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Innovation in Agri-food Systems – A Systematic Mapping of the Literature

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ABSTRACT

This study systematically explores, analyses, reports on and synthesises research on the topic of sectoral innovation systems related to agriculture and agri-food in OECD countries. It is based on systematic mapping of the literature (academic papers published in scientific journals) in the period 1997-2017. The aim is to show the state of current knowledge on sectoral innovation systems in agri-food, in order to identify knowledge gaps and future areas for research and provide methodological and theoretical perspectives. Abstracts for a total of 320 papers were analysed, using a qualitative approach. Key elements of agricultural innovation systems identified were organised into 8 main themes/topics: agents, basic technologies, knowledge and learning processes, mechanisms of interaction, institutions, end-users, system transition and contextual variables. Areas identified as requiring research included making the sector more consumer- and market-oriented, increasing interactions outside conventional system boundaries, including the consumer perspective and societal changes, and determining the role of gender in innovation in agri-food systems.

Keywords: *Agri-Food; Agriculture; Innovation systems; Agricultural knowledge and innovation system (AKIS); Systematic mapping*

1 Introduction

The agricultural knowledge and innovation system (AKIS) currently manages knowledge dissemination from universities and research institutions in a linear fashion, through different forms of advisory services for end-users in agriculture and agri-food (e.g. farmers or the food industry). Innovation and innovation management are widely studied topics, but few such studies have specifically targeted the case of agriculture and agri-food (Baregheh et al., 2012; Caiazza, 2015). In addition, there are challenges in transferring results from research into practice and in channelling practitioner demand for knowledge into research and advisory agendas (Dockès et al., 2011; EU SCAR, 2012). The existing knowledge and innovation system in the food sector is now changing and is also under pressure from critical food system challenges such as issues of food security, climate change, biodiversity losses and a need for increased circularity (see e.g. Garnett, 2011; Ingram, 2011; Sabaté et al., 2015; Vittersø and Tangeland, 2015; Jurgilevich et al., 2016; Govindan, 2018; Willett et al., 2019). This stresses the importance of innovation to meet future challenges and of developing ways to facilitate innovation and strengthen knowledge processes in the agri-food system.

The AKIS consists of the many actors involved in the agri-food system. Using the AKIS as a contextual frame, it is possible to describe the roles of these actors and how change and transformation of the system may occur. Dockès et al. (2011) identify the main categories of actors within AKIS as: 1) information and knowledge system actors (including research institutions, advisors, schools, farmers' unions), 2) socio-economic system actors (farmers, food processors, networks), 3) public decision-making system actors (authorities at regional and local level), and 4) end-user actors (consumers, NGOs). Some other actors may also operate between research and practice dealing with innovation, acting as innovation brokers (Batterink et al., 2010) or change agents (Rogers, 2003). However, the AKIS is not an isolated entity and, like most systems, interacts with the external environment, see e.g. Ison (2010) on systems practice and Ingram (2011) on the special case of food systems. Tentatively, external effects may derive from the ecological (e.g. biological and geological effects, climate change), social (e.g. societal changes, culture) or economic (e.g. financial markets, demand, policy, market structure) environments.

In agricultural productivity research, the AKIS has difficulties in transferring appropriate new knowledge to the agricultural sector. Problems include actors in the research environment influencing research and development issues in a way that does not reflect farmers' innovation needs or address users' needs (Klerkx and Leeuwis, 2008; Martin et al., 2011), gaps and knowledge differences between researchers and practitioners (McCown, 2001; Thompson and Reeve, 2011) and sub-optimal institutional and policy arrangements (Hunt et al., 2014; Ciliberti et al., 2015; Klerkx et al., 2017). Agricultural research thus appears to target the wrong research issues and there is a low degree of innovation and low competitiveness in the agricultural sector (Dockès et al., 2011; European Commission, 2016a). There are also long lags from research to economic impact (see e.g. Renborg, 2010; Sun et al., 2016). This implies that conventional knowledge chains may be ineffective and that other forms of dynamic knowledge transition and translation are needed to enhance the rate and speed of innovations within the agri-food sector.

The Organisation for Economic Co-operation and Development (OECD) conducts national reviews on AKIS in OECD countries and uses the results as a basis for policy recommendations. For example, it has reported on innovation, agricultural productivity and sustainability in the Netherlands (OECD, 2015a), Australia (OECD, 2015b), United States (OECD, 2016) and Sweden (OECD, 2018). While the OECD evaluates national systems and makes policy recommendations, national governments decide upon and implement policies. In a European perspective, the European Union (EU) has worked on AKIS through the Standing Committee on Agricultural Research (SCAR-AKIS), which concluded that the old linear model of technology transfer from scientists to users should be replaced by a more interactive model of systems integrating knowledge production, adaptation, advice and education (European Commission, 2016b). The agricultural innovation partnership programme (European Commission, 2012) is a response to this. The "EU Framework Programme for Research and Innovation Horizon 2020, research agenda for agriculture" seeks to encourage cooperation across basic and applied research disciplines, researchers, practitioners, businesses and other stakeholders, to overcome the long time lag from research to practice (European Commission, 2014). The framework "FOOD 2030: Research & Innovation for Tomorrow's Nutrition & Food System" also recognises the lack of a food system approach in food and nutritional security research and lack of innovation policy coherence and coordination (European Commission, 2016a).

With the OECD, EU and national bodies proposing and implementing policies affecting AKIS, research on the prerequisites for establishing a successful and effective system is needed. This calls for knowledge on how the sectoral innovation system can be better integrated and how its constituent elements can best

facilitate knowledge exchange, transfer and translation within the agri-food sector in order to meet present and future challenges. The gaps in the current AKIS can be tentatively attributed to lack of knowledge within firms on how to implement innovation processes, how new information can be communicated and translated from research to practice, and how responsibilities and risk taking are distributed within the system. This raises questions about the roles other intermediaries and actors should take and, not least, about the future structure of the AKIS.

The aim of this study was to systematically explore, analyse, report on and synthesise research on the topic of sectoral innovation systems related to agriculture and agri-food. Specific objectives were to determine variables important for supporting innovation in the sector and thus increasing its competitiveness; to identify knowledge gaps in research; and to assess the implications for research policy and practice and suggest areas for development and improvement. Relevant literature was identified through systematic mapping in combination with exploratory analysis.

2 Theoretical background

The AKIS is a sectoral system of innovation, which is defined by Malerba (2002:250-251) as *"a set of new and established products for specific uses and the set agents carrying out market and non-market interactions for the creation, production and sale of those products. A sectoral system has a knowledge base, technologies, inputs and an existing, emergent and potential demand".* The basic elements of a sectoral system in Malerba's conceptualisation are products, agents, knowledge and learning processes, basic technologies (inputs, demand and related links and complementarities), mechanisms of interactions (both within firms and outside firms), processes of competition and selection, and institutions. Within the related analytical and methodological discussion, Carlsson et al. (2002) review various concepts of innovation systems, e.g. national innovation systems (NIS), regional innovation systems (RIS) and sectoral or technological innovation systems, and define a system as consisting of: 1) components (i.e. operating parts such as actors, organisations, artefacts and institutions), and 2) relationships (links between the components). Carlsson et al. (2002:235) argue that the function of an innovation system is "*to generate, diffuse and utilize technology*", with the implication that "*the main features of the system are the capabilities (together representing economic competence) of the actors to generate, diffuse and utilize technologies (physical artefacts as well as technical know-how) that have economic value*".

According to Geels (2004), the systems of innovation (sectoral system) approach has a strong focus on development of knowledge, but pays less attention to diffusion and use of technology, impacts and societal transformations. Geels (2004) discusses the dynamics of socio-technical systems as sectoral systems of innovation in transition and co-evolution of technology and society. He concludes that the approaches adopted by Carlsson et al. (2002) and Malerba (2002) share an emphasis on interlinkages between elements, with innovation as a co-evolutionary process, and states that the user environment (i.e. the demand side) should be included in the definition of innovation system. Geels (2004) also points out that the linkages between basic elements suggested by Malerba (2002) need to be better understood, that institutions need to be considered more thoroughly and that issues of system change need to be addressed.

In the dynamic framework of Geels (2004), economic activities and processes are interrelated with transforming sociological structures, where attention in long-term analysis should be paid to social learning and institutional change. Carlsson et al. (2002) suggest that the dynamic properties of the system (robustness, flexibility, ability to generate change and respond to changes in the environment) are among its most important attributes. Geels (2004) claims that a systems of innovation approach need to explicitly incorporate the user side in the analysis, widening the unit of analysis from sectoral systems of innovation (focused on the production side) to socio-technical systems, including co-evolution of technology and society and emphasis on the role of institutions. Geels (2004) proposes three interrelated analytical dimensions: 1) Socio-technical systems; 2) rules and institutions that guide actors' perceptions and activities; and 3) human actors, organisations and social groups (end-users). In a later contribution in the context of sustainable production and consumption research, Geels et al. (2015) propose a new re-configurational position focusing on transitions in socio-technical systems towards new systems. It follows that system analysis has to consider the constant transition and evolution of a system, and that there may be different future development directions or trajectories of the system.

3 Analytical framework

The analytical framework used in the present study for mapping the literature was based on components derived from the theoretical frameworks of Carlsson et al. (2002), Malerba (2002), Geels (2004) and Geels et al. (2015). These yielded seven of the main elements included in the framework (Table 1): 1) Agents in the system (firms and non-firm organisations) (Malerba, 2002; Carlsson et al., 2002); 2) basic technologies, input, demands (for knowledge) and related complementarities (Malerba, 2002); 3) knowledge and learning processes (Malerba, 2002; Carlsson, 2002) and diffusion of knowledge and technology (Carlsson, 2002; Geels, 2004); 4) mechanisms of interaction (Malerba, 2002; Carlsson, 2002); 5) institutions (Malerba, 2002; Geels, 2004); 6) end-users (consumers and related groups) (Carlsson et al., 2002; Geels, 2004); and 7) system transition and innovation trajectories (Geels, 2015). The framework also included 8) contextual variables, to cover interactions with society and external influences (Ison, 2010; Ingram, 2011). In addition; 9) other system typologies; and 10) other elements, were added.

