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Crop diversification and low-input farming across Europe: from practitioners' engagement and ecosystems services to increased revenues and value chain organisation

Systematic overview of agri-food value chains in the EU as connected to crop diversification

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Executive summary

In this report we present an approach to analyse and evaluate factors facilitating and limiting the adoption and diffusion of crop diversification practices (CDPs). Based on an extensive literature review we have identified the main definitions, approaches and issues to crop diversification as well as their main conceptual dimensions. Diversification is understood as a multi-level process which involves all actors operating in an agri-food value chain and context. Currently diversified practices are adopted in niches of innovation, in which farmers experiment novel approaches to farm management as well as “netchain relationships”, thus both vertically and horizontally. Proximity, quality and types of relations in the netchains are key aspects to consider to analyse, evaluate and eventually support CDPs adoption and diffusion. Our research has highlighted that current conventional value chains, and the wider institutional context in which they are embedded, are not the most favourable context for the adoption and diffusion of CDPs. Therefore, the Diverfarming project will need to further develop a conceptual framework and support experimental approaches for co-designing organisational and institutional changes which might be supportive of adoption and diffusion of CDPs. This will need to be implemented as a participatory and multi-actor oriented research strategy.

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1. Introduction

1.1. The purpose of diversification

This report focusses on *crop diversification practices* (CDPs), such as crop rotations, multiple cropping, intercropping and the inclusion of minor crops within cropping systems. While uptake of CDPs has been slow in the past, adoption seems to be speeding up in recent years (Kassam, Friedrich, Derpsch, & Kienzle, 2015). Yet, the drivers and barriers behind the adoption and diffusion of CDPs in Europe are still not sufficiently understood (Borremans, Marchand, Visser, & Wauters, 2018).

Diversified farms still formed the majority in Europe until the 1950s and 1960s (Roest, Ferrari, & Knickel, 2018). Since the 70's, actors operating in agricultural systems have focused on maximizing productivity by adopting new technologies and modernizing production techniques, such as using high-yield plant varieties, monoculture, mechanization and agrochemicals (Bernstein, 2014; Tilman et al., 2001). This system of hyper-specialisation has led to shortening of crop diversification practices and increased use of agrochemicals. Side effects of these practices have been the increased risks of systemic spread of pests and diseases at crop and farm level, as well as increased ground and surface water contamination, a declining soil health and biodiversity and an overall increasing economic risks for farmers (Le Bail et al., 2014; Magrini et al., 2016; Roest et al., 2018). These social, economic and environmental issues generated by a highly specialized and intensive mono-cropping agriculture could be mitigated trough CDPs at farm and value chain level (Blasi, Ruini, & Monotti, 2017; Kremen, Iles, & Bacon, 2012; Pretty & Bharucha, 2014).

Generally, the aim of CDPs is to reduce the use of agrochemicals and resulting pollution, improve soil quality, reduce GHG emissions and improve the overall delivery of ecosystem services. They are also said to reduce production costs and the risk of crop failure. Trials have found them to be both profitable and income-stabilizing for farmers, smoothing labour demand and beneficial to the environment (Castaneda-Vera & Garrido, 2017; Duru, Therond, & Fares, 2015; Knowler & Bradshaw, 2007; Lahmar, 2010; Reckling et al., 2016; Roest et al., 2018; van den Broeck et al., 2013). CDPs are even said to help limit and mitigate effects of climate change (Basch, Friedrich, Kassam, & Gonzalez-Sanchez, 2015; FAO, 2018). Yet, most European countries are characterized by field crop specialization (Magrini et al., 2016) and adoption of CDPs in Europe is lagging behind that of other regions (Lahmar, 2010). To illustrate, in 2014 grain legumes, an important group of diversification crops, were grown on only 1.5% of arable land in Europe while they were grown on 14.5% of arable land globally (Watson et al., 2017).

Much research into farmers' decisions of adopting CDPs has been limited to assessing the influence of farm and farmer characteristics (see for example Carlisle, 2016 and Knowler & Bradshaw, 2007 for reviews). While this information is useful and farm-level conditions certainly matter, farmers do not exist independently of their surroundings. Their institutional and business environment, such as markets and business relationships, policies and research, may be favouring a particular set of (conventional) practices and put the profitability and adoption of diversification with minor crops at a disadvantage (Knowler & Bradshaw, 2007; Magrini et al., 2016). It may thus be inappropriate to assume that only the farmer's agency is pivotal in predicting adoption. There is a need to expand the focus beyond the farmer and the farm and to include contextual considerations in the analysis of farmers' choices (Borremans et al., 2018). Therefore, this report uses a multi-level approach to identify conditions conducive to crop diversification. Particularly, it aims to identify barriers and enablers in farmers' value chains. The farm and institutional levels will only be

considered to the extent that they are related to the value chain. This is done by reviewing a large variety of literature. Based on the results, a typology is designed that can help assess value chains and their potential for crop diversification.

The remaining report is structured as follows: the remainder of this section covers definitions and the approach to the literature review. Then, identified barriers and enablers will be presented in section 3 based on the multi-level approach. Section 4 will explain the developed value chain typologies. Section 5 will summarize and conclude.

1.2. Definitions

This section defines the concept of *diversification* and *value chains*. Diversification here refers specifically to crop diversification, i.e. crop rotations, multiple cropping and intercropping, with a particular focus on the inclusion of minor crops such as grain legumes. These CDPs are often combined with a broader set of *low-input practices*, e.g. reduced or no tillage, mulching and integrated pest control (see e.g. Kassam et al., 2015; Knowler & Bradshaw, 2007). It is important to point out that when referring to diversification in this report, the focus lies on *agricultural and crop diversification*.

In this perspectives more specifics diversification practices are developed and suggest to the rural contexts aimed to complex the agroecosystems at farm level and landscape level such as improving the ecological focus areas, maintenance landscape features in high natural value area, improve hedges, grassland and pasture and agroforestry technique. These practices and other types of rural diversification such as pluri-activity or multifunctional agriculture that focus on diversifying into e.g. tourism or off-farm employment, are not part of this report.

The *value chain*, or supply chain, is a series of *physical and decision-making actors connected by material and information flows and associated flows of added value and property rights that cross organizational boundaries*. The supply chain not only includes the manufacturer and its suppliers, but also (depending on the logistics flows) transporters, warehouses, retailers, service organizations and consumers themselves (Van der Vorst, da Silva, & Trienekens, 2007). The competitiveness and functioning of a value chain depend on the capacity for collaboration and coordination of the various parties that comprise it. It is important to note that any one organization can be part of numerous chains at the same time (Mentzer et al., 2001). To capture this complexity, Lazzarini, Chaddad, and Cook (2001) use the concept of ‘netchains’ to describe the combination of horizontal networks of actors in sequential vertical ties within a chain. This concept will be followed in this report and is further elaborated in Chapter 2. The unit of analysis in this report is the agri-food value chain starting from a focal farm and extending to other actors related to the focal farm. Figure 2.1 illustrates an exemplary version of such a chain.

