentil cultivation in the region. Some farmers stated that the first documentary, which was produced in 2006 by the regional television station was probably also pushing the demand substantially. One of the interviewees stated that he participated in the production of the documentary that was produced by Arte in 2014, instead of W. Mammel who was originally contacted but had no time. The respondent and other farmers stated that they consider the cooperation with the media as very important, not in order to push the demand which is still higher than the production, but in terms of informing society about the value of regional organic food production. Several farmers pointed out that they consider medial attention also as potentially helpful to get in contact with supportive actors or organisations.

Bioland association: All farmers who want to join the producer group have to be members of one of Germany's organic farmer associations. The farmers stated that the majority of lentil producers belong to the Bioland Association, and with the exception of one, all interviewees were members of Bioland. The farmers highlighted, that today most of the organic farmers in the region are also lentil growers. Thus an organic farmer in the region is very likely at the same time a member of Bioland and the lentil producer group. The majority of them pointed out that they usually participate in the monthly group meetings organised by Bioland, where they also exchange experiences regarding lentil cultivation. That means a conventional farmer who converts to organic farming in the region, will probably get in contact to several lentil growers who may inspire him to start also growing lentils. Several farmers mentioned that this was actually often the case, particularly within the last years. The interviews with producer group members have shown that the Bioland association plays an important role in bringing the lentil growers together on a regularly basis through the Bioland group meetings, and thus provides a platform of knowledge exchange which also creates a feeling of belonging. The fact that most of the lentil producers and most of the organic farmers in the region are members of Bioland has probably helped the producer group to grow relatively fast within the last years. However, it became not clear to what extent actors of the Bioland Association played an active role in promoting organic lentil production in Germany.

Regional Office of Agriculture: W. Mammel and some of the lentil growers emphasised the important role of an advisor for crop production and plant protection at the regional Office of Agriculture in Münsingen. The advisor was described as very committed and it was brought up that he has supported the producer group in several ways. He assisted the producer group in developing the lentil intercropping system and initiated for instance contacts to other actors in the AIS, such as to the specialist for electrophoresis at the Agricultural Technology Center Augustenberg (LTZ), who has been mentioned in the section on the research domain. W. Mammel emphasised that there is continuous exchange between the producer group and the advisor and that he is an important source of knowledge and ideas, particularly when it comes to possible companion crops for the lentils. He pointed out that the advisor carried out field trails for them at his experimental plots, and tested different cultivars of malting barley. The advisor was also the person who had the idea to try a black malting barley cultivar as companion crop to lentils, in order to deliver barley to a nearby brewery which was searching for an alternative way to brew dark beer (usually dark beer is made by malting common malting barley extra dark).

4.5.5 Enterprise domain

This section illustrates the connections and interactions between the producer group or groups of farmers within the producer group, and the demand side, like food processors or food producers, and highlights in particular the novel products which originated from those interactions.

Berg Brewery: Two of the respondents stated that they were searching for a companion crop that could be marketed well and would be more profitable as oat or naked barley. Together with the advisor mentioned in the previous section and a nearby brewery, the Berg Brewery, they had the idea to to grow lentils intercropped with malting barley and started the cultivation several years ago. Today a few more farmers deliver malting barley to the brewery where it is used to brew different types of organic beer. The two lentil growers mentioned that, due to the popularity of the Alb-Leisa lentils, the brewery use the fact that the barley is grown in mixture with the lentils, for advertisement purposes by providing the information on the beer bottles. The farmers pointed out that lentil-malting barley intercropping works well, but that the processing is a bit more challenging when compared to naked barley. The problem is that the husk of the malting barley can not always be entirely separated from the lentil, which can decrease the quality of the final lentil product. This topic was also brought up by L. Mammel, who stated that this cultivation system is a compromise between profitability and quality, and that the potential to extent the production of malting barley is limited. However, the collaboration with brewery is seen as promising and has recently be extended by testing a black naked malting barley as companion crop which may be used for brewing organic dark beer. One

farmer stated that brewing dark beer by using malting barley that is malted extra dark, creates substances that are suspected to be carcinogenic. Thus, the basic idea of brewing dark beer by using black malting barely is, that it would create a beer that is assumed to be more healthy.

Alb-Gold: Another promising collaboration started in 2014 with Alb-Gold a large regional pasta producer that has grown strongly in recent years. L. Mammel stated that he has developed together with that company a new vegan variant of a very popular food from the region. The food is called "Maultaschen" and is a stuffed pasta commonly filled with pork and vegetables. The new variant is filled with lentils from the producer group. The selling will start this year. It is notable that Alb-Gold uses the fact that the lentils for the vegan stuffed pasta come from the Alb-Leisa-producer-group, to advertise their new product on their web page.

Spread producer: L. Mammel stated that he is always searching for possibilities to widen the product range of his company, particularly in terms of new types of food based on lentils. He pointed out that he stays in contact with a small spread producer and together they work on the development of one or more lentil spreads. The idea is that the spread will be produced on behalf of the Alb-Leisa company which will then be sold over the existing marketing channels.

Alb-Leisa-Pig: One farmer mentioned that he has a small organic piggery with traditional pig races, and in 2012 he had together with four other farmers who also keep pigs and together with a nearby butcher, the idea to use the broken lentils, which are a by-product of the processing and can not be sold as food, as fodder for their pigs. Now the pigs are fed with at least 10 % broken lentils, which accounts for about 50 % of the pigs protein ration. The idea was to utilise this by-product in the most reasonable and profitable way, to archive higher prices for their pigs and preserve at the same time traditional pig races. The farmer stated that they created that way a novel food, pork from the Alb-Leisa-Pig, which is sold in nearby butcheries and restaurants.

The new foods, like the vegan stuffed pasta with lentils, meat from the Alb-Leisa-Pig or the dark organic beer made from black malting barely, provide good examples how the collaboration between the producer group and other food producers have stimulated novel ideas and the development of innovative food products in the region.

An overview of the innovation system of organic lentil production on the Swabian Alb is shown in figure 2., which contains actors, organisations and factors that supported the development of the Alb-Leisa-prodcuer-group and the organic lentil production. The arrows in the figure illustrate the interactions between actors in the AIS, as well as the mutual influence of the innovation process and structural conditions, institutional conditions and actors attitudes towards collaboration. The direction and the thickness of the arrows illustrate the direction of

the major influence and demonstrate the importance of the interaction or influence for the development of organic lentil production. Thick circles highlight actors or groups of actors that have been of particular relevance for the development of the innovation.