As the systematic mapping was limited to the agriculture, food and agri-food sector, the basic element of "products" in sectoral systems of innovation according to Malerba (2002) comprised products from the whole food value chain from primary production at farm level to processing, distribution and marketing of food. This 'products' variable was used as one of the inclusion criteria in systematic mapping (see Material and Methods section). The "basic technologies" element in Malerba (2002) was not mapped, as these technologies can be considered an integral part of the agri-food system and were outside the scope of the study.

Table 1.
Analytical framework used in mapping the literature, showing the 10 basic elements/themes used for categorisation. (AKIS = agricultural knowledge and innovation system, RIS = regional innovation system)

Basic element/theme used for categorisation	Note
1) Agents (firms, non-firms, individuals, universities)	The agents were actors in the AKIS. Types of actors were mapped, as were their roles, characteristics and behaviours.
2) Basic technologies, inputs, demand (for knowledge), and related links and complementarities	The point of departure was that the AKIS covers certain technologies and inputs and that users in the AKIS have a demand for knowledge and technologies. Basic technologies (and products) were not mapped here.
3) Knowledge and learning processes, diffusion and use of knowledge and technology	This category includes factors affecting knowledge building and elements of capabilities (selective/strategic capability, organisational/ coordination ability, functional ability and learning/adaptive ability) and processes of knowledge and technology diffusion in the AKIS.
4) Mechanisms of interaction	The focus in mapping was not primarily the mechanisms of interaction *within* firms, but the interactions between firms and other actors in the system, and interactions between actors in the system that do not necessarily include a producing firm. Networks, governance of networks and processes of co-innovation were included.
5) Institutions	Institutions include standards, regulations, labour markets etc., and conventions, norms and culture. The role and effects of policies and (governmental) agencies were also included.
6) End-users (consumers and related groups)	End-users comprise both demand and interactions with customers and consumers, but market conditions (as a contextual variable) were also included.
7) System transition and innovation trajectories	This category includes transition at different system levels or contexts (e.g. food system transition, societal transition, sustainability transition), co-evolution, regime changes, niche development, trajectories or path dependency.
8) Contextual variables	The role of different contextual variables (e.g. biology, sustainability, production system, spatiality).
9) System typology/studied system	RIS, cluster, etc.
10) Other	Aspects not covered by the other categories.

4 Materials and methods

The primary objective of the analysis was to identify variables on systems level that affect knowledge building, learning, innovation development or/and improvements in innovation capabilities in the agri-food sector. The analysis was based on mapping of relevant literature (academic papers in scientific journals) published in the period 1997-2017. Following systematic mapping, the papers were analysed on abstract level by extracting the key elements studied. A qualitative approach was used and the 10 different themes/topics in the analytical framework were quantified based on the number of papers in which they were included.

Systematic mapping, which sets out to describe the state of knowledge on a question or topic, was performed using an established procedure for systematic reviews (e.g. Higgins and Green, 2011; Shea et al., 2009). However, the question in a mapping study may be more open and broader than that covered in a systematic review, and there are fewer limitations on the types of articles that can be included. The mapping method can be used to obtain evidence on e.g. policy-relevant questions, to fill knowledge gaps or for knowledge cluster and evidence synthesis. The data are usually catalogued in a database (see e.g. Haddaway et al., 2016; James et al., 2016). A stage-wise procedure for systematic mapping proposed by James et al. (2016) was employed in this study (Table 2).

Table 2.
Stages in the mapping process following James et al. (2016) and measures taken

Stage	Measure taken
1. Establishing the review team and engaging stakeholders	Two researchers were involved in the mapping, working in parallel, while a third team member was responsible for establishing a reference group from industry and stakeholders. A team at the university library was involved in developing a search strategy.
2. Setting the scope and question	The scope and questions were set based on the background provided in the introduction. The scope was broadly a combination of agriculture/agri-food and innovation, in a time period of 20 years (1997-2017).
3. Setting inclusion criteria for studies	A set of inclusion criteria was established (see Table 3).
4. Scoping stage	Different sets of search variables and databases were tested. The first 200 items in this stage were checked, based on title and abstract, by two researchers working independently and then 'calibrated'. The search variables were adjusted to avoid excluding items relevant to the question.
5. Protocol development and publication	The list of inclusion criteria was extended and, concurrently, exclusion criteria were set. A protocol was developed after the first screening processes. The protocol has not been published, but follows the final database in Supplementary Material.
6. Searching for evidence	Using three databases (Web of Science, Scopus, CABI), initial items were collected (n=41,551).
7. Screening evidence	The collected items were screened step-wise: 1) Duplicates and incomplete references were removed, 2) non-relevant items based on title were excluded, as were studies from non-OECD countries, 3) records were excluded based on abstract and 4) further scrutiny of abstracts in the analysis phase revealed that some other papers were outside the scope.
8. Coding	Abstracts were read through in detail after the third screening step. Following the protocol (an Excel sheet that constitutes the final database), key elements of studies were recorded, along with a list of pre-set variables (country of study, method, type of data, product, theory, number and size of firms studied) if applicable and mentioned in the abstract.
9. Production of a systematic map database	The results from the coding phase were recorded in the Excel sheet constituting the final database.
10. Critical appraisal (optional)	Dubious studies and incomplete abstracts were removed in the screening phases, and other items were removed if deemed to meet any of the exclusion criteria.
11. Describing and visualising the findings	The data entered in the Excel sheet were analysed and, if possible, quantified. Using qualitative methodology, themes were categorised.
12. Reporting production and supporting information	This paper reports the findings from the study. Open Supplementary Material in form of the Excel data sheet and a 'meta-table' with all key-words categorised and unique identification numbers for each item (reference) is provided.

Procedure used for search, screening and selection

Two researchers worked in parallel on the mapping and received support from library staff at the Swedish University of Agricultural Sciences in selecting the search strategy and procedure. One team member coordinated a reference group representing industry, authorities and stakeholders in the AKIS. This reference group provided input on current issues in innovation in the industry and discussed and commented on the preliminary results in a workshop, as a way to broaden the conclusions and the impacts for policy.

Pre-testing of search strings led to a decision to apply a broad approach in the initial search, to reduce the risk of excluding relevant papers. Non-relevant papers were then removed later in the screening process, based on titles and abstracts.

The final search was made on August 1, 2018. The search strings used for each database (Web of Science Core Collection, Scopus, CABI) are shown in Appendix 1. The search period (second half of 2018) was selected to allow database indexing, which may lag behind the previous publication year. The initial number of papers yielded by the database searches amounted to 41,551 (Figure 1).

During the screening steps (Table 2), a set of inclusion and exclusion criteria was applied (Table 3). Besides limiting the mapping to a 20-year period (1997-2017), it was decided to limit the final mapping to studies in OECD countries, where economic conditions are more similar. As the study was funded by the Swedish government to provide data support for national research agenda and policy development and as the OECD conducted an evaluation of the Swedish AKIS during the same period (OECD, 2018), the latter criterion (no. 12 in Table 3) was deemed appropriate.

Table 3.

Inclusion and exclusion criteria used in screening. AKIS = agricultural knowledge and innovation system

Inclusion criteria
1. The paper concerns aspects of sectoral innovation systems in agriculture and agri-food.
2. The paper concerns knowledge transfer to agricultural firms, knowledge exchange and learning.
3. The paper concerns external functions supporting innovation processes in agri-food firms.
4. The paper concerns the functions of organisations and governance of/within the AKIS.
5. The paper concerns interactions between firms, actors in the sector, society and technology in the domain of innovation.
6. The paper concerns interactions with external environmental factors (e.g. market, policy, biological effects) on the sectoral system.
7. The paper concerns knowledge building, and learning in agri-food or transfer of knowledge.
8. The paper concerns successful or failed cases of innovation and the reasons behind the outcomes in the context of the role of AKIS.
9. The paper concerns policies facilitating and promoting innovation in agri-food and its effects on the sectoral system.
10. The paper describes competition and innovation on sectoral level.
11. The paper identifies a need for help from the AKIS to promote knowledge building and innovation in agri-food, based on firms' expressed needs.
12. The country in which the study was performed is an OECD member.
13. The paper is published in a scientific journal.
14. The paper is based on empirical data (primary or secondary).
15. The paper was published between 1997 and 2017.
Exclusion criteria
1. The language is not English.
2. The paper presents chemical, technical or biological details, not on firm or system level.
3. The paper describes development of innovative/novel products/processes/methods not tested in firms, not based on original empirical material.
4. The paper provides a description of novel probiotics/health products/technological solutions/inventions.
5. The paper concerns food sufficiency.
6. The paper describes farming practices.
7. The paper concerns wastewater/energy.
8. The paper presents historical descriptions with unclear supporting data.
9. The paper presents descriptions (cases) of "successful" research projects that do not provide original data.
10. The paper presents descriptions (cases) of "successful" regions/networks/policies/measures, without providing data.
11. The country in which the study was performed is not an OECD country.
12. The paper is a discussion or conceptual paper.
13. The paper is not published in a scientific journal (e.g. it is a book chapter, report, grey literature).
14. The paper is a review paper.
15. The paper focuses only on internal processes in the firm (innovation management) and not the AKIS.
16. The paper is a duplicate, has a missing/unclear/defective abstract, or describes a dubious study.

The items retrieved from the databases were screened stepwise by two researchers in parallel, who initially calibrated to each other by separately assessing the first 200 items. Papers for which the interpretations by the two researchers differed were thoroughly discussed and the inclusion and exclusion criteria were adjusted and refined to delimit uncertainties. Unclear cases were discussed by the researchers during the process, if necessary. The step of validating rigor and relevance of the selected papers (step 10 in Table 2) (Shea, et al., 2009; Ivarsson and Gorschek, 2011) was not performed in the initial mapping, as it was not possible to evaluate quality in depth on the basis of the abstracts.

A flow diagram showing the process of selection and funnelling toward the final items used in the mapping (n=320) is presented in Figure 1. All the items included were given a unique identification number, as shown in the open supplementary material (Swedish National Data Service, Dataset SND 1116-001, see further information in Appendix 2). The excel data file shows the list of items and items removed in the latest stage of the screening process, together with a note on the reason for exclusion. Items only pertaining to innovation at firm level, without special attention to sectoral systems or AKIS, were excluded from the mapping in the screening process and not given an identification number.