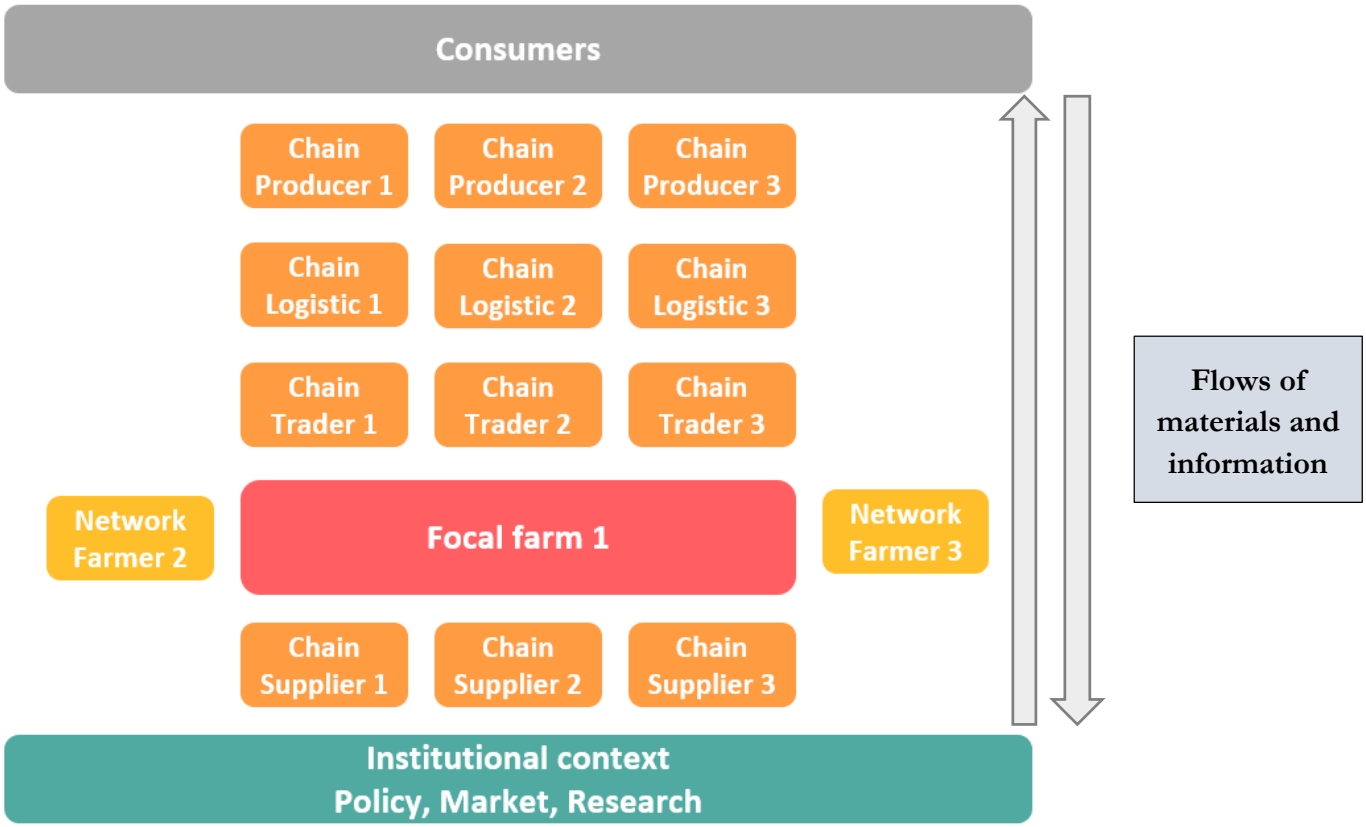

Figure 2.1: An exemplary diversified value chain

1.3. Approach

This report is based on an ***extensive literature review on adoption of crop diversification and associated practices and concepts***. A data base search of Scopus and Web of Science delivered 1815 studies. Further literature searches were conducted on EU and FAO data bases, Google and Google Scholar. Overall, most of the literature found focussed on the effects of adoption of CDPs, rather than the transition and adoption process itself. A similar observation was made by Lamine and Bellon (2009) on the adoption of organic farming. In the end, 47 studies were reviewed. The papers were coded to extract barriers and enablers of adoption of crop diversification as related to the farmers' value chain. While all papers were assessed and coded, much of this report largely relies on a smaller subset of these studies that were more focussed on diversified value chains. Other papers, though fully reviewed, focussed on field or institutional level and were thus included only to a limited extent, or disregarded.

2. A conceptual framework to analyse processes and practices of crop diversification: a multi-level approach

The two conceptual starting points of this report refer to the *concept of netchains* on one hand (Lazzarini et al., 2001) and the theoretical underpinnings of *transition* theories *in innovation systems* on the other hand (Bui, Cardona, Lamine, & Cerf, 2016; Ingram, 2015; Meynard et al., 2017; Smith, 2007).

The netchain perspective in fact, considers the value chain as a system with vertically and horizontally connected nodes (e.g. farmers, processors, distributors, and so on) that interact and influence each other. Netchain analysis is of particular interest since it combines the perspectives of supply chain analysis, focused on vertical relationships, and network analysis, focused on horizontal relationships. In this approach, there is a clear distinction between relationships and interdependencies within horizontal networks, and within vertical links (Lazzarini et al., 2001).

While the netchain approach already combines perspectives of horizontal and vertical relationships in supply chain networks, it does not deal with the particularities of transitions in innovation processes or the institutional and business environment beyond the netchain, such as research or financial institutions (please see figure 2.1). Therefore, when looking to how a netchain can change over time, the transitions in an innovation system perspective is considered as more informative. For instance, it allows for a dynamic perspective and the inclusion of actors beyond the netchain. In the innovation system perspective, innovations, such as CDPs, are first practiced at smaller scale, in so called 'niches', which are the sources of change in the overall system (Bui et al., 2016; Ingram, 2015; Smith, 2007). *Niches* are "networks of pioneering organisations, technologies and users" that "provide space for new ideas, artefacts and practices to develop without being exposed to the full range of selection pressures that favour the [socio-technical] regime" (Smith, 2007). The socio-technical regime here refers to a structure of more established practices and rules that promote the persistence of the current system driven by its dominant actors (Ingram, 2015). As such, a regime exerts, through a set cognitive, social, economic, institutional and technological processes, a lock-in effect of the current situation that makes it difficult even for promising solutions to flourish (Ingram, 2015; Le Bail et al., 2014; Meynard et al., 2017).

This approach recognizes that value chains do not exist in a vacuum but are connected to and influenced from the wider context (e.g. institutions) in which they operate, as well as actors' preferences and relationships. While this report focusses on the netchain level, the multi-level approach allows for the recognition of interdependencies between levels. Therefore, this report acknowledges the complexity of adoption and diffusion of CDPs as related to a multilevel dynamic which implies farm, netchain and wider institutional considerations. In particular it evaluates adoption ad diffusion of CDPS at farm and the institutional and business environment level, yet only includes them when directly related to value chain considerations.

Based on these perspectives, literature on adoption and diffusion of CDP and related practices was analysed ***to identify factors related to value chains limiting or promoting adoption***. This overall approach proposes that the particular dynamics in and constellation of the netchain and innovation system may impede or encourage the adoption of diversification at farm level. Figure 3.1 illustrates this approach. The remainder of this chapter delivers the results of the literature analysis for the value chain, the farm and the institutional level.