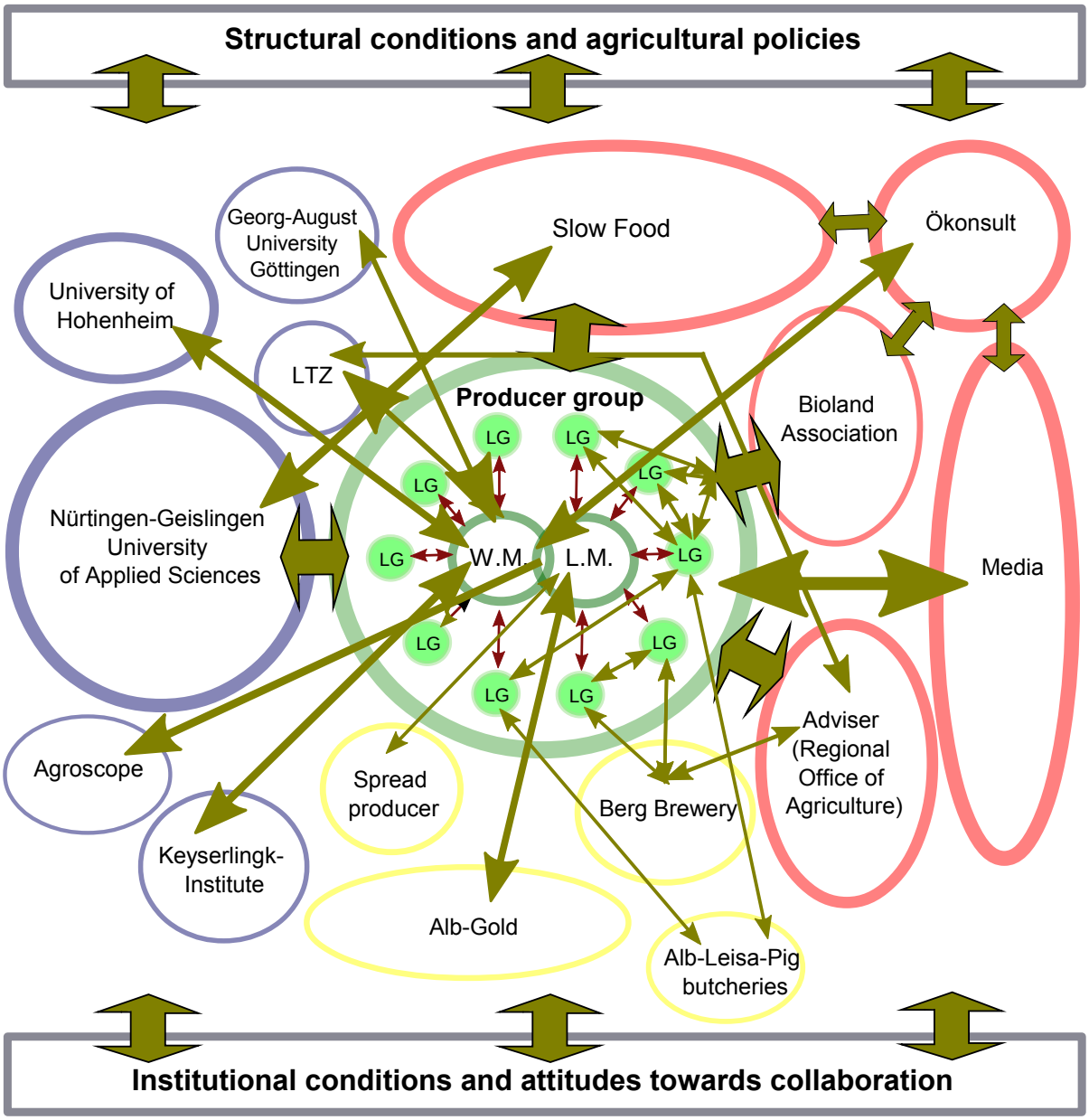

Figure 2: The agricultural innovation system of the Alb-Leisa-producer-group and organic lentil production on the Swabian Alb, with the initiator of the producer group W. Mammel (W.M.) and the company owner L. Mammel (L.M.) at the centre of the producer group of lentil growers (LG). (blue circles: research domain; red circles: intermediary domain; yellow circles: enterprise domain; grey rectangles: supportive structures and conditions). Source: author, adapted from The Word Bank (2006).

5 Discussion

5.1 Research question 1. Farmers' motivation and attitudes towards lentil cultivation

The literature review on challenges and possibilities in grain legume and particular in lentil cultivation, had lead to the assumption that the high perceived risk of potential economic losses could prevent farmers from cultivating lentils. Or that farmers would probably not start lentil growing for financial reasons. This assumption has been confirmed by the results when it comes to the original motivation, where all farmers with the exception of one, stated other reasons than financial incentives. Interestingly the study revealed that curiosity and the desire to try out something new was a strong incentive for farmers to start cultivating lentils, which was stated by almost half of the farmers. Curiosity and the desire to do something that comprises unfamiliar practices or unknown difficulties, presupposes the will to learn about new practices and to find solutions to those difficulties. Further, many farmers stated that they continuously try to improve their cultivation system through experimentation and are always looking for new ideas. Openness to novelty and the willingness to learn were frequently stated in the literature as a prerequisite to innovation (The World Bank 2006; IAASTD, 2009; Klerkx et al., 2012). Thus, it is likely that those farmers' attitudes towards learning and experimentation have enhanced the development of organic lentil production on the Swabian Alb.

The other half of the farmers stated agronomic reasons as their main motivation. Thus, in the perception of these farmers, the benefits provided by lentils in the crop rotation such as nitrogen supply and break crop effects, outweighed the disadvantages. It is notable in this context that most of the farmers have cereal based cropping systems, where the potential benefits provided by legume grains are particularly high, which was emphasised in the literature (Nemecek et al., 2008; Preissel et al., 2015). Thus, the fact that cereals and in particular spelt, are very common and widespread crops in organic farming on the Swabian Alb, had probably a positive influence on the farmers' motivation to start cultivating lentils.

A very interesting outcome of the results is, that almost all farmers stated as on of their main motivation to continue with lentil cultivation, the profitability of the crop. This is in strong contrast to the findings of Bues et al. (2013) and Preissel at al. (2015), who emphasised that the low profitability of grain legumes is the major reason for the decline in grain legume cultivation and the main reason for its current low use. One factor that is likely to increase the profitability of lentil cultivation in the case of Alb-Leisa when compared to examples stated in the literature, is the direct selling of lentils exclusively to small retailers and restaurants by L. Mammels company. As already mentioned in this study, this sales strategy allows it L. Mam-

mel to buy the lentils from the producer group members at a price that makes lentil cultivation profitable for them, despite low and unstable yields. This makes obvious that improving the cultivation system is only one option to improve the profitability of grain legume cultivation, and that developing an appropriate sales strategy may have even a larger impact on profitability and thus attractiveness of lentil cultivation for farmers.

Several farmers emphasised that the image of the lentils and the demand for it are among the major motivating factors for them to grow lentils. This is a quite interesting point, because it shows that the positive public perception of the lentils, and the provided feedback to the farmers has a direct positive influence on their motivation to grow lentils. It indicates very clearly that the positive feedback from customers and a high acceptance for the lentil in the region has probably not only increased sales, but has probably also increased the motivation to start cultivating lentils and to continue with it, despite the challenges it brings.