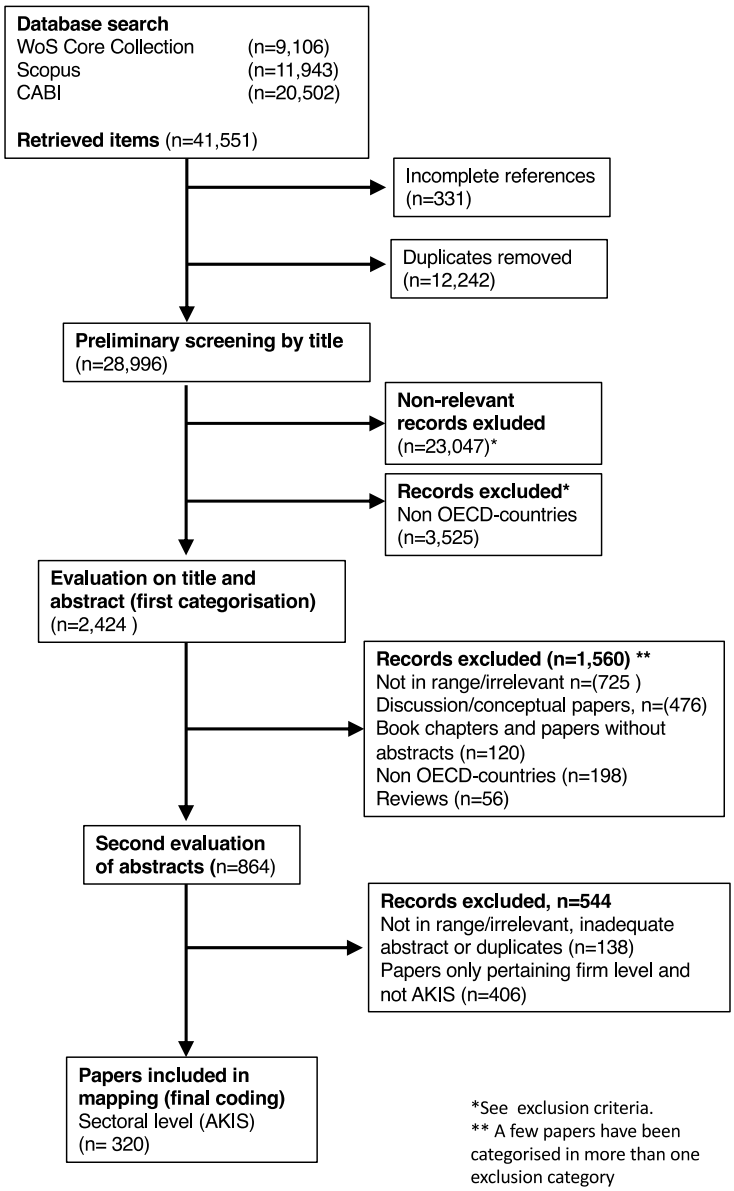

Figure 1. Flow diagram of screening and selection of final items in the mapping.

Coding/analysis

In the final step, the items selected for the mapping were entered into an Excel sheet that constituted the final database and analysed following a protocol. Based on availability of information in the abstracts, the following characteristics were noted: Period of study; country or countries of study; data type (qualitative, quantitative, mixed); data source (qualitative or quantitative); firm size; number of firms in the study; food product/category (e.g. agriculture, organic food, vegetables, wheat, dairy; food industry); research method (e.g. case study, econometric, survey); key elements and outcomes studied; theory/framework applied; and additional notes (not always applied). Papers meeting any of the exclusion criteria at this stage were removed and denoted "records excluded", as shown in the flow diagram (Figure 1). These items are still present in the database (Supplemental material), but separated from the other items, with a note on the reason for exclusion. It is worth reiterating that the selection was based on analysis of abstracts, and not full papers.

In the final stage, key elements in the items included were recorded, based on the abstracts. The key elements, subject or main findings were then summarised in a qualitative interpretation based on the abstracts.

The key elements were thematised and categorised following the thematic analysis method (Boyatzis, 1998; Knight et al., 2007), using the steps described by Seidel and Kelle (1995). These included noting relevant features, collecting examples of these and analysing them, in order to find commonalities, differences, patterns and structures. This process was performed manually, using an ordinary word processor and the recorded key elements from the Excel sheet. The elements were sorted following the theoretical framing (Table 1), and by adding sub-headings for more specific key elements.

The final synthesis in the mapping procedure included a variety of studies (qualitative/quantitative and based on different methodologies, theoretical approaches), but treated based on the key elements studied, and not on the way in which these were studied. The categorisation of key words/main elements, together with the unique identification number (provided in the open supplementary material, Swedish National Data Service, Dataset SND 1116-002, see further information in Appendix 2), made it possible to find the corresponding reference in the Excel data sheet.

5 Results

Following the systematic process of searching, scanning and finally deciding upon the studies to be included in the mapping following the inclusion criteria, 320 items were deemed eligible for inclusion.

5.1 Descriptive data of the studies

The number of published studies on the topic showed a gradual yearly increase, from a few papers per year in the beginning of 2000 to over 40 per year in the last years of the study period (Figure 2). This follows a similar increase in academic publication in general (Bornmann and Mutz, 2015).

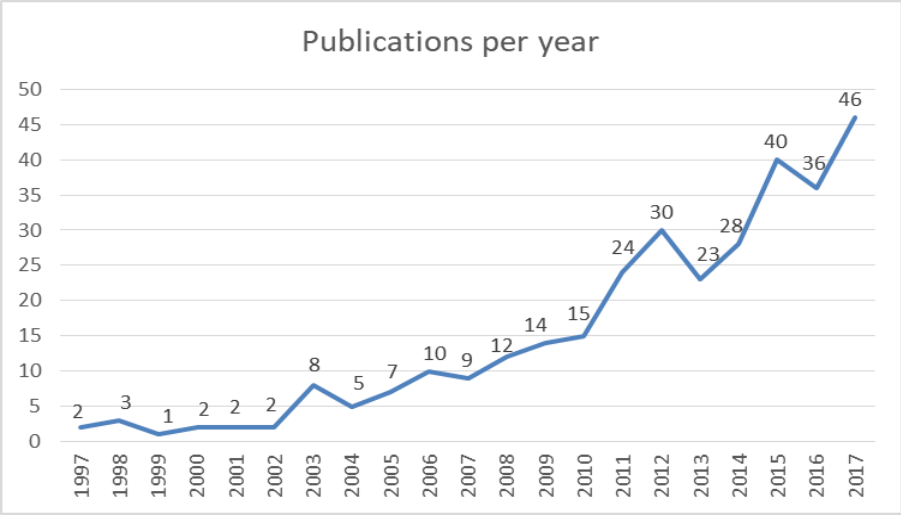

Figure 2. Change in the number of published papers on the agricultural knowledge and innovation system (AKIS) and sectoral systems related to innovation in agriculture.

The mapped studies were published in 165 different outlets, with an average of 1.9 studies per journal. The top journals for publication, representing one-third of the mapped studies on the topic, were: *Journal of Agricultural Education and Extension* (23), *Journal on Chain and Network Science* (13), *International Journal on Food System Dynamics* (11), *Agricultural Systems* (9), *British Food Journal* (8), *Food Policy* (8), *Studies in Agricultural Economics* (8), *Journal of Rural Studies* (7), *Outlook on Agriculture* (7), *Land Use Policy* (6) and *Research Policy* (6).

Based on the abstracts, 212 of the studies used primary data, 24 used secondary data and five used mixed data, while the character of the data in the remaining studies could not be determined. Among those specifying methodology, case study methodology was the most commonly used method (n=58), followed by interviews (n=51), surveys (n=39), econometric or sociometric analyses (n=37), participatory approaches and action research (n=16), workshops (n=8), observations (n=7) and focus groups (n=7). Some studies used mixed methods (n=27). The case studies included most probably used several different types of data. It is worth mentioning that, based on abstracts, it was not always possible to determine whether surveys were of a quantitative or qualitative character, or the data material on which "case studies" were built. Similarly, survey studies may include econometric or sociometric analyses. The majority of studies were performed for a single country, with the Netherlands, Italy, Mexico, USA and UK being most frequently represented (Table 4). Fifty of the studies covered multiple countries, mostly two or three countries.

Table 4.
Countries of studies*

Country	
The Netherlands (25) (+9)	Belgium (6) (+4)
Italy (22) (+9)	Canada (5) (+2)
Mexico (20)	Greece (3) (+3)
USA (17) (+1)	Switzerland (0) (+6)
UK (14) (+8)	Norway (2) (+3)
Australia (13) (+2)	Chile (3) (+1)
France (12) (+7)	Poland (-) (+4)
Spain (12) (+2)	Japan (3) (-)
Germany (11) (+5)	Finland (3) (-)
Sweden (10) (+4)	Other studies with multiple countries
New Zealand (8) (+2)	(not specified) (50)
Denmark (7) (+2)	n/a (67) (+8)

*The figure in the first set of brackets is the number of studies in which the country in question was the only country studied. The figure in the second set of brackets is the number of studies in which the country in question was studied as one of several countries. For example, there were 25 studies on the Netherlands alone, and an additional 9 studies on the Netherlands together with one or more countries (total n=34).

5.2 Content analysis/categorisation of key elements based on abstracts

The theoretical framing was adhered to when categorising the studies based on their abstracts. Table 5 provides an overview of the 320 mapped studies following the original components with added subcategories identified throughout the process. The category 'Other' (n=7) was added to include key words not covered by the other nine categories in the analytical framework. Each category is presented and discussed below and some examples are given of mapped items included in the category. Detailed results are not presented, as this was a mapping exercise and not a review.

The meta-table on key elements categorised (Swedish National Data Service, Dataset SND 1116-002, see Appendix 2) shows the specific coding for each item grouped into categories and subcategories, together with a unique identification number for each item. In the Excel file (Swedish National Data Service, Dataset SND 1116-001, see Appendix 2), each item is presented with the identification number, followed by full reference data, abstract, coding and eventual notes.