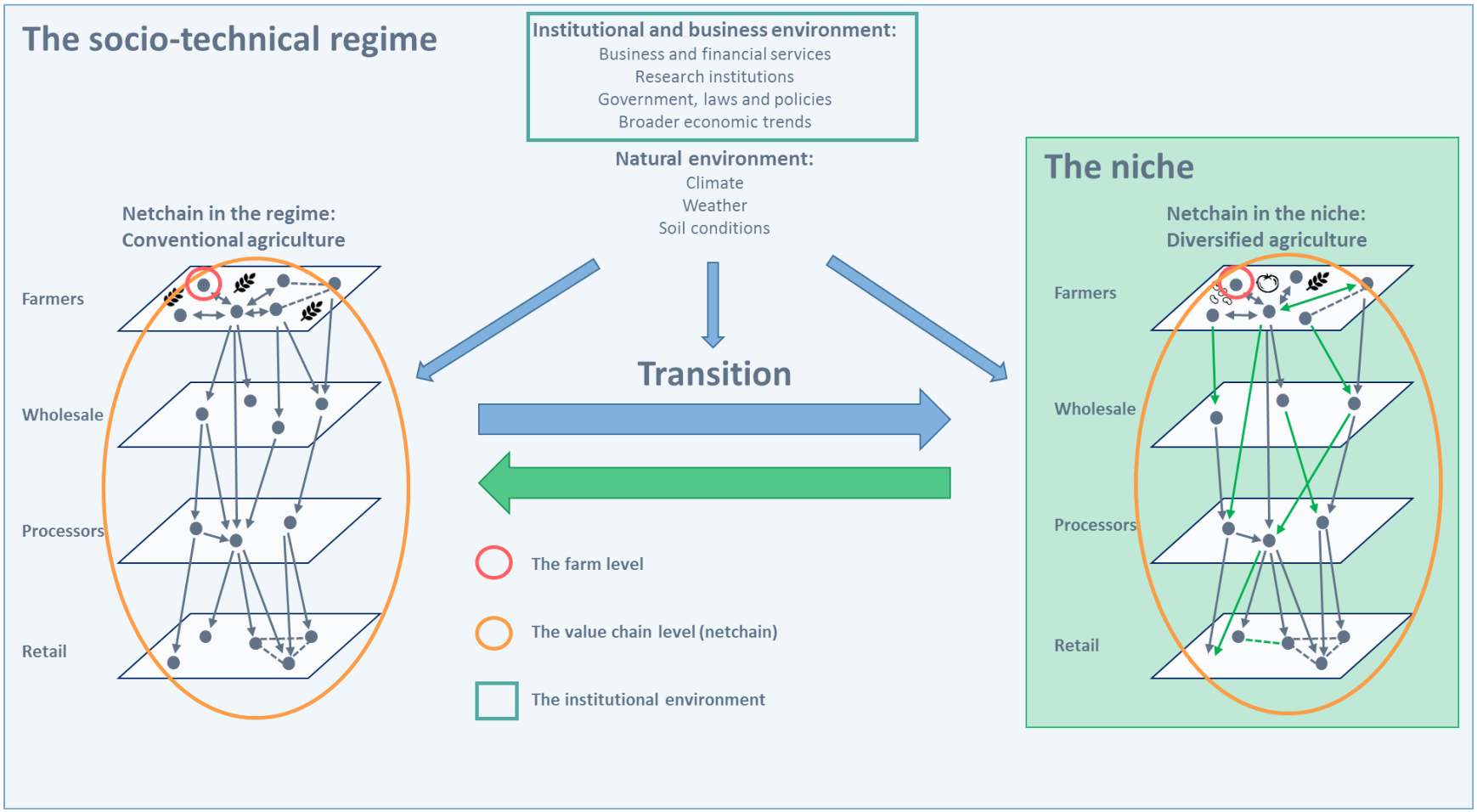

Figure 3.1: The conceptual starting point: Netchains in an innovation system transition

3. Results: Barriers and enablers at value chain level

This chapter presents the results of the literature analysis. It focusses on farmers' value chains in relation to crop diversification. Whenever aspects of the farm or institutional level are relevant to the functioning of the value chain, they are included here.

3.1. Proximity

Proximity is one of the features that the literature has identified to explain barriers and enablers of crop diversification. Proximity can be understood as related to two intertwined aspects which refer to the *structure of the value chain*, namely: the ***geographical distribution*** of the chain activities, and the ***length of the chain*** (in terms of the number of steps and actors).

In value chains, economies of scale downstream (storage, processing, marketing) leads to specialization on a few dominant species (Magrini et al., 2016). These economies of scale are likely to be more important in long and global value chains and may thus create an additional barrier in chains of that type. Further, minor species are hardly used in processed foods. For example, most protein in processed foods in France comes from wheat and imported soy (Magrini et al., 2016). These highly-processed food chains tend to be longer and more global which means that minor species are less likely to flow in these kinds of chains. Yet, there are exceptions of high quality exports for human consumption (faba bean to Egypt and peas to India from France) where chances of success for minor crops are better than in the local feed market (Magrini et al., 2016).

Diversified farming systems may suffer from lack of recognition from buyers and consumers of their improved sustainability performance due to lack of communication in the sector (Borremans et al., 2018). Transmitting this information on what are often credence attributes that are difficult to measure, is more difficult in longer chains as more actors have to be involved. Global chains may have additional communication problems due to cultural and language barriers. Thus, the added value of products from diversified systems may get lost in longer and more global chains. According to Borremans et al. (2018), recent policy developments in Belgium recognising the value of shorter supply chains and niches are favouring the implementation of diversified systems as it would lead to more support and recognition of these systems and their benefits.

Niche marketing is often very important for alternative agricultural systems as the produced products are often not new, mainstream standards cannot not always be complied with and price competition is tough in regular markets (Borremans et al., 2018). Diversified farmers tend to seek shorter channels and more direct connections with consumers in order to avoid the pressure of scale enlargement common in industrial chains, and to gain higher added value and margins on farm (Borremans et al., 2018; Casagrande et al., 2017; Roest et al., 2018). At the same time, niche markets tend to favour local production and chains with few intermediaries for easier traceability (Borremans et al., 2018; FAO, 2018; IPES-Food, 2016). This has implications for the farmers location: farmers located closer to (urban) markets are more likely to have access to these shorter value chains (Bowman & Zilberman, 2013).

Beudou, Martin & Ryschawy (2017) give an example of agro-ecological livestock products in France showing how short marketing channels can open doors for niches in which concepts such as agroecology can flourish (Beudou et al., 2017). Meynard et al. (2017) give another French example, in arable farming, illustrating the simultaneous organisational innovation by a cooperative to allow for diversification, specifically the

intercropping wheat and lentils. The aim was to increase protein content in wheat to comply with bakery standards, while decreasing fertilizer use to save costs. The cooperatives solution was to develop a new value chain for lentils for human consumption, next to their existing industrial chain for wheat for bakeries. The marketing for lentils included direct sale to consumers and a somewhat longer chain for mass catering (Meynard et al., 2017). This example illustrates how opening of an alternative shorter chain for a minor crop may actually improve performance in industrial chains. However, the options for farmers that want to stay integrated in industrial food chains are not clear (Beudou et al., 2017). Yet, as diversified systems can reduce production costs, integration in global trade systems where price is the driving force, may also favour adoption of these practices (Lahmar, 2010). Further, switching to or opening new short chains also implies some additional barriers in itself as it has implications for breeding of varieties: storage ability becomes much less important while the importance of taste is much higher for consumers in short chains (Meynard et al., 2017).

As shown here, two dimensions emerge in the theme of proximity in value chains: ***globalization*** (e.g. geographical scope and scale) and ***length of the chains***. Both characteristics are intertwined as, for example, international chains are more likely to involve more actors and processing and distribution steps, while local chains are likely to involve more direct interactions of fewer actors. Yet, it seems advisable to consider the two conditions separately when assessing value chains on their conduciveness to diversification. For example, long, local chains, such as highly processed foods for the local market, are likely to face some but not all of the problems faced by a global chain. Overall, the literature showed that integration in longer and more global chains appears to make the implementation of diversification strategies at farm level more difficult, while more local and more direct marketing channels, while riddled with barriers of their own, still seem to allow more flexibility to the farmer to implement a diversified strategy.

3.2. Quality

From the literature analysis, two aspect emerged as relevant with regard to the theme of ***quality***. The first is ***the importance of product quality standards***; the second is the ***quality and type of innovations to be implemented by the value chain*** when the farmer diversifies.

3.2.1. Standards

Any economic assessment of diversified systems needs to take effects on quality into account; strict quality standards are imposed not just for grain crops destined for industrial processing but also for perennial and other crops (Vastola et al., 2017). The industrialisation of the agri-food system went along with an increase of agricultural and production standards, e.g. a high protein content in wheat which requires high levels of nitrogen in the soil (Magrini et al., 2016). Compliance with these standards is of utmost importance for farmers, which makes a switch to a diversified system more risky, particularly if it is not clear to farmers how a diversified system can be used achieve the same product standards for the main crop. Even within-crop diversification, such as the use of different varieties in the same field to reduce disease pressure and agrochemical use, can be hampered by standards in processing as illustrated by French millers that prefer to mix varieties to their own specifications but do not buy variety mixtures from the field (Meynard et al., 2017).

Standards (e.g. product form and size) and price competition imposed by supermarkets often encourage a focus on scale enlargement. It can be difficult for farmers to withstand that pressure when they are integrated in this type of supply chain (Roest et al., 2018). Yet, for example intercropping with legumes has been shown to increase protein content (Watson et al., 2017) which has already been applied by farmers in France particularly with that aim in mind (Meynard et al., 2017). Thus while diversification can be considered risky in terms of standard compliance, it may actually be a tool to comply with the strict standards from the processing industry and can thus be beneficial for farmers integrated into industrial value chains. Yet, this leaves open questions on outlets for the intercropped legume and logistic issues such as sorting and storage that may still require more organisational and marketing innovation.

To ensure quality standards, when trading in a larger number of crops, collection centres (e.g. cooperatives) would need a larger number of storage cells or silos to ensure ideal storage conditions for each crop. This implies an additional investment. Therefore, since silos with minor crops may not be used at full capacity, collection centres are likely to prefer selling minor crops quickly and make storage space available to store major crops (Magrini et al., 2016). Additionally, heterogeneous batches of minor crops may be mixed in storage making quality initiatives in these crops challenging (Meynard et al., 2013). This is likely to lead to minor crops being sold at lower prices close to harvest.