When it comes to the farmers' attitudes towards financial support for lentil cultivation, almost all farmers made very clear that there is currently no need for financial support. Moreover, the majority of farmers expressed critical views on this topic and emphasised the importance of the slow and "healthy" growth in the past, so that the production never exceeded the demand. Some farmers raised concerns over the possible consequences of state funding for lentil cultivation. Several farmers pointed to the example of the German Renewable Energy Act (EEG), which was aimed at driving the transition of the German energy system towards increased sustainability, by increasing the part of renewable recourse for energy production. Some farmers emphasised that this act lead to an intensification of agriculture in the region, because the EEG supported the cultivation of energy crops via subsidies, and many farmers shifted their production emphasis towards more profitable, but also more input intensive energy crops. It was brought up that this lead to increased rental prices for agricultural land across Germany, which caused increased competition between farmers. It became apparent that many farmers had the fear that subsidies for lentil cultivation could attract to many farmers who would also start to grow lentils, which would lead to increased competition between farmers and in turn to decreasing prices for lentils. This fear is probably not unfounded. Several farmers pointed out that at least two other lentil producer groups and one single producer emerged in recent years in the wider surroundings, and that without the prospect on subsidies. Several farmers mentioned that these producers sell their lentils at a lower price (up to 1 € cheaper for the half kilo package), but also stressed that the quality of other producers is so far lower too. Even though the question regarding farmers' attitudes towards subsidies, was originally asked in order to identify which supportive measures are needed and desired by the lentil farmers, the answers revealed a fundamental dilemma. At the moment, lentil cultivation in the region is only profitable because of the comparatively high price the farmers receive. L. Mammel can buy the lentils at that high price from the farmers, because the customers are also willing to pay a high price for the lentils. However, this may partly be due to the fact that

there is no possibility (or only to a certain extent) to buy cheaper lentils from other lentil producers in the region. Thus, a strategy aimed at promoting lentil cultivation has to take into account how an increase in cultivated area can be achieved while the production remains profitable for growers in the long term. One strategy that is currently pursued by the producer group in order to stay competitive, is the attempt to label the lentils with the protected designation of origin (PDO). This may be also a promising strategy for emerging lentil growing initiatives in other regions of Central Europe, to stay competitive and to achieve prices high enough to motivate farmers to produce lentils in the long term.

5.2 Research question 2. Challenges faced by farmers

The results of this thesis clearly confirm what was stated in the literature on challenges in grain legume cultivation. Almost all farmers mentioned weed infestation as the most challenging problem in lentil cultivation. However, the results have also indicated that the extent of weed infestation is highly dependent of the individual crop rotation, which is strongly influenced by the production emphasis or production focus of the particular farmer. Those farmers whose main focus was on milk cows or suckler cows had fewer problems with weed infestation compared with farmers who had no cows in their farming system. The major explanation for this difference is obviously that those farmers with milk or suckler cows, have more clover grass in their crop rotation (used as fodder for their cows) which is often grown for two or three years in a row. The farmers emphasised that growing clover grass for several years suppresses weed effectively, leaving a weed free field for lentil cultivation. This may lead to the assumption that lentil growing is less challenging on farms with cows, and thus would be better suited for these farming systems. However, the interviews also revealed that farmers who have cows often cultivate a triticale-pea mixture in order to produce protein rich fodder for their cows. The pea in the mixture can increase the risk of soil born diseases for the lentil and vice versa as indicated in the literature. This potential risk is also the reason why the Mammels introduced the rule that there has to be a break of 5-6 years between lentils and other grain legumes in the crop rotation. Thus, the farmers with cows face a dilemma: their crop rotation prevents weeds in lentil effectively which means less work and probably results in higher yields, but if they want to grow more lentils, they have to reduce the cultivation of the triticale-pea mixture, which in turn means they would have to buy more protein fodder for their cows. One farmer with milk cows stated that he tested intercropping of lentil-fava bean in order to producer fodder and lentils on the same field. However, that worked very well in one year and pretty badly in the next year, partly due to very unfavourable weather conditions in the latter case. So he mentioned he will try it again, because he wants to keep the lentil, but he just has to buy to much fodder.

Although most farmers stated they have serious problems with weeds, opinions concerning the applicability of mechanical weed control differed considerably among them. Most of the farmers stated that they try to prepare the seedbed as good as possible in order to prevent weed problems and harrow only if the weed infestation is very high. Some farmers stated that they made good experiences with blind harrowing, while others did not. This may partly be due to the fact that mechanical weed control is certainly a practice that requires skills and experience, which was brought up during the interviews and which may differ from farmer to farmer. However, the major reason for the different opinions is probably something else that was brought up by some farmers. Those stated that in particular on the Swabian Alb local conditions can differ substantially, particular in terms of soil type or temperature, from field to field and from farm to farm, which may determine whether harrowing works properly or not. The different local conditions in the region have also implications on the universal applicability of other measures like sowing dates or seed rates. What works on one farm may lower the yield potential on another farm. It becomes obvious that it had been difficult in the past, and will be difficult in the future to find solutions that work for all farmers. This issue had probably also a strong influence on what farmers considered as challenging and difficult. Thus, a final statement on that issue could be: it depends on the local conditions in the fields. The same is probably true concerning the outcomes of collaborations between the producer group and research institutes on weed control. The interviews did not reveal whether these collaboration have resulted in a universal improvement of practices such as weed control, seed rates, sowing dates or harvest dates. Which is very likely also due to the fact that different farmers made different experiences at different sites with regard to practices recommended by researchers. Apart from the fact that local conditions determine what works and what not, the weather will of course always have a major influence on the results of cultivation methods, particularly in a region where the weather is in general not especially favourable for agriculture. Some farmers mentioned that the weather was quite variable in recent years, which made it difficult to assess which cultivation practices worked best. The discussion above makes clear that several variables have an influence on what problems may occur and as how challenging they are perceived by farmers.

Problems that where also frequently mentioned concerned the challenge to find appropriate sowing dates and harvesting dates. Several farmers brought up that they are continuously experimenting with early or late sowing dates which can have a major effect on weed infestation, and that they made good and bad experiences with both. Again, several farmers stated that in particular the weather often had a strong influence on the outcome and it was sometimes difficult to assess whether the attempt to try an early sowing date would have worked well if the weather would not have been so unfavourable, or if it just did not work because of other factors.