Table 5.
Categorisation of the mapped literature (n=320) based on the 10 main elements of innovation systems. (AKIS = agricultural knowledge and innovation system)

Key element/category	Number of studies
1. Agents	
Agri-food firms	101
Extension and advisory services	42
Universities and research institutes	17
Farmers' organisations	9
Educational organisations (other than university)	7
Innovation brokers and change agents	6
Market-related actors	1
Other stakeholders and intermediaries	19
2. Basic technologies, inputs, demands (for knowledge) and related links and complementarities	
Needs/demands (for knowledge and innovation support)	16
3. Knowledge and learning processes, diffusion and use of knowledge and technology	
Methods for knowledge transfer, education and training	49
Adoption (diffusion) of innovations	45
Learning	20
The role of the AKIS (generally for knowledge, learning and innovation processes)	20
Extension processes	17
Knowledge sources	10
Knowledge sharing and exchange	9
4. Mechanisms of interaction	
Networks	98
Specified networks/aim of network	*9*
Regional and local networks	*8*
Innovation networks	*3*
Social networks	*3*
LINSA (Learning and Innovation Networks for Sustainable Agriculture)	*2*
Governance of innovation and knowledge systems/networks	44
Governance and implementation	*31*
Governance of networks etc.	*9*
Organisation of innovation and knowledge systems	*9*
Strategies and visions	*6*
Risk management	*2*
Co-innovation and cooperation for innovation	31
Social aspects of AKIS/sector/network (social capital, trust, other)	19
Relationships	17
Value chain/supply chain relations	16
Interactions/cooperation between actors in AKIS/sector/network	15
System/network capabilities and capacity	15
Communication	8
Engagement	6
5. Institutions	
Policy (and public financing of AKIS)	32
Norms, conventions and culture	13
The role of institutions	7
6. End-users (consumers and related groups)	
Market conditions	6
7. System transition and innovation trajectories	
Transition and innovation/development trajectories	19
Socio-technical regimes/systems	18
Socio-technical niches	7
Path dependency	3

Table 5 (continued).
Categorisation of the mapped literature (n=320) based on the 10 main elements of innovation systems. (AKIS = agricultural knowledge and innovation system

Key element/category	Number of studies
8. Contextual variables	
Sustainability in agri-food and agricultural production systems	47
Regional characteristics/regional context	11
Production system (agricultural production) and natural resources context	10
Spatiality, proximity	3
Sectoral context	2
9. Other system typologies used	
Innovation system	23
Socio-technical system	18
RIS (Regional Innovation System)	11
Cluster	8
Agricultural/food system	9
10. Other	
Performance of research/impact of research	7

5.2.1 Agents

Based on the abstracts, specified agents at the innovation system level were identified. It should be noted that far from all studies specified "agent/s" in the abstract. The most common agents were found to be agri-food firms (firms related to agri-food or agriculture) (n=101), followed by extension and advisory services (n=42), universities and research institutes (n=17), and other stakeholders and intermediaries (n=19). The firm category was identified as the studies included therein primarily pertained to innovation at firm level and the relations between firms and the surrounding sectoral system. Given that the scope of the studies included in the mapping was related to innovation systems at sectoral level, it is most probable that if the full text were scrutinised, it would provide a more nuanced picture of agents in the systems. However, the numbers presented give an indication of what can be expected from the literature. The results indicate that the role of extension and advisory services and that of universities and research institutes in the AKIS is rather well studied, whereas the role of market-related actors is not (although there are some studies on the theme of supply or value chain relations within the category 'Mechanisms of interaction' (category 4).

5.2.2 Basic technologies, inputs, demands (for knowledge) and related links and complementarities

It was assumed that the sector has a technology and knowledge base. The mapping was not aimed at screening the literature on what basic technologies agriculture and agri-food encompasses. Inputs of new technologies and knowledge are covered in other categories in the mapping, particularly category 3 ('Knowledge and learning processes, diffusion and use of knowledge and technology'), which also includes different sources of knowledge. Only studies that pertained to needs and demands (for knowledge and innovation support) were included (n=16). This category covers many different aspects, such as general innovation demand (Cannarella and Piccioni, 2003), future skills and training needs (Jack et al., 2014; Sandrini et al., 2014) and demand for scientific and technical knowledge among firms in the sector (Pol and Visscher, 2010; Tveden-Nyborg et al., 2012; Gallego-Bono and Chaves-Avila, 2015).

5.2.3 Knowledge and learning processes, diffusion and use of knowledge and technology

This category regards the multi-faceted aspects of knowledge and learning processes and knowledge and technology diffusion. A large number of studies examined methods for knowledge transfer, education and training (n=49). These studies focus on different actors in the AKIS and the transfer of knowledge and technology, often through extension and advisory services, but also through education and other actors involved in supporting firms in agri-food with knowledge. The different methods studied include teaching, e.g. in vocational schools, colleges and universities (Reichardt and Jurgens, 2009) or 'farm schools' (Orozco Cirilo et al., 2008), participatory activities by different stakeholders (Gonzalez-Ramirez et al., 2005; Le Bellec et al., 2012), farm demonstrations and champion farmers (Risgaard et al., 2007; Takoutsing et al., 2014), good practice models (Morgan et al., 2003) and communities of practice and

exchange of experience (Hinton, 2003; Risgaard et al., 2007). There are also more diffuse descriptions in the abstracts, such as "'transmission of new ideas" (Oumarou et al., 2015) and "distribution of research, education and advisory services" (Lapple et al., 2016).

The second largest subcategory covers studies that in particular use the theory of adoption and diffusion of innovations (n=45), following the outline of Rogers (2003). A characteristic of many of these studies is that they concern adoption of novel production systems, for example organic farming (Parra-Lopez et al., 2007; Risgaard et al., 2007), novel production technologies (Hoes et al., 2012; Prager and Creaney, 2017) or precision farming (Reichardt and Jurgens, 2009; Reichardt et al., 2009). It should be mentioned that there is a relationship between knowledge and learning processes and diffusion and use of knowledge and technology, which makes it difficult to separate them into different categories. However, it appears that the issue of diffusion and adoption of new technology is well studied.

Closely related to methods of knowledge transfer was the subcategory 'The role of the AKIS in knowledge transfer' (n=20). This includes other forms of innovation systems, such as national or regional innovation systems, but with more focus on the issues of developing knowledge (Tisenkopfs et al., 2015; Geerling-Eiff et al., 2017) and innovation support (Morriss et al., 2006; Klerkx and Nettle, 2013). In contrast, the subcategory 'Extension processes' (n=17) contains studies on extension and advisory service processes in transferring knowledge, for example through "the education of extension" (Strong and Irani, 2011), different functions of extension (Monsalvo Zamora et al., 2017) and extension models and processes (Sewell et al., 2017).

The subcategory 'Knowledge sources' (n=10) contains studies from the agri-food firms' perspective on where they source information and knowledge (Batterink et al., 2006; Parra-Lopez et al., 2007; Gailhard and Bavorova, 2014). The subcategory 'Knowledge sharing and exchange' (n=9) includes studies on how knowledge in particular is shared and exchanged (Van Baalen et al., 2005; Wood et al., 2014).

The subcategory 'Learning' (n=20) refers to deeper studies into processes of learning, with the involvement of actors in the AKIS. Special cases cover e.g. reflexive approaches in learning (Alroe et al., 2017), lifelong learning approaches (Munchhausen and Haring, 2012) and co-learning (Quiedeville et al., 2017).

5.2.4 Mechanisms of interaction

In the category 'Mechanisms of interaction', networks as platforms for interaction are most widely studied. Almost one-third (n=98) of the mapped studies cover the role of networks in innovation or knowledge diffusion of any kind. Research almost unanimously indicates that networks facilitate innovation and innovation opportunities among their members (Colurcio et al., 2012; Shiri et al., 2015), through knowledge sharing and exchange (Klerkx and Proctor, 2013; Wood et al., 2014; Specht et al., 2016). Research also indicates that networks can raise members' innovation competence (Gellynck, et al., 2006) and innovation capacity (Kuhne et al., 2011; Kühne et al., 2015).

Some network research also focuses on network governance or management (n=44) (Munchhausen and Haring, 2012; Nettle et al., 2013; Brink, 2016; Pancino et al., 2016). However, this includes the governance of other more formal or informal network-like structures, for example co-operatives (Lins and Pires, 2011), university-industry relationships (Malik et al., 2011), clusters (Burress et al., 2008; Garbade et al., 2012) and the governance and organisation of regional and national innovation systems and the case of the AKIS (Sandall et al., 2011; Materia, 2012; Espejel-Garcia et al., 2016; Maietta et al., 2017). Some special types of network relations are also covered, e.g. supply or value chain networks and the governance of these relations (Gellynck and Kühne, 2008; Pol and Visscher, 2010; Vazquez-Casielles et al., 2013). It is worth highlighting two subcategories, in the governance of innovation and knowledge systems and networks, namely 'Strategies and visions' (n=6) and 'Risk management' (n=2), for which very few items were found.

Another form of interaction concerns the more concrete forms of 'Co-innovation and cooperation for innovation', often between fewer actors (or even in dyadic relationships) in the system. This subcategory (n=31) contains studies on processes of co-innovation and collaboration (Park et al., 2015; Cock et al., 2016; Vereijssen et al., 2017). The special case of co-innovation and collaboration with consumers is very sparsely described, although Kuhne and Gellynck (2010) point out the relevance of collaboration for innovation in the supply chain and Beckeman et al. (2013) show that very few firms in the food industry have such forms of collaboration.

From these broader categories, other subcategories regarding mechanisms of interaction were found to address e.g. 'Social aspects of AKIS, sector and networks' (n=19), including aspects of social capital

(Iivonen et al., 2011; Hunecke et al., 2017) and trust (Beckeman et al., 2013; Ruitenburg et al., 2014). The subcategory 'Relationships' (n=17) includes the role of relationships between actors in general (Chiffoleau, 2009; Lambrecht et al., 2015), and more specific areas such as relationship quality (Frykfors and Jonsson, 2010), power dependency (Elg and Johansson, 1997) and friendship ties (Gailhard and Bavorova, 2014; Enriquez-Sanchez et al., 2017).

The subcategory 'Interactions/cooperation between actors in AKIS/sector/network' (n=15) covers more general forms of interactions and cooperation within the system and some special cases of interaction between e.g. industry, universities and research institutes (Larsson et al., 2009; Henwood et al., 2017). The particular forms of 'value chain and supply chain relations' (n=16) have also been studied. This subcategory contains various aspects such as power relationships in the chain (Hoskins, 1998; Pol and Visscher, 2010), alternative and short supply chains (Chiffoleau, 2009; Chiffoleau and Prevost, 2012), new forms of collaboration (Matthyssens et al., 2008) and forms of governance structures (Wiersinga et al., 2012; Vazquez-Casielles et al., 2013).