Creating a certification system for more sustainably produced agricultural products could be a way to assure the consumer of the higher standards in diversified systems and the higher added value associated with that. Alternatively (public or private) quality labels, e.g. for nutritional value or environmental quality may also achieve this goal (Meynard et al., 2017; Vastola et al., 2017). Overall, it is indicated that diversified production system may need to differentiate their products in order to reap the full economic benefits associated with their better environmental performance. Roest et al. (2018) actually see this potential for differentiation as an opportunity for diversified farming systems. Marketing products as sustainable, pesticide-free or local may actually help farmers deal with output market risks in commodity markets (Bowman & Zilberman, 2013; Roest et al., 2018). Thus, using credence attributes may help improve the added value gained by farmers. However, it can be a challenge to translate diversification into a marketable attribute if it does not align with any known categories such as organic labels.

Many minor crops have existing or potential outlets in the animal feed sector, yet there is a lot of competition between different raw materials suitable for use in feed mixes to achieve the same outcome (Le Bail et al., 2014; Meynard et al., 2013). In these markets, price is the main coordination mechanism in these commodity markets. This also implies highly standardized and simplified products with well-defined characteristics for easy substitution when prices change. Minor crops often do not have equally well-known characteristics and standards (Le Bail et al., 2014). This leads to a strong tendency of processors to prefer simple formulas for feed mixes (Meynard et al., 2013). That combined with their reduced volume and accessibility, and geographical dispersion make it hard for them to compete in this market due to high transaction and logistical cost (Le Bail et al., 2014; Meynard et al., 2013). Again, the only option seems to differentiate the product, in this case possibly based on nutritional properties such as high Omega-3 content (for linseed) or particularly high protein content (for lupin seeds) (Le Bail et al., 2014; Meynard et al., 2013).

Yet, the use of quality labels may not always favour diversification as illustrated by the example of non-GM labels. While non-GM labels seemed to favour more locally sourced animal feed ingredients instead of

imported soy, the added value of these products actually allowed for the implementation of traceability systems in the non-GM soy value chain. Local protein crops were not able to benefit from this labelling system (Meynard et al., 2013). Additionally, certification, or other types of quality assurance for process attributes, that quality labels for diversified farms may require, are more difficult to implement than, e.g., observing input restrictions since the entire farming system would have to be inspected over time (Lamine & Bellon, 2009). Moreover, implementing this product differentiation of crops from diversified systems also bears additional costs in the form of transaction costs in collection, storage and traceability, particularly if production sites are dispersed, that will reduce their economic value. Coordination among value chain actors is thus essential (Meynard et al., 2013). Still, additional costs in relation to labelling and marketing of these products remain.

An important aspect on the topics of standards is that the imposition of standards is purely one-directional. Farmers have little to no means to induce processors or buyers to change their procedures in order to implement changes to farm practices as processors have no motivation to do so if their businesses is not affected (Meynard et al., 2017). An example of that is pressure applied by authorities on cereal farmers to reduce the use of nitrogen fertilizer in order to reduce its negative environmental consequences. At the same time, processors require farmers to deliver cereals with high protein content, achieved by use of increased nitrogen fertilization. This situation only changes if there is a mutual dependency between farmers in processors such as the case when produce has to be sourced close to the processing facilities (Meynard et al., 2017). In relation to this, these imposed standards are often action-oriented, e.g. good agricultural practices, while result-oriented schemes, with indicators allowing farmers to evaluate their practices, often leave more flexibility for farmers to learn and adjust to the local circumstances and customer needs (Meynard et al., 2017).

If farmers switch to different types of (shorter or more local) chains favoured for diversified production, this has consequences for the standards they have to comply with, e.g. with regard to taste, nutritional value (Meynard et al., 2017) or production criteria as local channels with direct links to consumers may require a complete switch to organic cultivation instead rather than just diversification. Finally, standards do appear out of nothing but have to be developed and agreed upon. Pre-existing networks of actors in certain sectors and chains have already agreed on common standards for major crops. These networks and standards do not yet exist for minor crops (Meynard et al., 2017). The lack of agreed upon standards may also discourage breeders and input providers to develop solutions for diversified products and systems (Le Bail et al., 2014).

Lastly, standards do not only exist in processing but also at consumer level. In some countries such as France, legumes are grouped with starchy foods in the food pyramid, such as bread, while in others (e.g. UK and Spain), they are grouped with high-protein foods such as meat and fish. Countries in which they are grouped with other proteins, consumption is higher (Meynard et al., 2017). This implies that with accurate nutrition advice to consumers, demand for these crops for human consumption, a higher value-added market, may actually arise.

In conclusion, an absolute focus on commodity product standards is an obstacle to the implementation of diversification. Even though diversification can be a tool to achieve product standards within the commodity system, such as the use of legumes in rotation or intercropped to improve the protein content in cereals, much of the added value of diversified production systems is not recognised within that system. Branching

out into marketing based on credence attributes and process standards, and thus differentiating the product away from pure commodities appears to be an advantage when implementing diversification strategies at farm level. Thus, whether a farmer's value chain focuses on product or process standards appears to be an important distinction.

3.2.2. Elemental vs. holistic innovation

Elemental innovations are easier to adopt as they do not require large changes but rather incremental steps. For the farmer, ***adopting crop diversification practices is certainly a more holistic innovation***, changing not only some inputs but overall farm management practices, possibly marketing channels and trading partners. This section discusses how the current state of the value chains determines the nature of innovations and influences its adoption at the value chain level. Simply put, the more a new practice is perceived as an 'innovative system', the more it will be perceived as a risky option (Ridier, Chaib, & Roussy, 2016).

Farmers perceptions of what agriculture means will influence their willingness to adopt CDPs. Cognitive paradigms and the concept of cognitive lock-in play a large role in that (Borremans et al., 2018; Lamine & Bellon, 2009). To recognise the benefits of diversification farmers may require a change of perspective towards a more eco-systemic approach to agriculture and soil health (Casagrande et al., 2017; Vankeerberghen & Stassart, 2016). To illustrate that, using examples from Denmark and the Netherlands, Lamine & Bellon (2009) show how perceiving organic farming as a simple case of input substitution is a different approach than an agro-ecological or system redesign conceptualisation of farming. Having already an agro-ecosystem-based idea of what farming is will likely facilitate the implementation of diversification as considering an entire rotation and the interaction between crops is much closer to a farmer's existing idea of farming. Diversification then becomes an elemental innovation. For farmer experiencing farming as a (conventional) input-output concept, the switch to crop diversification is likely much more difficult as it requires a holistic rethinking of the farming system to recognise the benefits of CDPs (Lamine & Bellon, 2009). Further, there is a lack of recognition in Europe of undesirable or risky consequences of remaining within the conventional paradigm (Basch et al., 2015). This is likely to also the case for other actors in the value chain. For farmers involved in value chains that already recognise eco-system services as important aspects of agriculture, their recognition of the added value of diversification is likely much easier to achieve. For farmers operating in conventional value chains, it will be much harder to convince trading partners of this added value. If actors in the chain doubt the usefulness or importance of diversification, they are unlikely to seek or accommodate these changes (Borremans et al., 2018). Generally, social norms in the farmer's background and environment will have an influence on his or her opinion on diversification (Louah, Visser, Blaimont, & Canniere, 2017; Vankeerberghen & Stassart, 2016).

Further, Roest et al. (2018) discuss three different case studies in France, Spain and Israel and show that for very specialised farmers, that are price takers and often dedicate marketing of products to specialised agencies, diversifying their production system would a holistic innovation, as they then have to change their production and marketing processes. On the other hand, for farmers that are already used to executing some of the marketing activities, e.g. participating in shorter, organic value chains, diversifying their crops may be much more of an incremental step (Casagrande et al., 2017).

Pest control may also be an obstacle. Using rotations to control pests takes much more time and is much less direct than using chemicals which is deeply ingrained with the conventional approach to agriculture (Magrini et al., 2016). It is thus likely to be an innovation of the holistic type for many farmers. Additionally, the relatively low economic value of minor crops used in diversified systems offers little motivation for input providers to develop pest control methods for these crops which currently only exist to a limited extent, creating an additional barrier to farmers adopting diversification (Le Bail et al., 2014).