5.3 Research question 3. Access to knowledge and knowledge exchange within the producer group

The results clearly indicated that there was in general almost no information on lentil cultivation available when W. Mammel started growing lentils in the 1980s, and in particular not on lentil cultivation in temperate climate. Lentil cultivation had disappeared decades ago, and agricultural research had focussed on other, more productive crops as has been stressed in the literature (Gruber et al., 2012). Thus, the early lentil cultivation system of the producer group was almost entirely based on the experiences gained by W. Mammel and his son M. Mammel. In view of the challenges and problems discussed in the previous sections, it becomes obvious that the limited knowledge available, has very likely hindered the development of organic lentil production in the region. The literature emphasised the importance of appropriate knowledge for innovation in agriculture, that must be available and accessible for farmers in order to support their ability to innovate (IAASTD, 2009; Knickel et al., 2009). This was clearly lacking, which was in all probability the reason why it took W. Mammel and his son 15 years to develop a functioning cultivation system. The lack of information on lentil cultivation in Central Europe, however, is still present, which was also expressed in the literature (Gruber et al., 2012).

When it comes to knowledge generation and exchange, this study revealed that the decision to found a producer group was probably crucial for the learning about promising practices and methods, and thus for the development of the lentil production. The possibilities to experiment had been very limited as long as the Mammels had only their own farm for experimentation. When other farmers started the cultivation of lentils on their farms, the cultivation area increased substantially, and as a result the potential experimentation area increased too. Several farmers stressed that they have seen the recommendations provided by W. Mammel not as practices set in stone, but rather as the starting point for experimentation and improvement of the cultivation system. This means, from the date on when the producer group had been founded, it was possible to evaluate every year the attempts, experiments and practices of several other farmers too. Several of the early members stressed that in the first years, W. Mammel visited their lentil fields regularly, discussed problems with them and was present at every harvest. Thus, not only the potential experimentation area increased with every new member, also the number of individual perspectives on problems and solutions increased, which very likely enhanced the generation of knew knowledge on organic lentil production in the region.

As illustrated in the results, several places of knowledge exchange have been identified. Even though some of these places concern only a small number of farmers and are based on occasional meetings, it is assumed that they contributed to the flow of information within the producer group, and thus probably enhanced learning about promising practices or methods applied by other lentil growers. This is particularly conceivable, in the case where several net-

works overlap. One place of knowledge exchange that is considered to be especially important, are the monthly Bioland meetings in the respective region. The fact that the majority or organic farmers in the region are members of Bioland and the fact that most of the organic farmers in the region grow lentils, makes the Bioland meetings to a sort of lentil producer meetings. Even though several farmers stated that those meetings always focus on a certain topic, it was expressed that talks on lentil cultivation are common. Considering that the meetings take place every month, they are probably the most frequent occasion where several lentil farmers meet and exchange experiences. Thus, the Bioland meetings have probably played a supportive role in the development of the organic lentil cultivation in the region. This assumption is supported by the literature which emphasised the important role of farmer associations in facilitating interaction among farmers, enhancing learning and in supporting the development of agricultural innovations (The World Bank, 2006).

5.4 Research question 4. Institutions, actors and roles

The literature on agricultural development and innovation systems clearly pointed out that the lack of openness, trust and mutual respect as well as the presence of top-down cultures can prevent collaboration between actors in the food sector and thus can hinder innovation processes. The attitudes and practices of actors are influenced by institutional settings and policies, which can be major obstacles to innovation. Therefore, institutional changes are mentioned in the literature as an important prerequisite for innovation. One institutional change that has very likely enabled the collaboration between the producer group and researchers, is the foundation of scientific institutes focussed on organic farming in Germany. It is assumable that the absence of these institutes would have meant less collaborations between the producer group and researchers. The increasing interest among researchers in the topic of organic lentil production is certainly driven by the increasing demand for organic products in Germany, and the increasing economic relevance of the sector. The increasing interest in organic farming has presumably lead to institutional changes, like the foundation of relevant institutes, which has in all probability also influenced the attitudes of involved researchers towards low input farming systems, and positively influenced the willingness to do research in the topic of organic grain legume cultivation.

Another important institutional change that certainly affected the willingness to support the producer group and which has probably influenced the attitudes of a wide set of actors in the agri-food sector of the region, is an agricultural policy that is shifting the focus from quantity towards quality and which is increasingly promoting the importance of organic farming for the environment and the development of rural areas. The "Aktionsplan Bio" (action plan organic) illustrates that shift very clearly, which is aimed at increasing the area farmed organically and promotes the purchase of organic and regionally produced food. The establishment of

the PLENUM programme for nature conservation and rural development in Baden-Württemberg is another clear indicator for this institutional change. The presence of these policies has certainly positively influenced the attitudes of local and regional authorities and researchers of public and private institutes, towards collaboration with the Alb-Leisa-producer-group.

The results of this thesis revealed a comprehensive network of actors and collaborations that played in all probability a crucial role in the development of organic lentil cultivation in the region. The majority of these collaborations came about personal contacts between W. Mammel and a wide set of actors that often fulfilled more than one role in supporting the development of organic lentil production in the region. Establishing and maintaining contacts to a diverse set of actors certainly needs communication skills and commitment. In this context it is notable that several farmers emphasised the engaging personality and the exceptional communication skills of W. Mammel, and pointed out that the producer group would not be as popular as it is without his commitment. Several of the actors that stay in contact with W. Mammel, initiated contacts with other actors which lead in some cases to comprehensive collaborations. One example is the contact with an active member of Slow Food Germany who is also professor at the Nürtingen-Geislingen University of Applied Sciences, and who initiated contacts to other research institutes of the same university. These new established contacts lead to comprehensive research collaborations between the producer group and several researchers and students. These collaborations included the multiplication of lentil seeds, different field trails, a genotype screening and a public taste test. Another active member of Slow Food Germany who works at a consulting agency, not only discovered the traditional lentil varieties in the seed bank of the Vavilov Institute, but also organised the travel to the institute, invited representatives of the press to join the travel, and initiated contacts to actors at the Federal State Ministry of Rural Areas and Consumer Protection Baden-Württemberg, who later subsidised the seed multiplication of the traditional lentil cultivars. These contacts and the resulting collaborations, not only helped the producer group to include the two traditional lentil varieties into their assortment, it also helped to increase the awareness of the producer group and their products. This makes obvious how important contacts to well connected actors can be for the development of agricultural initiatives, which is something that is indeed supported by the literature. Tisenkopfs *et al.* (2015) emphasised for instance the importance of committed actors for innovation processes, who have the ability to facilitate interaction between different actors and domains in the AIS. Thus, not only contacts to many actors are important for the development of an innovation, but in particular contacts to the "right actors" are crucial for a successful development.