The subcategory 'System and network capabilities and capacity' (n=15) includes aspects covering capabilities of the actors to generate, diffuse and utilise technologies, as described by Carlsson et al. (2002), as well as the capacity to innovate. Several studies focus on the role of networks and collaboration as a way to improve capabilities and competences (Zanquetto Filho et al., 2003; Vagnoni et al., 2016). The findings indicate that collaboration enhances innovation capacity among network members (Lambrecht et al., 2014; Kühne et al., 2015).

'Communication' (n=8) refers to more general communication between different actors (Morriss et al., 2006; Rossi et al., 2014), as clearly expressed in the abstracts. Many of the identified papers within category 4, 'Mechanisms of interaction', most likely also include communication, which may imply that the subcategory 'Communication' does not provide a full picture on this variable. Finally, the subcategory 'Engagement' (n=6) includes e.g. engagement between the education sector and industry (Jack et al., 2014), engagement among stakeholders (Blok et al., 2015) and engagement by firms in research (Morrissey and Almonacid, 2005).

5.2.5 Institutions

The main category 'Institutions' contains three subcategories. 'Policy and public financing of AKIS' is the largest (n=32), including studies covering a wide range of different policy instruments like the role of subsidies and support for innovation (Batterink et al., 2006; Taplin, 2012) and innovation networks (Hermans et al., 2016), regulatory context (Curry et al., 2012; Avolio et al., 2014) and support for research, education and extension (financing of AKIS) (Tokgoz, 2006; Coca et al., 2017; Midmore, 2017). The subcategory 'Norms, conventions and culture' contains 13 studies on the role of these types of institutions on innovation, e.g. the influence of values (Frykfors and Jonsson, 2010), norms (Hunecke et al., 2017), social barriers (Rodriguez et al., 2009) and culture (Henwood et al., 2017). Finally, papers in the subcategory 'The role of institutions' (n=7) do not always specify in the abstracts the type of institution studied.

5.2.6 End-users (consumers and related groups)

In the category 'End users, consumers and related groups' (n=6), the single subcategory 'Market conditions' includes aspects such as consumer demands (Wikstrom et al., 2016), food demand (Elg, 2008), market dynamism (Rodrigo-Alarcon et al., 2017) and market requirements (Ambrosius et al., 2015). It is worth noting the small number of studies considering the demand side and inclusion of consumers in the process of innovation at system level. However, these aspects may be covered in other mapped items (e.g. those related to the distribution or supply chain or to co-innovation or cooperation for innovation) that do not clearly describe the end-users in the abstract.

5.2.7 System transition and innovation trajectories

This category includes studies on socio-technical systems, system transition and innovation trajectories. The largest subcategory includes studies on 'Transition and innovation and development trajectories' (n=19). The items are rather diverse and may pertain to system transition (Yakovleva and Flynn, 2009; Elzen et al., 2011), often specifically focusing on sustainability transition (Roep et al., 2003; Alroe et al., 2017). A group of studies also focus on innovation trajectories (Allaire and Wolf, 2004; Klerkx et al., 2010), innovation journeys (Lambrecht et al., 2014) and processes of social transformation (Ely and Marin, 2016). The subcategory 'Socio-technical regimes' (n=18) follows a similar pattern, although the items more clearly express that the studies adhere to the theoretical framing of "socio-technical system" as described by Geels (2004). Some of the items are coded as describing industry, technology or sectoral regimes (Vanloqueren and Baret, 2009; Audet et al., 2017) and the relationships and interactions between regimes and niches (Ingram, 2015; Paschen et al., 2017). The subcategory 'Socio-technical niches' contains items specifically focusing on niche development, and is also included in the previous category. The final subcategory contains three items using the vocabulary of 'Path dependency'.

5.2.8 Contextual variables

Within the category 'Contextual variables', the subcategory 'Sustainability in agri-food and agricultural production systems' (n= 47) includes the most items. It covers topics such as sustainable farming practices (McCown, 2001; Roep et al., 2003; Rodriguez et al., 2009; Ely and Marin, 2016) and new and alternative production methods such as organic (Parra-Lopez et al., 2007; Quiedeville et al., 2017) and agroecological production systems (Ryschawy et al., 2016; Ortolani et al., 2017). 'Regional characteristics/regional contexts' (n=11) is the second largest area, with a focus on regional characteristics (Gellynck et al., 2006; Gellynck et al., 2007; Fernandez Aldecua and Vaillant, 2010; Avolio et al., 2014) and local conditions (Chiffoleau and Touzard, 2014). The subcategory 'Production system (agricultural production) and natural resource context' (n=10) includes certain production systems and practices (Vuylsteke and Gijseghem, 2012; Sutherland et al., 2017) and landscape management (Hermans et al., 2016). Finally, two minor subcategories, 'Spatiality and proximity' (n=3) and 'Sectoral context' (n=2), were identified.

5.2.9 Other system typologies used

All items in the mapping were identified as dealing with areas related to the AKIS. However, some of the items use other types of system typologies, which were also mapped here. These are 'Innovation system' (n=23), 'Socio-technical system' (n=18), 'Regional innovation systems' (n=11), 'Clusters' (n=8) and 'Agricultural, or food, system' (n=9).

5.2.10 Other

The final category includes seven items that mainly study performance (Deiters and Heuss, 2014; Espejel-Garcia et al., 2016) and the impact of research (Maistry et al., 2017; Midmore, 2017).

6 Discussion and conclusions

Research on sectoral innovation systems related to agriculture and agri-food was systematically explored, analysed and synthesised into categories. A total of 320 items identified by a process of systematic mapping were analysed in a qualitative process involving coding key elements in available abstracts. These elements were synthesised using an analytical framework, rendering a full overview of published research 1997-2017 and the main topics studied. This enabled identification of variables important in supporting innovation within the agricultural sectoral innovation system and potential areas for development and improvement.

The mapping revealed that some areas are rather well studied. Mechanisms of interaction, one of the main elements in sectoral systems of innovation, appear to be the most widely studied. The literature clearly shows the important role of networks and interactions for innovation within the agri-food sector, whereas other elements in the innovation system appear to be less well studied.

Research on innovation in the agri-food system often focuses on the existing boundaries of the system, i.e. existing agents are related to the conventional structure of the sector that involves "agricultural extension", "agricultural research", "agricultural infrastructure", "buyers of agricultural produce", but does not extend beyond sector boundaries. This is particularly apparent as regards the relation to end-consumers, where only six studies could be interpreted as considering market demand. The role of

customers and end-consumers as sources of innovation or as innovation partners was not covered by the studies identified in this mapping. Considering the proposal by Geels (2004) that the user side should be explicitly incorporated in the analysis, existing research on innovation in the agri-food system appear to be lacking. This could imply that the sector needs to be more consumer- and market-oriented in order to increase innovation and that it would benefit from more interaction outside conventional system boundaries. It is also possible that competence in this field needs to be strengthened. Research on the agricultural socio-technical system and system transition could consider the consumer perspective and societal changes to a greater extent, as our mapping revealed that studies on these are limited.

In the case of the agri-food system, biological aspects and the context of production systems were covered in the selected literature, but not in the theoretical frameworks used for the analysis (i.e. Carlsson et al., 2002; Malerba, 2002; Geels, 2004, Geels et al., 2015). This is possibly because these frameworks are based on other sectors where biological aspects are not influential. For example, innovation involving biological processes is highly dependent on natural and environmental circumstances such as soil, water, weather, climate, biotic and abiotic factors influencing plant growth, postharvest conditions etc.

Another under-researched issue is interactions with other types of industries or generally with actors not traditionally considered members of the agri-food system. This may inhibit the progress of innovation in the agri-food sector.

One aspect apparently not considered at all in the mapped literature is the role of gender in innovation in agri-food systems. Some of the mapped studies consider the influence of norms, conventions, culture and values, but it is not obvious that the role of gender is considered and how the innovation system behaves in relation to gender perspectives. These aspects may have been studied in other academic fields, but it is worth mentioning that in the present mapping, we found no research exploring the gender perspective in a, tentatively, male-dominated industry. In general, the low number of studies regarding gender, norms, values, culture and conventions in the sector in relation to innovation in the system indicates a need to broaden the field of research, in order to gain a better understanding of system functionality and how to improve the preconditions for successful innovation in the sector.

A number of studies identified in mapping address issues of sustainability, although mainly focusing on novel production systems such as “organic farming” or “agroecology”. The mapped items mainly focus on how farmers should change their practices and behaviours, and less on how other actors in the AKIS should act to support the sustainability transition. This is in line with the traditional linear system, where the producer is considered the final user of developed knowledge. In this respect, less attention is given to actors outside the sectoral system (such as consumers, interest groups and other societal actors). The mapped research on system transition, using the framework of “socio-technical systems”, possibly considers these aspects. Nevertheless, there are indications that research on innovation in the agri-food sector could benefit from a more interdisciplinary approach and draw on progress made in other sectors.

Much of the research on knowledge transfer and dissemination assumes a linear model where universities and research institutes develop knowledge that is transferred by extension and advisory services using a portfolio of communication tools (e.g. reports, newsletters, teaching, farm schools, trade press, advisory meetings). A few studies in the mapping used participatory methodological approaches, which include farmers as “co-researchers” and partners in identifying relevant problems. This is in line with the ambitions of new research programmes such as Food 2030 (European Commission, 2016a). An issue arising is whether such research will only benefit those farms or firms that are actively participating in research projects, or whether methods on disseminating results to ‘passive’ firms will also succeed. A striking aspect of the traditional linear knowledge transfer model is the gap between research and practice, which seem to be increasing. Associated problems identified are e.g. that research does not reflect farmers’ or users’ needs (Klerkx and Leeuwis, 2008; Martin et al., 2011), that there are gaps and knowledge differences between researchers and practitioners (McCown, 2001; Thompson and Reeve, 2011), that institutional and policy arrangements are not optimal (Hunt et al., 2014; Ciliberti et al., 2015; Klerkx et al., 2017) and that the institutions shaping organisations have remained static (Espejel-Garcia et al., 2016). New methods may be needed in the interaction between research and practice (e.g. sometimes described as participatory approaches in this mapping), but also in identifying and selecting the right research questions with implications for practice. It is possible that the academic culture and reward system does not prioritise applied research and collaboration with industry.