Another reason crop diversification is a holistic innovation for many farmers is the need for several innovation to happen alongside each other (Meynard et al., 2017). It requires not only changes to agronomic and technological aspects but also to organisational ones. ***To implement diversification, changes in contracts and relationships, logistics and standards need to adapt alongside to the changes in the farming system*** (Meynard et al., 2017). It is thus important that diversification is recognised as a systematic change and a possible solution to challenges of the current agri-food system by all actors across the value chain and related institutions (Meynard et al., 2013).

Overall, one can say that small steps are more easily made for all actors in the value chain. For most farmers following the current conventional paradigm of agriculture in Europe, crop diversification is a holistic innovation requiring vast changes to several parts of farm and chain, while making small changes, implementing elemental innovations while remaining in the same paradigm is much more conceivable. Yet, the more aspects of diversified systems are already present within the value chain, in terms of cognitive paradigm, current practices, marketing channels and existing relationships, the more crop diversification becomes an elemental innovation that is much easier to achieve, for farmers and their value chain.

3.3. Relations

As indicated in chapter 2, the relationships between actors in the value chain are important to the adoption of innovations. This section will consider both the vertical relationships to input supplier and buyers, as well as the horizontal and network relationships among farmers and other actors.

3.3.1. Vertical relationships

Upstream: input supply relations

Upstream of farmers, several barriers impede the adoption of crop diversification, particularly related to the availability of adequate and locally-adapted seeds and adequate pest, disease and weed management methods, and machinery. Diversified systems are less likely to make profits for large agribusinesses, particularly on the supply side (seeds, agrochemicals, machines) particularly as currently demand for these inputs is quite low, specific needs due to local soil and climatic conditions of farms, as well as quality standards for these new markets yet being undefined or outlet markets being fragmented with different needs and specifications, (Borremans et al., 2018; Carmona et al., 2015; Le Bail et al., 2014; Meynard et al., 2013; Vincent-Caboud, Peigne, Casagrande, & Silva, 2017). This is a vicious cycle as the unavailability of inputs leads to low uptake of diversified systems and low uptake leads to a lack of incentive for companies to develop inputs for diversified systems (Borremans et al., 2018; IPES-Food, 2016). Research and development currently focus on few plant species, both in breeding as in licensing and distributing pesticides, since investment in research aims for large production volumes to increase returns on these investments

(Magrini et al., 2016). In Europe, genetic progress is much slower for minor crops, such as chick pea, linseed or lupins, compared to major species such as wheat, maize or rapeseed (Meynard et al., 2017). Further, breeding generally for major and minor crops does not take the interactions of subsequent or simultaneous crops in diversified systems into account (Himanen, Makinen, Rimhanen, & Savikko, 2016; Lamichhane et al., 2017). The same applies to the economic valuation of these crops (Meynard et al., 2013). The lack of plant protection also seems to be perceived as a risk by farmers and while non-chemical alternatives for plant protection exist, they are still little known (Le Bail et al., 2014). All this leads to the development of minor crops lagging behind and an insecurity about their yield stability, implying a larger risk as perceived by farmers (Magrini et al., 2016; Watson et al., 2017). Additionally, the actors and chains of minor crops are often too small and lack the resources to invest in research themselves. Investment in public research may be needed to encourage the development of these inputs and diversified systems in general (IPES-Food, 2016; Le Bail et al., 2014; OECD, 2001). This research particularly needs to consider practical implementation and performance, solutions, representativeness and local applications, as well as a long-term perspective, to be effective in supporting adoption (Basch et al., 2015; Carmona et al., 2015; Casagrande et al., 2017). Networks on agroecology also suggest that performance indicators need to be redefined in order to reflect the full benefits of diversified systems (FAO, 2018; IPES-Food, 2016). An example of successful variety development with public-private coordination can be found for peas in particular (Meynard et al., 2013).

But also more generally growth and success of diversified systems may decrease the revenues of these large agribusinesses as diversified systems encourage reduced use of inputs and use of local or self-produced inputs, including locally-adapted varieties instead of standard varieties (Borremans et al., 2018; FAO, 2018; IPES-Food, 2016). Therefore, far from supporting diversified systems, these large businesses and their lobby are likely to object to the spread of the use of crop diversification. They may also buy up smaller innovating companies in agro-technology (OECD, 2001). These small companies may be more likely to produce local solutions. This is particularly challenging as public research is unlikely to be able to fill this void and develop locally-adequate inputs for crop diversification without the support of the private sector (Borremans et al., 2018).

This is also related to a less tangible input: advice. Input providing companies have become the main source of advice for many farmers. Agronomic advice is thus often focussed on the use of chemicals that offer simple treatment, rather than more complex preventative agronomic practices that make use of diversification (Magrini et al., 2016). This is aggravated by the lack of technical and economic references adjusted to local circumstances (Meynard et al., 2013).

Downstream: buyer relations

When implementing diversification, farmers need to make use of economies of scope, i.e. using the same inputs for multiple outputs and achieve high technical efficiency using the benefits of crop diversification, and create access to markets for all their products competing on both quality and price (Roest et al., 2018). Yet, this also implies that farmers have knowledge of all markets, including their standards, traders and prices, in which they are involved which is not always the case (Bachev, 2012).

Economies of scale in storage, process and marketing favour the specialisation on a few dominant species (Le Bail et al., 2014; Magrini et al., 2016). The choice of crops to be planted is often a decision made jointly

by farmers and collection agencies (whether they are cooperatives or traders) and is dependent on the profitability of the crop, not just for the farmer but also for the collection agency. For the collection agency, profitability is closely related to not just market price but volume of the crop from all its suppliers (Meynard et al., 2013). An example for this is the case of a French cooperative that diversification of harvested crops would require more storage cells in order to ensure quality standards and to be able to store crops while waiting for the right business opportunity for sale. Due to the large investments in storage and the economies of scale associated with trading in dominant crops, the cooperative only reluctantly dealt with minor crops and sold them off quickly (Le Bail et al., 2014; Magrini et al., 2016; Meynard et al., 2013). Intercropping is also often impeded by traders and cooperatives not accepting grain-legume mixtures as the collection points lack the required sorting machinery (Casagrande et al., 2017; Himanen et al., 2016; Magrini et al., 2016). Also product development in food processing has focussed on products using cereals, particularly wheat. This has also led to an increase in the consumption of cereals over minor crops (Magrini et al., 2016). Additionally, in the European market, the focus for grain legumes was almost exclusively on feed rather than food. They were thus restricted to the feed market with lower added value and in direct competition with cheap imported soy products. Promotion of legumes in high value outlets has been lacking (Magrini et al., 2016).

High demand for protein crops for livestock feed in Europe, currently a 70% deficit, is largely met by imported soy bean and meal (Watson et al., 2017). This would imply a good market opportunities and demand for an increased local production of grain legumes. Yet, grain-legumes content has fallen to only 2% of feed formulas in Europe (Magrini et al., 2016). This is a vicious cycle as low demand makes it risky for farmers to produce these crops which in turn makes it unattractive for feed producers to include them in their formulas for fear of lack of supply (Magrini et al., 2016). Further, the feed market is largely organised through simple market transaction without further coordination or integration, giving little security to farmers and buyers alike (Le Bail et al., 2014). This type of organisation also does not favour the exchange of knowledge and information that may be needed for the development of these crops and diversified systems in general. Thus, farmers have to cope not just with market insecurities and competition but also with a lack of technical support (Meynard et al., 2013). In some regions, in the absence of public support, value chain initiatives may be the only source of support available to farmers (Bachev, 2012).

Thus, diversification crops are often difficult for farmers to sell which implies a large risk for farmers (Vankeerberghen & Stassart, 2016; Vereecke, 2015). However, some niche markets for legumes have been created. Examples are functional ingredients such as pea proteins, lentils with quality labels or beans and peas for the export market (Magrini et al., 2016; Vereecke, 2015). Since these outlets offer higher prices, they provide extra incentives for farmers to grow legumes. Yet, Roest et al. (2018) show with case studies from France and Spain, that in serving these niche markets, farmers have to not only diversify production but also marketing in order to gain access to markets with less price competition. Further, if new product niches require changes or investments in the, e.g. processing, activities of buyers, they are less likely to want to engage in these markets (Meynard et al., 2013).