When it comes to collaboration between researchers and the producer group, one striking finding of this study is that in most of the cases researchers actually focussed on finding solutions to challenges and practical problems faced by the farmers. The two researchers of the University of Hohenheim for instance, visited W. Mammel and asked what problems the lentil

growers face and what kind of support they need. This practice clearly demonstrated goals consistent with those of the lentil growers and illustrated openness towards farmers perspectives. One of the most striking findings of this study concerns the knowledge exchange between the producer group and other actors of the AIS. The results revealed that there was not only a flow of knowledge from research institutes towards the producer group, but there was also a comprehensive flow of knowledge towards public research institutes like the LTZ-Augustenberg or Agroscope, and towards private institutes like the Keyserlink-Institut. In particular researchers from the LTZ and Agroscope have explicit asked the producer group for their support in designing lentil cultivation systems or in creating a guide to lentil growing for farmers in Germany. It became apparent during this study, that the experiences and the knowledge hold by the members of the Alb-Leisa-producer-group was very appreciated by actors in the AIS with diverse backgrounds, which is according to the literature often not case. In the case of Alb-Leisa the lentil growers are obviously viewed as the experts when it comes to organic lentil cultivation, and the knowledge they provide is considered as valuable enough to inform official research programmes. Thus, a top-down culture or a hierarchy between researchers and farmers was clearly absent. On the contrary, the collaborations were obviously based on mutual appreciation of competencies and knowledge, and demonstrated openness towards others views and perspectives.

6 Reflections on the methodology used in the study

When reflecting on the outcome of the study and the questions used in the interview guides, some shortcomings of the study become apparent. Some answers from the interviews, such as answers concerning the farmers' perspective on strengths, weaknesses, opportunities and threats, have not been analysed partly due to time constraints and partly due to the belief that they would not be relevant for the purpose of the study. Analysing these answers would probably have yielded valuable insights regarding the farmers views and opinions on increasing competition with other lentil growers that are likely to appear in the future. Knowledge on that subject would enable researchers and implementers, who are engaged in designing policies and projects aimed at stimulating or fostering organic lentil production, to take in consideration fears of lentil growers and conflicts that are likely to occur in future. Further, answers related to strengths and weaknesses of the producer group would probably have yielded helpful insights regarding characteristics of the producer group that may have been crucial for the development of organic lentil production on the Swabian Alb. Knowledge on that topic could help researchers to assess whether organic lentil production organised in producer groups may have in general advantages compared with other production systems or not.

When it comes to the research question focussing on what motivates farmers to grow lentils, it would have been interesting to explore whether organic farmers have in general different attitudes towards novel crops or practices than conventional farmers or not. Knowledge on this aspect could have helped to assess whether the curiosity, the openness towards novelty and the willingness to experiment, is a special characteristic of the lentil growers of Alb-Leisa, or if other organic or conventional farmers would have had comparable attitudes under similar conditions. To generate this knowledge would have required a literature review on that topic in the introduction.

Although, including the topics mentioned above in the study would probably have yielded helpful insights, it also would have made the research even more complex, covering even more topics. This consideration leads to another weakness of this study. During the analysis of the interviews it became apparent that there would not be sufficient time to explore all topics originally planned. Thus it had to be decided on which of the topics may be the most relevant to generate the desired knowledge. When reflecting on the number of topics included in this thesis, it may have been more reasonable and more effective to decide on less topics and to analyse those in more detail.

The way how the AIS concept has been applied in this study, has revealed an extensive system of actors and factors that in all probability enhanced the development of organic lentil production on the Swabian Alb. However, working with the concept and reflecting on the outcome of the study has also given rise to many issues and questions. One issue concerns the question, whether one of the domains of the AIS was more important for the development of organic lentil production than another. In order to inform policies and projects aimed at stimulating and enhancing agricultural innovation, it would be helpful if the domain could be identified, where the facilitation of collaborations would have the greatest effect on the development of the innovation. However, it may be possible to assess which actors of the respective domain have been more important than others, but it is difficult to assess which domain has probably been more influential in supporting the innovation than another. This may be due to the fact that the AIS concept takes a systemic perspective on agricultural innovation and thus presumes that the function of the system (enhancing innovation) is in general influenced by actors from all domains. Further, it is conceivable that the influence of a certain domain on the innovation process varies depending on the particular development phase of the innovation. Thus, an approach that takes in consideration the differences in the particular phases of the development of an innovation, may be more appropriate to provide the necessary knowledge to assesses which measures are needed and when they are needed the most to support the innovation. Be that as it may, applying the AIS concept in this way would also require a retrospective analysis of the different phases and the roles of actors in supporting the innovation, which may be in particular a problem when the initial phase is long time ago.

7 Conclusion

The changing institutional conditions in Baden-Württemberg and beyond, have very likely positively influenced the attitudes of food producers and processors, officials, the media and customers, towards organic farming and alternative cultivation practices. These changing attitudes were in all probability a prerequisite for the development of an innovative lentil production system, which is obviously adopted to local conditions and needs. This study clearly demonstrated that local intervention, like the financial support for the purchase of investment goods, can effectively support the development of lentil grower initiatives in the long term. The important difference between locality specific intervention and area-wide measures of intervention like the single are payment schemes of the EU, is that the former measure allows it to develop a comprehensive, region specific production and marketing system while the latter ignores context specific conditions, which could lead to unintended developments. This was also strongly emphasised by several farmers who stated that it needs a "healthy growth with the demand" in order to be sustainable in the long term. Although, this study revealed some factors and conditions that enhanced the development of the Alb-Leisa-producer-group and the organic lentil production on the Swabian Alb, it does not necessarily mean that the same factors would lead to the same outcome in other regions.

However, the growth of the producer group and the increasing level of awareness has very likely enhanced the development of other initiatives of lentil production in the region. As mentioned before, within the last few years at least two other lentil producer groups have been established in the wider surroundings of the producer group, which was in all probability stimulated and enhanced through the knowledge and structures developed by the Alb-Leisa-producer-group, and which was presumably driven by an increasing awareness of lentil cultivation in the region.

The outcome of this study shows that local intervention that is focussed on the actual needs of lentil producers, supported by enabling policies and committed actors, has the potential to increase lentil cultivation beyond the local level. Further, this study provided insights, into a for Central Europe exceptional situation, of organic lentil production and generated understanding of a system of actors and collaborations that demonstrated the ability to enhance an agricultural innovation. Finally, this study provided findings that demonstrate a great potential for organic lentil production in Central Europe, and may inform projects aimed at stimulating initiatives comparable with the Alb-Leisa-producer-group on the Swabian Alb.

8 Recommendations for further research

- In order to support the development of the lentil cultivation system of the producer group, research could focus on improving the experimentation of the lentil growers. As mentioned in the discussion, the diverse local conditions make it difficult for the farmers to assess which cultivation practices are appropriate for the particular location. One first step could be to identify and map farms or fields with similar conditions. This map could then be used as basis for structured field trails where the same methods are tested on similar fields. Further, a structured design for the monitoring of the experiments and for the evaluation of the results could be designed, which could enhance the assessment of practices.

- The outcome of this study could also be used as a pre-study to extend the research on the AIS of the Alb-Leisa producer group. The study could explore the perspectives and attitudes of the identified actors in order to complete the understanding of the development of organic lentil production on the Swabian Alb.

- The outcome of this study illustrates how important collaborations between farmers, local authorities, associations, food producers and researchers are, in order to support innovations towards more sustainable agriculture. Therefore, greater emphasis needs be put on establishing links between these actors. One way to achieves this, may be to increase the support for interdisciplinary and collaborative research projects, focussed on stimulating organic grain legume cultivation in Europe. These projects could also include measures focussed on establishing links between already known farmer initiatives and other research projects related to the topic, in order to enhance the learning about already available solutions to the various challenges in organic grain legume cultivation.