During the present mapping, a category on performance or impact of research was identified, although with a limited number of studies (n=7). Very little seems to be known about the effects of research on performance and innovativeness in the agri-food sector, indicating a need for further study.

The proposed analytical framework (Table 1) functioned well in mapping and analysis, although aspects such as 'products', 'the firm as an agent' and 'basic technologies' were not covered by the selection procedure. It is possible to consider these elements as part of the definition of the agri-food system. It would have been difficult to conduct a broader mapping in this study, owing to the number of items in the screening process and lack of available resources to analyse the material.

The method employed was based on the principles of systematic mapping, but refined so that abstracts were analysed in a qualitative way through the theoretical framework and synthesised accordingly. It is worth stressing that this was a mapping study, and not a review. However, the Supplementary Material and database could be used for in-depth studies on certain topics. As regards retrieval of data during searches, the chosen databases (Web of Science, Scopus, CABI) could have the limitation that studies presented in non-indexed journals are not included. Historical descriptions are also not included. The screened literature including such aspects did not provide sufficient information in the abstracts. Such literature may tend to be published in anthologies or books, which were excluded from the screening process. In addition, although the search words were broadly chosen with the intention to yield a large body of initial items in the screening process, relevant literature not containing the selected keywords may have dropped out. A final methodological note should also be made on the quality of abstracts. During screening, many studies had to be excluded due to incomplete information in the abstracts, which made it impossible to evaluate the quality of the paper and to draw conclusions on key elements studied. It is possible that some relevant items were excluded due to these issues. This is a potential area for improvement in general as regards academic publication.

Given the low profitability in the agri-food sector in many countries, development of the sector for increased innovativeness and competitiveness could be facilitated through national research agendas on the topic. The implications for research policy are wide. The research area would benefit from longer perspectives in research, closer connection to end-users needs and the use of more 'demanding' research approaches such as participatory research and active participation to gain in-depth knowledge on innovation processes and innovation management in the agri-food system.

To sum up, the agri-food system has specific and unique characteristics and is not always directly comparable with systems in other industries. Its characteristics include the norms and conventions present in the system, the special arrangements in the AKIS with a linear knowledge chain consisting of long-established actors and positions, a strong production focus but perhaps less market orientation. Its most distinct characteristic is the biological component, where innovation cannot proceed faster than biological systems allow or natural and environmental boundaries can withstand. In this mapping, we attempted to determine the state of current knowledge as regards the sectoral system of innovation in agri-food, AKIS, in order to identify knowledge gaps and future areas for research and provide methodological and theoretical perspectives.

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References

Allaire, G., Wolf, S. A. (2004). Cognitive representations and institutional hybridity in agrofood innovation. *Science Technology & Human Values*, **29** (4): 431-458. DOI: 10.1177/0162243904265896.

Alroe, H. F., Sautier, M., Legun, K., Whitehead, J., Noe, E., Moller, H., and Manhire, J. (2017). Performance versus Values in Sustainability Transformation of Food Systems. *Sustainability*, **9** (3). DOI: 10.3390/su9030332.

Ambrosius, F. H. W., Hofstede, G. J., Bock, B. B., Bokkers, E. A. M., and Beulens, A. J. M. (2015). Modelling farmer decision-making: the case of the Dutch pork sector. *British Food Journal*, **117** (10): 2582-2597. DOI: 10.1108/bfj-01-2015-0037.

Audet, R., Lefevre, S., Brisebois, E., and El-Jed, M. (2017). Structuring Tensions and Key Relations of Montreal Seasonal Food Markets in the Sustainability Transition of the Agri-Food Sector. *Sustainability*, **9** (3): DOI: 10.3390/su9030320.

Avolio, G., Blasi, E., Cicatiello, C., and Franco, S. (2014). The drivers of innovation diffusion in agriculture: Evidence from Italian census data. *Journal on Chain and Network Science*, **14** (3): 231-245. DOI: 10.3920/JCNS2014.x009.

Baregheh, A., Rowley, J., Sambrook, S., and Davies, D. (2012). Food sector SMEs and innovation types. *British Food Journal*, **114** (10-11): 1640-1653. 10.1108/00070701211273126.

Batterink, M., Wubben, E., and Omta, S. W. F. (2006). Factors related to innovative output in the Dutch agrifood industry. *Journal on Chain and Network Science*, **6** (1): 31-44. DOI: 10.3920/JCNS2006.x063.

Batterink, M. H., Wubben, E. F. M., Klerkx, L., and Omta, S. W. F. (2010). Orchestrating innovation networks: The case of innovation brokers in the agri-food sector. *Entrepreneurship & Regional Development*, **22** (1): 47-76. DOI: 10.1080/08985620903220512.

Beckeman, M., Bourlakis, M., and Olsson, A. (2013). The role of manufacturers in food innovations in Sweden. *British Food Journal*, **115** (7): 953-974. DOI: 10.1108/bfj-09-2010-0164.

Blok, V., Hoffmans, L., and Wubben, E. F. M. (2015). Stakeholder engagement for responsible innovation in the private sector: Critical issues and management practices. *Journal on Chain and Network Science*, **15** (2): 147-164. DOI: 10.3920/JCNS2015.x003.

Bornmann, L., Mutz, R. (2015). Growth rates of modern science: A bibliometric analysis based on the number of publications and cited references. *Journal of the Association for Information Science and Technology*, **66** (11): 2215-2222. DOI: 10.1002/asi.23329.

Boyatzis, R.E. (1998). Transforming qualitative information: Thematic analysis and code development. London: Sage Publications.

Brink, T. (2016). Governance of innovation and growth in SME networks. *International Journal of Innovation Management*, **20** (3). DOI: 10.1142/s1363919616500523.

Burress, M. J., Cook, M. L., and Klein, P. G. (2008). The clustering of organizational innovation: Developing governance models for vertical integration. *International Food and Agribusiness Management Review*, **11** (4): 127-153.

Caiazza, R. (2015). Explaining innovation in mature industries: evidences from Italian SMEs. *Technology Analysis & Strategic Management*, **27** (8): 975-985. DOI: 10.1080/09537325.2015.1038511.

Cannarella, C., Piccioni, V. (2003). Innovation transfer and rural SMEs. *Journal of Central European Agriculture*, **4** (4): 371-388.

Carlsson, B., Jacobsson, S., Holmén, M., and Rickne, A. (2002). Innovation systems: analytical and methodological issues. *Research Policy*, **31** (2): 233-245. DOI: https://doi.org/10.1016/S0048-7333(01)00138-X.

Chiffoleau, Y. (2009). From Politics to Co-operation: The Dynamics of Embeddedness in Alternative Food Supply Chains. *Sociologia Ruralis*, **49** (3): 218-235. DOI: 10.1111/j.1467-9523.2009.00491.x.

Chiffoleau, Y., Prevost, B. (2012). Short food supply chains as social innovations for sustainable food in territories. *Norois*, (224): 7-20.

Chiffoleau, Y., Touzard, J. M. (2014). Understanding local agri-food systems through advice network analysis. *Agriculture and Human Values*, **31** (1): 19-32. DOI: 10.1007/s10460-013-9446-6.

Ciliberti, S., Bröring, S., and Martino, G. (2015). Drivers of innovation in the European food industry: evidences from the community innovation survey. *International Journal on Food System Dynamics*, **6** (3): 175-190.

Coca, O., Stefan, G., and Mironiuc, M. (2017). Empirical evidences regarding therelationship between innovation and performance in the agriculture of European Union. *Scientific Papers-Series Management Economic Engineering in Agriculture and Rural Development*, **17** (1): 99-110.

de Cock, L., Taragola, N., Crivits, M., and Dessein, J. (2016). Networks for a competitive and innovative organic horticulture in Flanders. In Bellon, S., Granatstein, D., Urban, L. (Ed.., *Acta Horticulturae*, **1137**: 323-331. DOI: 10.17660/ActaHortic.2016.1137.45.

Colurcio, M., Wolf, P., Kocher, P. Y., and Spena, T. R. (2012). Asymmetric relationships in networked food innovation processes. *British Food Journal*, **114** (4-5): 702-727. DOI: 10.1108/00070701211229981.

Curry, N., Ingram, J., Kirwan, J., and Maye, D. (2012). Knowledge networks for sustainable agriculture in England. *Outlook on Agriculture*, **41** (4): 243-248. DOI: 10.5367/oa.2012.0106.

Deiters, J., Heuss, E. (2014). Factors influencing the performance of German food SME formal networks. *International Journal on Food System Dynamics*, **5** (2): 98-109.

Dockès, A., Tisenkopfs, T., and Bock, B. (2011). Reflection paper on AKIS, WP1. Collaborative Working Group Agricultural Knowledge and Innovation Systems. Retreived from: http://edepot.wur.nl/193703 [July 18, 2019].

Elg, U. (2008). Inter-firm market orientation and the influence of network and relational factors. *Scandinavian Journal of Management*, **24** (1): 55-68. DOI: 10.1016/j.scaman.2007.08.001.

Elg, U., Johansson, U. (1997). Decision making in inter-firm networks as a political process. *Organization Studies*, **18** (3): 361-384. DOI: 10.1177/017084069701800302.

Ely, A., Marin, A. (2016). Learning about 'Engaged Excellence' across a Transformative Knowledge Network. *Ids Bulletin-Institute of Development Studies*, **47** (6): 73-86. DOI: 10.19088/1968-2016.200.

Elzen, B., Geels, F. W., Leeuwis, C., and van Mierlo, B. (2011). Normative contestation in transitions 'in the making': Animal welfare concerns and system innovation in pig husbandry. *Research Policy*, **40** (2): 263-275. DOI: 10.1016/j.respol.2010.09.018.

Enriquez-Sanchez, J., Munoz Rodriguez, M., Altamirano-Cardenas, J. R., and Villegas-de Gante, A. (2017). Activation process analysis of the localized agri-food system using social networks. *Agricultural Economics* (*Zemedelska Ekonomika*), **63** (3): 121-135.

Espejel-Garcia, A., Barrera-Rodriguez, A., Herrera-Cabrera, B. E., and Cuevas-Reyes, V. (2016). Structural factors in the construction of the regional vanilla (Vanilla planifolia Jacks ex Andrews) innovation system in Mexico. *Agroproductividad*, **9** (1): 74-78.