Specialised farmers are dependent on large retailers and thus need a countervailing power, such as a strong marketing agency in order to avoid vulnerability (IPES-Food, 2016; Roest et al., 2018; Vereecke, 2015). Particularly smaller farmers are in need of better bargaining power (Bachev, 2012). Diversification could reduce the dependency on few buyers and the associated vulnerability (Roest et al., 2018). Diversification can be considered a risk management tool to reduce income variability, dependency on inputs and

dependency on prices of few crops (Casagrande et al., 2017; Castaneda-Vera & Garrido, 2017; Chongtham et al., 2017; Di Falco, Adinolfi, Bozzola, & Capitanio, 2014; Meynard et al., 2013). But countervailing power may also be needed in diversified chains. Long, Blok, and Coninx (2016) point out that the unequal distribution of costs and benefits in the chain discourages farmers to adopt sustainable technologies as they fear that the added value of the more sustainable products will be gained downstream (processors, retailers) and farmers may thus not be able to regain their investment. This imbalance of power also leads to the imposition of standards and contract specifications by buyers that influence the farmers' choice of practices (Louah et al., 2017; Meynard et al., 2017). Similarly, large businesses in global trade and processing may also resist as diversified systems favour local production and short chains that are less likely to benefit these businesses (Borremans et al., 2018).

Additionally, in order for there to be any added value to distribute, not only farmers need to be aware of the (environmental) benefits of diversified farming systems. It is also necessary that potential buyers and consumers are aware of these benefits in order to achieve higher prices (Borremans et al., 2018). This also goes for other differential characteristics, such as nutritional value (Meynard et al., 2013). Moreover, farmers are not the only actors in the chain that may have a short-term orientation (Borremans et al., 2018; Chongtham et al., 2017; Mary, Dupraz, Delannoy, & Liagre, 1998; Rodriguez-Entrena & Arriaza, 2013; Sklenicka et al., 2015; Vastola et al., 2017). Buyers do so also, making it difficult for farmers to react quickly to market demands due to the long-term planning required by many diversification strategies (Borremans et al., 2018). The commitment to long rotations is often perceived as risky by farmers as they can no longer easily react to prices, particularly high cereal prices (Casagrande et al., 2017; Chongtham et al., 2017; Ridier et al., 2016).

On the other hand, as diversified systems can reduce production costs, spot market interactions where price is the driving force, could also favour adoption of these practices. Yet the size of cost savings are not easily predicted and are dependent on several local factors (Havet et al., 2014; Lahmar, 2010). However, simple economic superiority of diversified system would be a strong incentive for many farmers to adopt this alternative system. Additionally, the reduction of market support measures in Europe has led to higher price volatility increasing economic risks and vulnerability for specialised farmers (Roest et al., 2018). Whether the profitability of diversified systems in a given year exceeds that of specialised farms is closely related to cereal and oil prices[1] (Magrini et al., 2016). Further, uncertainty about expected profits also lowers farmers' willingness to make investments and low cereal prices may therefore also not easily induce the inclusion of more diversified crops at farm level (Roest et al., 2018). Yet, this implies that reducing uncertainty, e.g. through contracting, may encourage farmers to invest in creating the right conditions for diversification (Meynard et al., 2013).

Le Bail et al. (2014) hypothesize that sustainable agricultural production in general, and diversification in particular, implies a high level of asset specificity within the associated niche markets. This implies that pure market interactions where price is the driving factor is not suited to deal with the sales transactions associated with these products. They suggest that an increased level of integration, upstream and downstream, is more suitable (Le Bail et al., 2014). Examples of such integration are contract farming, direct marketing, setting up farmer cooperatives or collective breeding. There are examples in the literature of successful diversified farming systems that would support this hypothesis. Several example cases are

[1] Oil prices are a major determinant of prices of chemical inputs (Magrini et al., 2016).

described by Meynard et al. (2013) for value chains of linseed, condiment mustard, field beans, lupins, hemp and chickpeas. All chains make use of production contracts, traceability systems and quality specifications. Further, risk is shared between farmers and other stakeholders in the chain, making the endeavour less risky for the individual actor (Bachev, 2012; Le Bail et al., 2014; Meynard et al., 2013). Additionally, this integration also needs to enable improved information exchange on the benefits and management of diversification as illustrated by a case for peas in France (Le Bail et al., 2014). Production contracts could also involve data collection for improved diagnosis of performance of diversified system under the local conditions therefore including farmers in a collective innovation process. This inclusion could increase farmers' willingness to invest in these new value chains (Le Bail et al., 2014; Louah et al., 2017). The rationale for more value chain integration is illustrated further in the next section when discussing the role of cooperatives and farmer organisations. Yet, setting up integrated value chains around diversified crops can be challenging as the highly diverse actors (breeders, farmer organisations, research institutes, farmers processors and retailers) often do not know each other making it difficult to coordinate their strategies (Meynard et al., 2017). As a first step, partnership agreements could support the development of networks and improve coordination and information sharing (Meynard et al., 2017). That could apply for multi-stakeholder platforms. Yet, it would then be necessary that actors are willing to share information despite possible opposing interests and aims (Meynard et al., 2017). The trend towards higher traceability needs of processors, traders and retailers seen across Europe may favour these arrangements and the adoption of associated technologies or local sourcing (Borges, Kernecker, Knierim, & Wurbs, 2017). Further, long-term contracts would also favour the more long-term planning needed for crop diversification. Overall, clear downstream demand is needed in order to build these integrated value chains (Meynard et al., 2013). Finally, for this approach of increased integration to be successful, relations between contracting parties need to be relatively equal so that contract specifications are not too skewed toward one party. Public regulation of these contracts may help to achieve this (Meynard et al., 2013). There may be regional variation to these effects. Bachev (2012) states that in some cases in Eastern Europe, integration actually may have led to increased specialisation of individual producers though he found no evidence of this was a common phenomenon.

This section has highlighted how lack of demand on the buyer side, lack of supply on the input side and low production at farm level go hand in hand and actually reinforce each other over time. The few successful examples show that in order to break this vicious cycle, closer integration among the different vertical actors in the supply chain is likely a necessary condition for success. This can take the shape of collective breeding activities, knowledge sharing and advice, as well as branching out into marketing activities and brand development.

3.3.2. Horizontal relationships

Diversification strategies are often initiated at a local level with cooperatives playing a major role in building these local supply chains (Meynard et al., 2013). Horizontal cooperation, in producer groups, cooperatives or informal networks can offer opportunities for crop diversification at farm level. This kind of coordination among peers, in producer organisations or otherwise, can create new, different economies of scale outside the farm that may replace the economies of scale lost at farm level due to moving away from specialisation. While diversified farmers may create economies of scope at farm level, their organisations can create economies of scale logistics and marketing rather than at field level (Bachev, 2012). Diversified farmers tend

to dedicate more time to marketing their produce than their specialised counterparts (Roest et al., 2018) and may therefore benefit even more from organisations that can create economies of scale in marketing.

The example of a horticultural cooperative in Spain illustrates this. The cooperative deliberately chose for a diversified product portfolio, and divers marketing channels and certification systems. Members make use of economies of scope by using similar inputs to serve distinct markets (Roest et al., 2018). According to Roest et al. (2018), this collective approach allowed members to further integrate production processes and further diversify the product range than would have been possible for individual farmers. They also mention the example of a French region where specialised and diversified farms exists alongside each other. According to their analysis, diversification was made possible through the activities of producer groups and civil society organisations focussed on environmentally friendly and local production. These organisational forms allowed for sharing of knowledge and developing diversification-based marketing strategies.