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References

Ackoff, R.L. (1971). Towards a System of Systems Concepts. *Management Science,* 17(11), pp. 661-671.

Bedoussac, L., Journet, E.-P., Hauggaard-Nielsen, H., Naudin, C., Corre-Hellou, G., Jensen, E.S., Prieur, L. & Justes, E. (2015). Ecological principles underlying the increase of productivity achieved by cereal-grain legume intercrops in organic farming. A review. *Agronomy for Sustainable Development,* 35(3), pp. 911-935.

Bernard, H.R. (2006). *Research methods in anthropology: qualitative and quantitative approaches*. Walnut Creek, CA: Altamira Press.

Bryman, A. (2012). *Social research methods.* New York: Oxford University Press.

Bues, A., Preißel, S., Reckling, M., Zander, P., Kuhlman, T., Topp, K., Watson, C., L., K., S., F. L., & and Murphy-Bokern, D. (2013). *The Environmental Role of Protein Crops in the New Common Agricultural Policy.* Brussels, Belgium: European Union. Available from: http://www.europarl.europa.eu/RegData/etudes/etudes/join/2013/495856/IPOL-AGRI_ET%282013%29495856_EN.pdf [11 July 2015].

Cernay, C., Ben-Ari, T., Pelzer, E., Meynard, J.-M. & Makowski, D. (2015). Estimating variability in grain legume yields across Europe and the Americas. *Scientific Reports,* 5, p. 11171.

Chen, W., Basandrai, A.K., Basandrai, D., Banniza, S., Bayaa, B., Buchwaldt, L., Davidson, J., Larsen, R., Rubiales, D. & Taylor, P.W. (2009). 17 Diseases and their Management. *The Lentil: Botany, Production and Uses*, p. 262.

Creswell, J.W. (2007). *Qualitative inquiry and research design: choosing among five approaches*. Thousand Oaks, CA: Sage Publications.

Crews, T.E. & Peoples, M.B. (2004). Legume versus fertilizer sources of nitrogen: ecological tradeoffs and human needs. *Agriculture, Ecosystems & Environment,* 102(3), pp. 279-297.

Darnhofer, I., Gibbon, D. & Dedieu, B. (2012). Farming systems research: an approach to inquiry. In: *Farming Systems Research into the 21st Century: The New Dynamic*. Dodrecht: Springer, pp. 3-31.

Davis, M.B. (2007). *Doing a successful research project: using qualitative or quantitative methods*. New York: Palgrave Mcmillan.

Dodgson, M. & Gann, D. (2010). *Innovation : A Very Short Introduction*. Oxford, GBR: Oxford University Press. Available from: http://site.ebrary.com/lib/slub/docDetail.action?docID=10464186. [accessed: 22 June 2015]

Edquist, C. & Hommen, L. (1999). Systems of innovation: theory and policy for the demand side1. *Technology in Society,* 21(1), pp. 63-79.

Elzen, B., Barbier, M., Cerf, M. & Grin, J. (2012). Stimulating transitions towards sustainable farming systems. In: *Farming Systems Research into the 21st century: The new dynamic* Springer, pp. 431-455.

Erskine, W. (2009). *The lentil: botany, production and uses.* Wallingford, Oxon, GBR: CABI Publishing.

Fagerberg, J. (2004). Innovation: a guide to the literature. In: *Oxford Handbook of Innovation*. Oxford: Oxford University Press.

FAOSTAT. (2012a). *Compare data: Production crops*. http://faostat3.fao.org/compare/E [accessed: 5 August 2015].

FAOSTAT. (2012b). *Crops and livestock products*. http://faostat3.fao.org/browse/T/TP/E [accessed: 5 August 2015].

FAOSTAT. (2013). *Crops*. http://faostat3.fao.org/browse/Q/QC/E [accessed: 5 August 20115].

Fernandez, A.L., Sheaffer, C.C., Wyse, D.L. & Michaels, T.E. (2012). Yield and Weed Abundance in Early- and Late-Sown Field Pea and Lentil. *Agronomy Journal,* 104(4), pp. 1056-1064.

Freeman, C. (1995). The 'National System of Innovation'in historical perspective. *Cambridge Journal of economics,* 19(1), pp. 5-24.

Gaba, S., Lescourret, F., Boudsocq, S., Enjalbert, J., Hinsinger, P., Journet, E.P., Navas, M.L., Wery, J., Louarn, G., Malezieux, E., Pelzer, E., Prudent, M. & Ozier-Lafontaine, H. (2015). Multiple cropping systems as drivers for providing multiple ecosystem services: from concepts to design. *Agronomy for Sustainable Development,* 35(2), pp. 607-623.

Godfray, H.C.J., Beddington, J.R., Crute, I.R., Haddad, L., Lawrence, D., Muir, J.F., Pretty, J., Robinson, S., Thomas, S.M. & Toulmin, C. (2010). Food Security: The Challenge of Feeding 9 Billion People. *Science,* 327(5967), pp. 812-818.

Gruber, S., Wahl, E., Zikeli, S. & Claupein, W. (2012). Perspektiven und Grenzen der Unkrautregulierungbei Linsen (Lens culinaris) im Okologischen Landbau. Perspectives and limitations of weed control in organic lentils (Lens culinaris). *Journal fur Kulturpflanzen,* 64(10), pp. 365-377. [German].

Hauggaard-Nielsen, H., Gooding, M., Ambus, P., Corre-Hellou, G., Crozat, Y., Dahlmann, C., Dibet, A., von Fragstein, P., Pristeri, A., Monti, M. & Jensen, E.S. (2009). Pea-barley intercropping and short-term subsequent crop effects across European organic cropping conditions. *Nutrient Cycling in Agroecosystems,* 85(2), pp. 141-155.

Hermans, F., Klerkx, L. & Roep, D. (2015). Structural conditions for collaboration and learning in innovation networks: using an innovation system performance lens to analyse Agricultural Knowledge Systems. *Journal of Agricultural Education and Extension,* 21(1), pp. 35-54.

Horneburg, B. (2000). *On-farm development of German landraces of lentil (Lens culinaris Medik.): an example of a strategy*. (ECP/GR In situ and on-farm conservation network. Report of a task force on wild species conservation in genetic reserves and a task force on on-farm conservation and management, Isola Polvese, Italy, 18-20 May, 2000. Rome, Italy: International Plant Genetic Resources Institute (IPGRI). https://books.google.se/books?hl=en&lr=&id=z-oqvKOlIL0C&oi=fnd&pg=PA49&dq=On-farm+development+of+German+landraces+of+lentil+(+Lens+culinaris+Medik.):+an+example+of+a+strategy&ots=XSA_vF2Dx-&sig=9AhLiRyRhHMQskVP-cEU3SLbIKKo&redir_esc=y#v=onepage&q=On-farm development of German landraces of lentil (Lens culinaris Medik.): an example of a strategy&f=false [accessed: 22 June 2015]

Horneburg, B. & Becker, H.C. (2008). Crop adaptation in on-farm management by natural and conscious selection: a case study with lentil. *Crop Science,* 48(1), pp. 203-212.