European Commission (2012). COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL - on the European Innovation Partnership 'Agricultural Productivity and Sustainability'. Brussels, 29.2.2012 COM(2012) 79 final. Retreived from: https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/communication_on_eip_-_en.pdf [July 18, 2019].

European Commission (2014). Horizon 2020 in brief. The EU Framework Programme for Research & Innovation. Brussels, European Commission, Directorate-General for Research and Innovation. Retreived from: https://ec.europa.eu/programmes/horizon2020/sites/horizon2020/files/H2020_inBrief_EN_FinalBAT.pdf [July 18, 2019].

European Commission (2016a). European Research & Innovation for Food & Nutrition Security, Food 2030 - High-level Conference background document. Research and Innovation. Brussels, European Commission, Directorate-General for Research and Innovation, Bioeconomy Directorate. Retrieved from: https://ec.europa.eu/info/events/food-2030-research-and-innovation-tomorrows-nutrition-and-food-systems-2016-oct-12_en [April 17, 2019].

European Commission (2016b). Agricultural Knowledge and Innovation Systems Towards the Future – a Foresight Paper. Standing Committee on Agricultural Research (SCAR); strategic working group AKIS. Brussels, Directorate-General for Research and Innovation, Bioeconomy. Retreived from: https://ec.europa.eu/research/scar/pdf/akis-3_end_report.pdf [April 17, 2019].

EU SCAR (2012). Agricultural knowledge and innovation systems in transition – a reflection paper. Brussels, European commission, Directorate-General for Research and Innovation, Directorate E – Biotechnologies, Agriculture and Food. Retreived from: https://scar-europe.org/images/AKIS/Documents/AKIS_reflection_-paper.pdf [April 22, 2019].

Fernandez Aldecua, M. J., Vaillant, Y. (2010). Social capital and business innovation: the case of the Priorat, Catalonia. *Revista Espanola de Estudios Agrosociales y Pesqueros*, **3** (227): 49-77.

Frykfors, C. O., Jonsson, H. (2010). Reframing the multilevel triple helix in a regional innovation system: a case of systemic foresight and regimes in renewal of Skane's food industry. *Technology Analysis & Strategic Management*, **22** (7): 819-829. DOI: 10.1080/09537325.2010.511145.

Gailhard, I. U., Bavorova, M. (2014). Innovation at rural enterprises: results from a survey of German organic and conventional farmers. *Technology and Innovation*, **16** (1): 3-17. DOI: 10.3727/194982414x-13971392823190.

Gallego-Bono, J. R., Chaves-Avila, R. (2015). The cooperative model of agri-food innovation systems: ANECOOP and the Valencian citrus industry system. *Itea*, **111** (4): 366-383.

Garbade, P. J. P., Fortuin, F. T. J. M., and Omta, S. W. F. (2012). Coordinating clusters: a cross sectoral study of cluster organization functions in the Netherlands. *International Journal on Food System Dynamics*, **3** (3): 243-257.

Garnett, T. (2011). Where are the best opportunities for reducing greenhouse gas emissions in the food system (including the food chain)? *Food Policy*, **36**: 23-S32. DOI: https://doi.org/10.1016/j.foodpol.2010.10.010.

Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy*, **33** (6): 897-920. DOI: https://doi.org/10.1016/j.respol.2004.01.015.

Geels, F. W., McMeekin, A., Mylan, J., and Southerton, D. (2015). A critical appraisal of Sustainable Consumption and Production research: The reformist, revolutionary and reconfiguration positions. *Global Environmental Change*, **34**: 1-12. DOI: https://doi.org/10.1016/j.gloenvcha.2015.04.013.

Geerling-Eiff, F. A., Hoes, A. C., and Dijkshoorn-Dekker, M. W. C. (2017). Triple helix networks matching knowledge demand and supply in seven Dutch horticulture Greenport regions. *Studies in Agricultural Economics*, (Budapest) **119** (1): 34-40. DOI: 10.7896/j.1052.

Gellynck, X., Kühne, B. (2008). Innovation and collaboration in traditional food chain networks. *Journal on Chain and Network Science*, **8** (2): 121-129. DOI: 10.3920/JCNS2008.x094.

Gellynck, X., Vermeire, B., and Viaene, J. (2006). Innovation in the food sector: Regional networks and internationalisation. *Journal on Chain and Network Science*, **6** (1): 21-30. DOI: 10.3920/JCNS2006.x062.

Gellynck, X., Vermeire, B., and Viaene, J. (2007). Innovation in food firms: contribution of regional networks within the international business context. *Entrepreneurship and Regional Development*, **19** (3): 209-226. DOI: 10.1080/08985620701218395.

Gonzalez-Ramirez, H., Bernsten, R. H., Oehmke, J. F., and Acosta-Gallegos, J. A. (2005). Adoption of improved bean varieties in Chihuahua, Durango and Zacatecas, Mexico. *Agricultura Tecnica en Mexico*, **31** (1): 73-88.

Govindan, K. (2018). Sustainable consumption and production in the food supply chain: A conceptual framework. *International Journal of Production Economics,* **195**: 419-431. DOI: https://doi.org/10.1016/j.ijpe.2017.03.003.

Haddaway, N. R., Bernes, C., Jonsson, B.-G., and Hedlund, K. (2016). The benefits of systematic mapping to evidence-based environmental management. Ambio 45 (5): 613-620. DOI: 10.1007/s13280-016-0773-x.

Henwood, R., Wood, B., Sewell, A., Gray, D., Blair, H., Cranston, L., Hartnett, M., Kemp, P., Kenyon, P., Corner-Thomas, R., and Morris, S. (2017). Engaging with individuality in agricultural learning: a sociocultural study of innovation in a farmer-scientist community. *Rural Extension and Innovation Systems Journal*, **13** (2): 76-85.

Hermans, F., Roep, D., and Klerkx, L. (2016). Scale dynamics of grassroots innovations through parallel pathways of transformative change. *Ecological Economics*, **130**: 285-295. DOI: 10.1016/-j.ecolecon.2016.07.011.

Higgins, J. P., Green, S. (editors) (2011). Cochrane handbook for systematic reviews of interventions Version 5.1.0 [updated March 2011]. The Cochrane Collaboration. Online handbook. Retreived from www.handbook.cochrane.org [March 14, 2018].

Hinton, B. (2003). Knowledge management and communities of practice: An experience from Rabobank Australia and New Zealand. *International Food and Agribusiness Management Review*, **5** (3).

Hoes, A. C., Beekman, V., Regeer, B. J., and Bunders, J. F. G. (2012). Unravelling the dynamics of adopting novel technologies: An account of how the closed greenhouse opened-up. *International Journal of Foresight and Innovation Policy*, **8** (1): 37-59. DOI: 10.1504/IJFIP.2012.044286.

Hoskins, M. (1998). Research, extension and innovative farmers. *Forests, Trees and People Newsletter*, (39): 4-6.

Hunecke, C., Engler, A., Jara-Rojas, R., and Poortvliet, P. M. (2017). Understanding the role of social capital in adoption decisions: An application to irrigation technology. *Agricultural Systems*, **153**: 221-231. DOI: 10.1016/j.agsy.2017.02.002.

Hunt, W., Birch, C., Vanclay, F., and Coutts, J. (2014). Recommendations arising from an analysis of changes to the Australian agricultural research, development and extension system. *Food Policy*, **44**: 129-141. DOI: 10.1016/j.foodpol.2013.11.007.

Iivonen, S., Kyro, P., Mynttinen, S., Sarkka-Tirkkonen, M., and Kahiluoto, H. (2011). Social capital and entrepreneurial behaviour advancing innovativeness in interaction between small rural entrepreneurs and researchers: a phenomenographic study. *Journal of Agricultural Education and Extension*, **17** (1): 37-51. DOI: 10.1080/1389224x.2011.536348.

Ingram, J. (2011). A food systems approach to researching food security and its interactions with global environmental change. *Food Security*, **3** (4): 417-431. DOI: 10.1007/s12571-011-0149-9.

Ingram, J. (2015). Framing niche-regime linkage as adaptation: An analysis of learning and innovation networks for sustainable agriculture across Europe. *Journal of Rural Studies*, **40**: 59-75. DOI: 10.1016/-j.jrurstud.2015.06.003.

Ison, R. (2010). Systems practice: how to act in a climate change world. London, UK, Springer Science & Business Media. https://doi.org/10.1007/978-1-84996-125-7.

Ivarsson, M., Gorschek, T. (2011). A method for evaluating rigor and industrial relevance of technology evaluations. *Empirical Software Engineering*, **16** (3): 365-395. DOI: 10.1007/s10664-010-9146-4.

Jack, C., Anderson, D., and Connolly, N. (2014). Innovation and skills: Implications for the agri-food sector. *Education and Training*, **56** (4): 271-286. DOI: 10.1108/ET-11-2012-0122.

James, K. L., Randall, N. P., and Haddaway, N. R. (2016). A methodology for systematic mapping in environmental sciences. *Environmental Evidence*, **5** (1): 7. DOI: 10.1186/s13750-016-0059-6.

Jurgilevich, A., Birge, T., Kentala-Lehtonen, J., Korhonen-Kurki, K., Pietikäinen, J., Saikku, L., Schösler, H. (2016). Transition towards Circular Economy in the Food System. *Sustainability*, **8** (1): 69. DOI: https://doi.org/10.3390/su8010069.

Klerkx, L., Leeuwis, C. (2008). Institutionalizing end-user demand steering in agricultural R&D: Farmer levy funding of R&D in The Netherlands. *Research Policy*, **37** (3): 460-472. DOI: 10.1016/j.respol.2007.11.007.

Klerkx, L., Proctor, A. (2013). Beyond fragmentation and disconnect: Networks for knowledge exchange in the English land management advisory system. *Land Use Policy*, **30** (1): 13-24. DOI: 10.1016/j.landusepol.2012.02.003.

Klerkx, L., Nettle, R. (2013). Achievements and challenges of innovation co-production support initiatives in the Australian and Dutch dairy sectors: A comparative study. *Food Policy*, **40**: 74-89. DOI: 10.1016/j.foodpol.2013.02.004.

Klerkx, L., Aarts, N., and Leeuwis, C. (2010). Adaptive management in agricultural innovation systems: The interactions between innovation networks and their environment. *Agricultural Systems*, **103** (6): 390-400. DOI: 10.1016/j.agsy.2010.03.012.