Improved horizontal coordination may be able to take over some of the currently lacking services and investments described in earlier sections. Cooperatives can mobilise farmers, invest in machinery, create and gain access to new market outlets, and negotiate with buyers (FAO, 2018; Le Bail et al., 2014). For example, a French cooperative was able to create a new value chain for lentils for human consumption that consequently allowed for the intercropping of lentils and wheat at field level. The cooperative invested in specialised sorting machinery, packaging and brand development, and hired highly-skilled personnel and set up a technical advisory services (Meynard et al., 2017). Single farmers are unlikely to make such investments due to insufficient returns on investment for just one farmer (Casagrande et al., 2017). Other cooperatives have implemented incentive structures to overcome obstacles in collection and storage of minor crops, such as incentivising farmers delivering their crop themselves or clustering of collection geographically (Meynard et al., 2013). Cooperatives dealing in particular minor crops also invest in research on the crop. Another cooperative in France that trades in lupin flour, maintained research into seed selection for the crop; a third is supporting research into chickpeas' ecophysiology and selection (Meynard et al., 2013). There are also examples of cooperatives taking over the development and distribution of technical references and support, and training schemes aimed at farmers, advisors and technicians at storage sites (Casagrande et al., 2017; Meynard et al., 2013). Generally, cooperatives and farmers' networks seem to be important sources of information and advice in adoption processes, e.g. to share knowledge on diversified cropping systems, marketing techniques and additional technologies. Having access to this knowledge is crucial for farmers to adopt new practices (Basch et al., 2015; Borges et al., 2017; Borremans et al., 2018; Bowman & Zilberman, 2013; Calatrava & Franco, 2011; Carmona et al., 2015; Casagrande et al., 2017; Ingram, 2010; OECD, 2001; Rodriguez-Entrena & Arriaza, 2013; Roest et al., 2018). Additionally, if farmer groups can distribute unbiased quantified knowledge on comparative financial performance, as well as share credible first-hand experiences, e.g. of 'lead farmers', their effectiveness in enabling and consolidating diversification strategies increases (Le Bail et al., 2014; Meynard et al., 2013; OECD, 2001). It is important to point out that a lack of knowledge and skills also implies a financial cost as it costs time and money to acquire additional knowledge. This affects the relative costs and benefits of adoption (Long et al., 2016). Reducing these costs may be an important contribution made by farmer groups. Yet, farmers' decision may be influenced by perceived, rather than objective, performance. This perception can also be determined by external actors such as technical advisors (Long et al., 2016). Particularly if advisory services are focused on conventional agriculture, they are unlikely to be able or willing to support conversion to alternative systems (Lamine & Bellon, 2009). Close links to opposing external actors may limit the effectiveness of proposing farmer organisations.

However, while this shows that farmer groups can improve the flow of knowledge to improve technical performance of diversified farms, a challenge to forming horizontal organisations among farmers can be that particularly farmers embracing new, more sustainable farming systems, such as biodynamic or organic farming, are likely to be a marginalized group among their peers. These farmers are often opposed to the conceptions and paradigms of mainstream farmers and tend to have closer relationships with their customers and consumers, rather than other farmers (Lamine & Bellon, 2009). This may also apply to farmers embracing diversified farming systems. Competing views and interests can obstruct collective action and marketing (Roest et al., 2018). Further, any circulation of knowledge can be difficult to achieve if farmers are unwilling to cooperate and share knowledge because they take pride in "doing things 'better' than others (Roest et al., 2018, p. 228).

Farmer organisations can also play a role in helping farmers break out of the cognitive lock-in. Borremans et al. (2018) suggest that farmer organisations could be "frontrunners" in promoting diversified farming systems due to their frequent contact and high credibility with farmers. However, as long as they subscribe to the paradigm of conventional farming themselves, they are unlikely to promote change (Borremans et al., 2018, p. 214). In that sense, such organisations can enable or impede the implementation of diversification strategies depending on their views, interests and aims (Borremans et al., 2018). Even if not opposed to concepts of diversification, farmer organisations may also take a very cautious approach and refrain from advocating diversification if particularly financial and productivity effects are not sufficiently clear to them (Borremans et al., 2018).

Supportive networks do not need to be limited to the participation of farmers and their organisations. It can be fruitful to include other actors from inside and around the value chain, such as researchers, buyers and processors, civil society and policy makers (Borremans et al., 2018). Such divers networks may allow for the integration of different types of knowledge needed to develop complex and long-term innovations such as diversification (Louah et al., 2017). Particularly, the private sector and agricultural advisors are currently often lacking from these types of networks (Borremans et al., 2018). Also Le Bail et al. (2014) point out the importance of including a divers set of actors in these types of networks. According to them the participation of actors in research and breeding is particularly important. However, cooperation can be especially challenging when actors do not know each other well (Meynard et al., 2017). This may be more likely if actors are divers and would also lead to limited willingness to share (sensitive) information.

Additionally, when there are existing networks that focus on dominant crops, diversifying into minor crops implies the loss of benefits that these networks bring. An example for this is cooperative unions that deliver market analysis services to its member organisations who may rely on them, but only for major crops. These services are not available for minor crops. This lack of support creates an obstacle (Meynard et al., 2013).

At times, more general regional cooperation is needed. Some biological or agronomic solutions for plant protection of minor crops need to be applied through collective management at regional scale which can be challenging to implement (Le Bail et al., 2014). Being the only producer of a particular crop in the region bears additional risks as fields may then be the sole attraction for certain pests (Meynard et al., 2013). Regional coordination may also be useful for cooperation between arable and livestock farms. This could imply an outlet for grain legume for animal feed as well as a source of manure for arable farms (Havet et al., 2014; Watson et al., 2017). This local sourcing of feed is even required for organic farmers according to EU regulations which provides incentives for farmers to grow grain legumes when situated near to organic

livestock farmers (Watson et al., 2017). However, there has been a trend towards regional specialisation due to agglomeration benefits, some cost advantages and policy incentives (Roest et al., 2018). If situated in a highly specialised region, farmers may struggle to diversify as it may lead to a loss of these benefits. Conversely, Lahmar (2010) states that when conservation agriculture practices, which include diversification, were well introduced and adopted by some farmers in areas of Spain, their adoption spread swiftly throughout the region. This highlights the importance of the existence of adopters in farmers' networks.

In conclusion, it seems that horizontal organisations and networks can be effective enablers of farmers' diversification strategies. Yet, this appears to only be true if these networks are actually in favour of and supporting such strategies which only seems to be the case if they are set up by like-minded farmers particularly with the aim of supporting trajectories of sustainability and diversification. If that is not the case, farmers' networks may actually have quite the opposite effect by re-enforcing technological and cognitive lock-in. Overall, farmers' existing commitments to actors in their network can be a barrier to changes in practices and products. These relationships are thus an important aspect to analyse when assessing a farmer's value chains (Lamine & Bellon, 2009).

4. Value chain typologies and their conduciveness to diversification

This chapter presents the diversified value chain typologies developed based on the results of the literature analysis. The framework summarises the enablers and barriers that emerged from the literature and transforms them into a general tool for value chain analysis. The developed typologies illustrate value chain structures that supporting or impeding crop diversification.

4.1. The framework

As a first step a framework of analysis was devised based on the literature analysis on value chain characteristics conducive or impeding crop diversification. The aim of the framework is to enable the evaluation of existing European value chains and identify potential barriers and enablers within these chains. The framework can be applied to all pedo-climatic regions as it focusses on value chain actors and coordination independent of local environmental conditions. The identified dimensions based on the literature are ***proximity***, in terms of geography and chain length; ***quality*** in relation to standards and innovation; and ***relationships*** of the vertical and horizontal nature. The framework is illustrated in Figure 4.1 and the rationale with regard to diversification is summarized in Table 4.1.