IAASTD. (2009). *International assessment of agricultural knowledge, science and technology for development (IAASTD): global report*. Washington, DC. http://apps.unep.org/publications/pmtdocuments/Agriculture_at_a_Crossroads_Global_Report.pdf [accessed: 20 August 2015]

ifls - Institut für Ländliche Strukturforschung. (2013). *Abschlussbericht des PLENUM-Programms im Projektgebiet Schwäbische Alb*. Frankfurt am Main: ifls. http://www.lubw.baden-wuerttemberg.de/servlet/is/238529/Abschlussevaluation_RT_2013_07_05_final.pdf [accessed: 10 April 2015] [German].

Jensen, E.S., Peoples, M.B., Boddey, R.M., Gresshoff, P.M., Hauggaard-Nielsen, H., Alves, B.J.R. & Morrison, M.J. (2012). Legumes for mitigation of climate change and the provision of feedstock for biofuels and biorefineries. A review. *Agronomy for Sustainable Development,* 32(2), pp. 329-364.

Klerkx, L., Aarts, N. & Leeuwis, C. (2010). Adaptive management in agricultural innovation systems: The interactions between innovation networks and their environment. *Agricultural Systems,* 103(6), pp. 390-400.

Klerkx, L., Van Mierlo, B. & Leeuwis, C. (2012). Evolution of systems approaches to agricultural innovation: concepts, analysis and interventions. In: *Farming Systems Research into the 21st century: The new dynamic* Springer, pp. 457-483.

Kline, S.J. & Rosenberg, N. (1986). An overview of innovation. *The positive sum strategy: Harnessing technology for economic growth,* 14, p. 640.

Knickel, K., Brunori, G., Rand, S. & Proost, J. (2009). Towards a better conceptual framework for innovation processes in agriculture and rural development: from linear models to systemic approaches. *Journal of Agricultural Education and Extension,* 15(2), pp. 131-146.

Knott, C. & Halila, H. (1988). Weeds in food legumes: problems, effects and control. In: *World crops: Cool season food legumes* Springer, pp. 535-548. Available from: https://books.google.se/books?hl=en&lr=&id=uHLvCAAAQBAJ&oi=fnd&pg=PR12&dq=+Integrated+control+of+diseases+of+cool+season+legumes.&ots=cpHCeYUhVj&sig=wlB04j-bU2nkxqb-wIaMle4Bjj-o&redir_esc=y#v=onepage&q=Integrated%20control%20of%20diseases%20of%20cool%20season%20legumes.&f=false [accessed: 10 August 2015].

Kumar, S., Barpete, S., Kumar, J., Gupta, P. & Sarker, A. (2013). Global lentil production: constraints and strategies. *SATSA Mukhaptra Annual Technical Issue,* 17, pp. 1-13.

Kvale, S. & Brinkmann, S. (2009). *Interviews: Learning the craft of qualitative research interviewing*. Los Angeles: Sage Publications.

Lamprinopoulou, C., Renwick, A., Klerkx, L., Hermans, F. & Roep, D. (2014). Application of an integrated systemic framework for analysing agricultural innovation systems and informing innovation policies: Comparing the Dutch and Scottish agrifood sectors. *Agricultural Systems,* 129, pp. 40-54.

Lauteracher Alb-Feld-Früchte. (2014). *Unsere Entwicklung*. http://lauteracher.de/unternehmen/alb-leisa-entwicklung.html [accessed: 20 March 2015] [German].

LEL - Landesanstalt für Entwicklung der Landwirtschaft und der ländlichen Räume Swäbisch Gmünd. (2013). *Daten zur Agrarstruktur im Regierungsbezirk Tübingen*. http://www.lel-bw.de/pb/,Lde/Startseite/Unsere+Themen/RP+Tuebingen [accessed: 2 August 2015] [German].

Lundvall, B.-Å. (2010). *National Systems of Innovation : Toward a Theory of Innovation and Interactive Learning*. London, GBR: Anthem Press. Available from: http://site.ebrary.com/lib/slub/docDetail.action?docID=10481536. [accessed: 12 June 2015]

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

Mammel, W. & Stephan, T. (2013). *Alb-Leisa: Linsen von der Schwäbischen Alb*. Radolfzell: Öko-EZG Alb-Leisa. [German]

Marlow, H.J., Hayes, W.K., Soret, S., Carter, R.L., Schwab, E.R. & Sabate, J. (2009). Diet and the environment: does what you eat matter? *American Journal of Clinical Nutrition,* 89(5), pp. S1699-S1703.

Mars, M.M., Hoskinson, S. & Libecap, G.D. (2013). A cross-disciplinary primer on the meaning and principles of innovation. Bingley, U.K.: Bingley, U.K.: Emerald.

Materne, M. & Siddique, K. (2009). 5 Agroecology and Crop Adaptation. *The Lentil: Botany, Production and Uses*, p. 47.

Midgley, G. (2000). *Systemic intervention: philosophy, methodology and practice*. New York: Kluwer Academic.

Millennium Ecosystem Assessment. (2005). *Ecosystems and Human Well-being: Synthesis*. Washington, DC: Island Press. Available from: http://www.millenniumassessment.org/documents/document.356.aspx.pdf [accessed: 12 April 2015].

MLRVBW - Ministerium für Ländlichen Raum und Verbraucherschutz Baden-Württemberg. (2014). *Aktionsplan Bio*. http://mlr.baden-wuerttemberg.de/de/unsere-themen/landwirtschaft/oekolandbau-ausbauen/aktionsplan-bio/ [accessed: 4 April 2015] [German].

MUKEBW - Ministerium für Umwelt Klima Energiewirtschaft Baden-Württmeberg. (2004). *Bodenlandschaften: Schwäbische Alb*. http://www.themenpark-umwelt.baden-wuerttemberg.de/servlet/is/12581/?path=4422;6114; [accessed: 26 June 2015] [German].

MUKEBW - Ministerium für Umwelt Klima Energiewirtschaft Baden-Württmeberg. (2010). *Schwäbische Alb: Klima*. http://www.themenpark-umwelt.baden-wuerttemberg.de/servlet/is/12581/?path=4422;6114;&part=14081&partId=6 [accessed: 26 June 2015] [German].

Moschitz, H. & Home, R. (2014). The challenges of innovation for sustainable agriculture and rural development: Integrating local actions into European policies with the Reflective Learning Methodology. *Action Research,* 12(4), pp. 392-409.