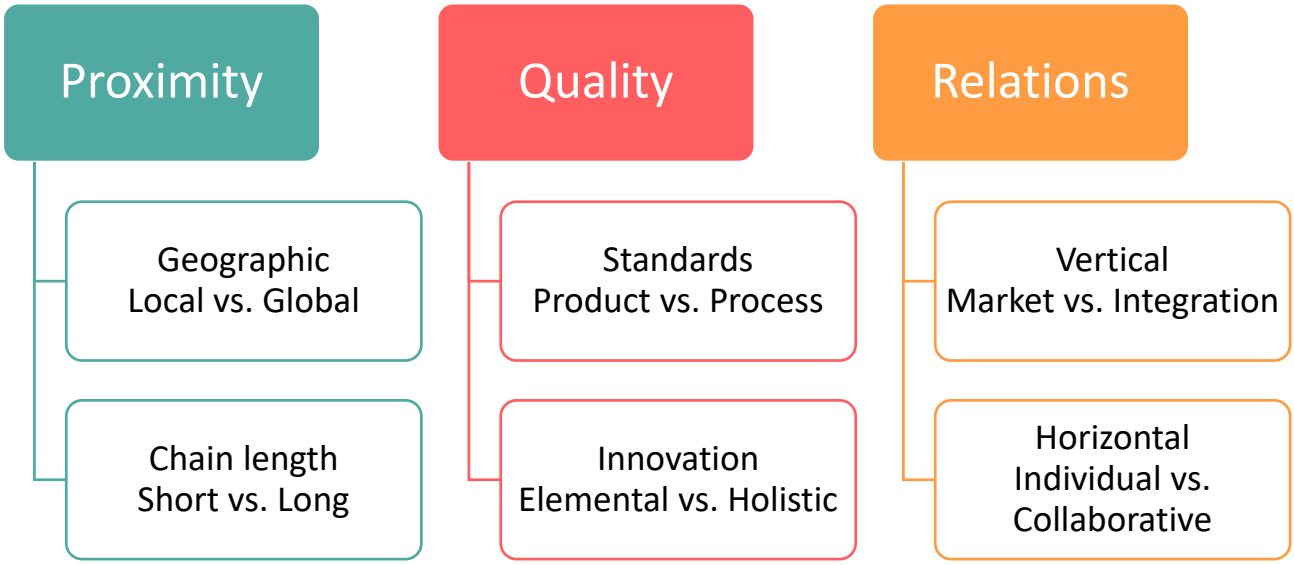

Figure 4.1. Dimensions within value chain typologies

Table 4.1. The value chain dimensions and their rationale

Dimension	Category	Specialised chain	Diversified chain	Reasoning
Proximity	Geographic	Global	Local	The further chain actors are apart, geographically and culturally, the more difficult it becomes to communicate and implement changes in processes.
	Chain length	Long	Short	The more steps in a supply chain between the farm and the consumer, the more actors need to be involved in coordinating and communicating changes.
Quality	Standards	Product	Process	Product-oriented standards can be measured on the product (e.g. protein content in grains) and are often associated with commodities where no further assurance is needed beyond the product itself. Process-oriented standards cannot be measured on the product but have to be assured differently, e.g. certification. Process standards largely refer to credence attributes, such as sustainability, fair working conditions, etc. Diversified production could be such a credence attribute for sustainable production. Chains that are already used to this type of transaction could more easily adjust.
	Innovation	Elemental	Holistic	This category focusses on the dominant paradigm in a value chain with regard to innovation. If actors in the chain are used to innovating incrementally, e.g. applying new technologies to the same processes, switching their entire production system to a diversification strategy would be difficult. If actors have a perception of more systematic and holistic innovation, e.g. because they have previously switched to, for example, organic production, stepping over to diversified production with all its implications could be easier.

Relations	Vertical	Market	Integration	Integrated value chains are likely to favour diversification due to more equal risk sharing, improved regularity of supply, agreements on quality standards, knowledge and information exchange, improved traceability and the associated appreciation of credence attributes, and better transfer of added value.
	Horizontal	Individual	Collaborative	Farmers that are already used to working with others, particularly when marketing products or sharing knowledge, could make use of these connections when diversifying. Diversified farmers may collaborate with other farmers to deliver a constant supply of a product to buyers, even if the individual farmer is not currently growing that particular product.

4.2. Typologies

Based on the identified dimensions one can devise value chain typologies. It is hypothesised that certain characteristics are more likely to appear in combination and thus lead to only four illustrative types that actually exist on a continuum between specialisation and diversification. These types are described in Table 4.2. It is suggested that the more the focal farm's current value chains carry characteristics of diversified chains, the easier it should be for the farm to adjust its value chain(s) to a diversification strategy.

Table 4.2: Value chain typologies

Type of value chain	Dimension of diversification	Governance	Example
Highly specialized	Global, long, product-oriented, elemental, market coordination, individual farmer	Spot market, commodities	Global commodity markets
Integrated specialized	Global, long, product- and **process-oriented**, elemental, market coordination, individual farmer	Certification, preferred supplier contracts, still anonymous	Global markets of certified organic products
Integrated diversified	Local, long, product- and process-oriented, elemental**, integrated coordination, collaborative**	Relational, collaborative contracting	Diversified, high-quality products based on sustainability and locality claims with well integrated chains
Highly diversified	Local, **short**, process-oriented, **holistic**, integrated coordination, collaborative	Direct marketing, cooperatives/ associations	Coordinated cooperatives sharing a vision of transforming the agri-food system towards sustainability, supplying local organic stores and consumers

5. Conclusion

In this report we have identified the main issues related to crop diversification. Based on an extensive literature review few key points have been presented and discussed. Firstly, crop diversification needs to be understood from a multi-level perspective: farmers may decide to adopt and further spread CDPs based on considerations at crop, farm, value chain and wider context level. In the current configuration of agri-food value chains, in fact, CDPs are not mainstream practices, and still constitute a niche of innovation which often is blocked by system-related aspects. For example, farmers are often locked-in within conventional value chain structures, particularly with regard to input suppliers, advisors, buyers and farmer organisations, "which are causing tunnel vision and blocking new information from entering" (Borremans et al., 2018, p. 213). This makes it difficult for farmers to get access to the knowledge and information they need in order to branch out into diversified farming systems.

Therefore, to understand this complexity and the tensions between conventional and diversified farming systems we have adopted explicitly the point of view of a multi-level perspective and combined it with a netchain approach, in which both vertical and horizontal relationships are considered to understand adoption and diffusion of CDPs. This approach has led to the identification of three key dimensions to evaluate diversification and to define typologies of diversified value chains.

The first dimension refers to the concept of proximity. Crop diversification, and more in general CDPs, are more likely to be adopted and diffused when chains are short and the relations between actors are tied and embedded in local markets and/or connected to products with a geographical scope or origin. The second dimension deals with quality considerations. Product and process quality standards are often designed and developed to fulfil the needs of monoculture-based or less diversified farm systems. As such they might tend to become a barrier for crop diversification since they might introduce elements of risk and uncertainty that are not encouraging the process of adoption and diffusion of CDPs. Quality also refers to the type of innovation introduced, and whether or not the farmers understand diversification as an elemental or more system/holistic change of the overall farm system management. Often CDPs imply systemic changes and a wider approach to innovation which again may turn into a set of barriers to crop diversification. The final dimension takes into account the vertical and horizontal relations in the value chains and the wider contexts. Contracts, arrangements, partnerships and cooperative relations do play a key role in shaping farmers decision to diversify and eventually to adopt CDPs. We have identified several sources of bottlenecks in the adoption process due to both upstream and downstream chain issues as well as the role of more horizontal relations, for example the role of cooperatives and farmers associations in supporting and facilitating adoption processes.

Our approach has also identified typologies of value chains that are more likely to be associated with adoption and diffusion of CDPs. At the current state of the art it seems unlikely that globalised value chains, oriented to the production and distribution of agricultural commodities, may constitute the institutional and organizational environment in which CDPs can be expected to be adopted. Instead globalised value chains specialised in the production and distribution of certifiable diversified crops, may constitute a more favourable context for adoption and diffusion of CDPs at international level. It is in fact the adoption of certification protocols and labels connected to forms of quality standards that might ensure CDPs to be adopted at that scale. Our analysis highlights that more localised and relational-based chains are those fostering conditions

to the adoption and diffusion of CDPs. They are still niches in a wider context in which CDPs are facing severe limitations in the adoption and diffusion process.

The framework and typologies that we have identified represent an interesting starting point to develop ideas and strategies to conceptualise and implement actions to further support adoption and diffusion of CDPs. Our typologies can be understood as working propositions that will need to be verified within the process of the Diverfarming project based on their application to the participating case studies. According to what we have found in the literature there are three lines of inquiries and interventions that can be developed. First, there is a need to better understand the organisational innovations that can be introduced to facilitate adoption and diffusion, working in the existing bottlenecks of both downstream and upstream contractual relationships between farmers, input providers, and buyers. Second, there is a need to further explore the potentials of adoption and diffusion mechanisms in internationalised value chains and how to implement quality standards and certification schemes to support these processes. Finally, CDPs need to be more clearly connected to innovation strategies which entail systemic changes. Although often CDPs are of concern to a single farmer and take the shape of a practice implemented at field or farm level, as we have indicated they are intertwined with a set of changes that involve multiple levels and perspectives. These are also connected to organisational and institutional changes, thus implying an interconnection between these three lines of inquiries and experimentations which will be the focus of the Diverfarming project for the years to come.

In practical terms the project will need to experiment novel organisational and institutional approaches to design value chains enriched with horizontal relations, with a new set of standards and/or certification processes, and knowledge-based and systemic-oriented innovation strategies. These will need to be discussed and implemented with stakeholders, and particularly farmers, thus identifying a multi-actor oriented co-designing and co-creation approach to crop and farming system diversification.

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