Muehlbauer, F.J., Kaiser, W.J., Clement, S.L. & Summerfield, R.J. (1995). Production and Breeding of Lentil. In: Donald, L.S. (ed. *Advances in Agronomy*Volume 54) Academic Press, pp. 283-332. Available from: http://www.sciencedirect.com/science/article/pii/S0065211308609025. [accessed: 17 May 2015]

Nemecek, T., von Richthofen, J.-S., Dubois, G., Casta, P., Charles, R. & Pahl, H. (2008). Environmental impacts of introducing grain legumes into European crop rotations. *European Journal of Agronomy,* 28(3), pp. 380-393.

Nleya, T., Vandenberg, A. & Walley, F.L. (2004). LENTIL | Agronomy. In: Wrigley, C. (ed. *Encyclopedia of Grain Science*. Oxford: Elsevier, pp. 150-157. Available from: http://www.sciencedirect.com/science/article/pii/B0127654909000793. [accessed: 20 March 2015]

Norgaard, R.B. & Sikor, T.O. (1995). The methodology and practice of agroecology. *Agroecology, the Science of Sustainable Agriculture*, pp. 53-62.

Pimentel, D. & Pimentel, M. (2003). Sustainability of meat-based and plant-based diets and the environment. *American Journal of Clinical Nutrition,* 78(3), pp. 660S-663S.

Preissel, S., Reckling, M., Schläfke, N. & Zander, P. (2015). Magnitude and farm-economic value of grain legume pre-crop benefits in Europe: A review. *Field Crops Research,* 175, pp. 64-79.

Pretty, J.N. (1995). Participatory learning for sustainable agriculture. *World Development,* 23(8), pp. 1247-1263.

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.

Röling, N. (2009). Pathways for impact: scientists' different perspectives on agricultural innovation. *International Journal of Agricultural Sustainability,* 7(2), pp. 83-94.

Saxena, M.C. (2009). Plant morphology, anatomy, and growth habit. *The lentil: Botany, production and uses. CABI, Oxfordshire, UK*, pp. 34-46.

SLBW - Statistisches Landesamt Baden-Württemberg (2014). *Landwirtschaft un Umwelt in Baden-Württemberg: Reihe Statistische Analysen*. https://www.statistik-bw.de/Veroeffentl/803314103.pdf [accessed: 2 June 2015] [German].

Slow Food Deutschland. (2012) *Alblinse*. https://www.slowfood.de/biodiversitaet/presidi/alblinse/ [accessed: 20 March 2015] [German].

Taylor, G.R. (2005). *Integrating quantitative and qualitative methods in research*: University press of America.

The World Bank (2006). *Enhancing Agricultural Innovation: How to go Beyond the Strengthening of Research Systems*: The World Bank Washington, DC, USA.

Tisenkopfs, T., Kunda, I., Sumane, S., Brunori, G., Klerkx, L. & Moschitz, H. (2015). Learning and innovation in agriculture and rural development: the use of the concepts of boundary work and boundary objects. *Journal of Agricultural Education and Extension,* 21(1), pp. 13-33.

Voisin, A.S., Gueguen, J., Huyghe, C., Jeuffroy, M.H., Magrini, M.B., Meynard, J.M., Mougel, C., Pellerin, S. & Pelzer, E. (2014). Legumes for feed, food, biomaterials and bioenergy in Europe: a review. *Agronomy for Sustainable Development,* 34(2), pp. 361-380.

Wang, L., Gruber, S., Claupein, W. (2012). Optimizing lentil-based mixed cropping with different companion crops and plant densities in terms of crop yield and weed control. *Organic Agriculture,* 2(2), pp. 79-87.

Wang, L., Gruber, S., Claupein, W. (2013). Effect of sowing date and variety on yield and weed populations in a lentil-barley mixture. *Journal of Agricultural Science,* 151(5), pp. 672-681.

Yenish, J.P., Brand, J., Pala, M. & Haddad, A. (2009). 20 Weed Management. *The Lentil: Botany, Production and Uses*, p. 326.

Appendix

The following pages contain the translated (the originals are in German) final versions of interview guides for the 14 lentil growers, W. Mammel and L. Mammel. Some of the questions in the interview guides were not included in the analysis as it became apparent that their analysis would ultimately not yield results relevant for the purpose of the study.

Interview guide - Farmers

Name: Address: Farmer number:

Lentil cultivation since:

Business type (primary / sideline):

Area of crop land (ha):

Lentil area (ha):

Production emphasis (in terms of revenues):

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1. What was your motivation to start growing lentils?
2. What was your motivation to continue growing of lentils?
3. What challenges did you face when you started cultivating lentils?
4. Where did you get the knowledge on lentil growing from?
5. Do you exchange your experiences on lentil cultivation with other growers? If yes how and where?
6. Do you have regular contact to an agricultural advisor or other actors that provide knowledge and advice?

7. As how difficult or laborious would you describe lentil cultivation compared to other crops?

8. What factors or conditions would you say have supported the development of lentil production on the Swabian Alb?

9. What factors hindered this development?

10. What kind of support was in your opinion crucial for the development of lentil production in the region?

11. Do you think the cultivation of lentils and other grain legumes should be subsidised?

12. What kind of support would be in your opinion particularly helpful?

13. What do you consider as strengths or weaknesses of the producer group?

14. What challenges or opportunities do see for the producer group in future?

Interview guide - W. Mammel

Name: Address:

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1. What was your motivation to start growing lentils?

1. From where did you get the knowledge to grow lentils?

2. What where the major challenges when you started cultivating lentils?

3. What do you think are the reasons for the current low use of grain legumes in agriculture?

4. What kind of support was in your opinion crucial for the development of the producer group and the lentil production in the region?

5. What kind of support would you have required or desired in the past?
6. Have you received any financial or technical support over the years?
7. Have you been in contact to persons or organisations that are interested in lentil production?
8. Has there been any kind of knowledge exchange or collaboration with those actors or organisations?
9. What kind of support would be in your opinion particularly helpful?
10. Do you think the cultivation of lentils and other grain legumes should be subsidised?
11. What do you think are the reasons for the successful development of the producer group?
12. Do you think the cultivation of lentils and other grain legumes should be subsidised?
13. What do you consider as strengths and weaknesses of the producer group?
14. What kind of challenges or opportunities do you see in the future?

Interview guide - L. Mammel

Name: Address:

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1. What was you motivation to take over the management of the producer group?
2. What were the reasons for establishing the lentil processing and marketing company Lauteracher-Alb-Feldfrüchte?
3. What where the major challenges when you started the business?

4. Where did you get the knowledge from concerning the processing and marketing of lentils?

5. How is the producer group and the lentil production organised?

6. Do some farmers have special roles or responsibilities?

7. What kind of support did you receive?

8. What kind of support would you have required or desired in the past?

9. What kind of support would you require today?

10. Which actors or organisations played in your opinion a crucial role in the development of the producer group?

11. Is there any collaboration with food processors or other actors in the food sector?

12. Where do you usually find the ideas for new companion crops?