Klerkx, L., Seuneke, P., de Wolf, P., and Rossing, W. A. H. (2017). Replication and translation of co-innovation: The influence of institutional context in large international participatory research projects. *Land Use Policy*, **61**: 276-292. DOI: 10.1016/j.landusepol.2016.11.027.

Knight, J., D. Holdsworth, and Mather, D. (2007). Determinants of trust in imported food products: perceptions of European gatekeepers. *British Food Journal*, **109** (10): 792-804. DOI: 10.1108/00070700710821331.

Kühne, B., Gellynck, X. (2010). Chain networks as a leverage for innovation capacity: the case of food SMEs. *International Journal on Food System Dynamics*, **1** (4): 279-294.

Kühne, B., Cochez, C., and Gellynck, X. (2011). Network experiences lead to the adaption of a firm's network competence. *International Journal on Food System Dynamics*, **2** (2): 114-125.

Kühne, B., Gellynck, X., and Weaver, R. D. (2015). Enhancing Innovation Capacity Through Vertical, Horizontal, and Third-Party Networks for Traditional Foods. *Agribusiness*, **31** (3): 294-313. DOI: 10.1002/agr.21408.

Lambrecht, E., Kühne, B., and Gellynck, X. (2014). How do innovation partners differ with respect to innovation type and stage in the innovation journey of farmers? *International Journal of Entrepreneurship and Innovation*, **15** (3): 191-203. DOI: 10.5367/ijei.2014.0155.

Lambrecht, E., Kühne, B., and Gellynck, X. (2015). Asymmetric relationships in networked agricultural innovation processes. *British Food Journal*, **117** (7): 1810-1825. DOI: 10.1108/bfj-05-2014-0183.

Lapple, D., Renwick, A., Cullinan, J., and Thorne, F. (2016). What drives innovation in the agricultural sector? A spatial analysis of knowledge spillovers. *Land Use Policy*, **56**: 238-250. DOI: 10.1016/-j.landusepol.2016.04.032.

Larsson, J., Ekelund, L., and Carlsson, M. (2009). Trends in the development of collaboration between horticultural research and education and the industry: 215-224. DOI: 10.17660/ActaHortic.2009.832.28.

Le Bellec, F., Rajaud, A., Ozier-Lafontaine, H., Bockstaller, C., and Malezieux, E. (2012). Evidence for farmers' active involvement in co-designing citrus cropping systems using an improved participatory method. *Agronomy for Sustainable Development*, **32** (3): 703-714. DOI: 10.1007/s13593-011-0070-9.

Lins, M. L., Pires, S. (2011). Cooperatives and production dynamics in disadvantaged areas. The case of small agricultural cooperatives in southern France. *Sociologias*, **13** (26): 228-261. DOI: 10.1590/s1517-45222011000100010.

Maietta, O. W., Barra, C., and Zotti, R. (2017). Innovation and University-Firm R&D Collaboration in the European Food and Drink Industry. *Journal of Agricultural Economics*, **68** (3): 749-780. DOI: 10.1111/1477-9552.12208.

Maistry, K., Hurreeram, D. K., and Ramessur, V. (2017). Total quality management and innovation Relationships and effects on performance of agricultural R&D organisations. *International Journal of Quality & Reliability Management*, **34** (3): 418-437. DOI: 10.1108/ijqrm-04-2015-0061.

Malerba, F. (2002). Sectoral systems of innovation and production. *Research Policy*, **31** (2): 247-264. https://doi.org/10.1016/S0048-7333(01)00139-1.

Malik, K., Georghiou, L., and Grieve, B. (2011). Developing new technology platforms for new business models: Syngenta's partnership with the university of Manchester. *Research-Technology Management*, **54** (1): 24-31. DOI: 10.5437/08953608x540124.

Martin, R., Moodysson, J., and Zukauskaite, E. (2011). Regional Innovation Policy Beyond 'Best Practice': Lessons from Sweden. *Journal of the Knowledge Economy*, **2** (4): 550-568. DOI: 10.1007/s13132-011-0067-2.

Materia, V. C. (2012). The Agricultural Knowledge and Innovation System in Italy: dynamics, incentives, monitoring and evaluation experiences. *Studies in Agricultural Economics (Budapest)*, **114** (2): 71-78.

Matthyssens, P., Vandenbempt, K., and Berghman, L. (2008). Value innovation in the functional foods industry: deviations from the industry recipe. *British Food Journal*, **110** (1): 144-155. DOI: 10.1108/00070700810844830.

McCown, R. L. (2001). Learning to bridge the gap between science-based decision support and the practice of farming: evolution in paradigms of model-based research and intervention from design to dialogue. *Australian Journal of Agricultural Research*, **52** (5): 549-571. DOI: 10.1071/ar00119.

Midmore, P. (2017). Agricultural science research impact in the Eastern European Union Member States. *Studies in Agricultural Economics*, **119** (1): 1-10. DOI: 10.7896/j.1064.

Monsalvo Zamora, A., Jimenez Velazquez, M. A., Garcia Cue, J. L., Sangerman-Jarquin, D. M., Martinez Saldana, T., and Pimentel Equihua, J. L. (2017). Characterization of the profile of the rural extension worker in eastern area of Estado de Mexico. *Revista Mexicana de Ciencias Agricolas*, **8** (3): 503-515.

Morgan, C. W., Blake, A., and Poyago-Theotoky, J. A. (2003). The management of technological innovation: lessons from case studies in the UK food and drink industry. *International Journal of Biotechnology*, **5** (3/4): 334-353.

Morriss, S., Massey, C., Flett, R., Alpass, F., and Sligo, F. (2006). Mediating technological learning in agricultural innovation systems. *Agricultural Systems*, **89** (1): 26-46. DOI: 10.1016/j.agsy.205.08.002.

Morrissey, M. T., Almonacid, S. (2005). Rethinking technology transfer. Journal of Food Engineering 67 (1-2): 135-145. DOI: 10.1016/j.jfoodeng.2004.05.057.

Munchhausen, S. v., Haring, A. M. (2012). Lifelong learning for farmers: enhancing competitiveness, knowledge transfer and innovation in the eastern German state of Brandenburg. *Studies in Agricultural Economics (Budapest)*, **114** (2): 86-92.

Nettle, R., Brightling, P., and Hope, A. (2013). How Programme Teams Progress Agricultural Innovation in the Australian Dairy Industry. *Journal of Agricultural Education and Extension*, **19** (3): 271-290. DOI: 10.1080/1389224X.2013.782177.

OECD (2015a). Innovation, Agricultural Productivity and Sustainability in the Netherlands. Paris, OECD Publishing. DOI: https://doi.org/10.1787/24114278.

OECD (2015b). Innovation, Agricultural Productivity and Sustainability in Australia. Paris, OECD Publishing. DOI: https://doi.org/10.1787/9789264238367-en.

OECD (2016). Innovation, Agricultural Productivity and Sustainability in the United States. Paris, OECD Publishing. DOI: https://doi.org/10.1787/9789264264120-en.

OECD (2018). Innovation, Agricultural Productivity and Sustainability in Sweden. Paris, OECD Publishing. doi: https://doi.org/10.1787/9789264085268-en.

Orozco Cirilo, S., Jimenez Sanchez, L., Estrella Chulim, N., Ramirez Valverde, B., Pena Olvera, B. V., Ramos Sanchez, A.,annd Morales Guerra, M. (2008). Farmer field Schools and adoption of agricultural ecotechnology. *Ecosistemas*, **17** (2): 94-102.

Ortolani, L., Bocci, R., Barberi, P., Howlett, S., and Chable, V. (2017). Changes in knowledge management strategies can support emerging innovative actors in organic agriculture: the case of participatory plant breeding in Europe. *Organic Farming*, **3** (1): 20-33. DOI: 10.12924/of2017.03010020.

Oumarou, D., Bryant, C., and Akkari, C. (2015). Social networks and the diffusion of innovations, towards a critical partnership for a successful adaptation strategy to climate change: a case study of agriculture in southwestern Quebec. *International Journal of Climate Change: Impacts and Responses*, **6** (3/4): 37-58.

Pancino, B., Pascucci, S., Blasi, E., Ruini, L., and Ronchi, C. (2016). The role of network creation and actor engagement in the adoption and diffusion of sustainable innovations in food value chains. *Rivista di Economia Agraria*, **71** (1, Supplemento): 78-85.

Park, N. M., Williams, T. A., Walker, J. T. S., Butcher, M. R., Turner, J. A., Botha, N., Vereijssen, J., and Taylor, N. M. (2015). Enhancing innovation and technology transfer in the New Zealand apple industry-learnings from Apple Futures. *New Zealand Plant Protection*, **68**: 291-298.

Parra-Lopez, C., De-Haro-Gimenez, T., and Calatrava-Requena, J. (2007). Diffusion and adoption of organic farming in the southern Spanish olive groves. *Journal of Sustainable Agriculture*, **30** (1): 105-151. DOI: 10.1300/J064v30n01_09.

Paschen, J. A., Reichelt, N., King, B., Ayre, M., and Nettle, R. (2017). Enrolling advisers in governing privatised agricultural extension in Australia: challenges and opportunities for the research, development and extension system. *Journal of Agricultural Education & Extension*, **23** (3): 265-282. DOI: 10.1080/1389224x.2017.1320642.

Pol, H., Visscher, K. (2010). The influence of power in supply chain innovation: a case study of the Dutch wheat chain. *Journal on Chain and Network Science*, **10** (1): 77-85.

Prager, K., Creaney, R. (2017). Achieving on-farm practice change through facilitated group learning: Evaluating the effectiveness of monitor farms and discussion groups'. *Journal of Rural Studies*, **56**: 1-11. DOI: 10.1016/j.jrurstud.2017.09.002.

Quiedeville, S., Barjolle, D., Mouret, J. C., and Stolze, M. (2017). Ex-post evaluation of the impacts of the science-based research and innovation program: A new method applied in the case of farmers' transition to organic production in the Camargue. *Journal of Innovation Economics & Management*, **1**(22): 145-170. DOI: 10.3917/jie.022.0145.

Reichardt, M., Jurgens, C. (2009). Adoption and future perspective of precision farming in Germany: results of several surveys among different agricultural target groups. *Precision Agriculture*, **10** (1): 73-94. DOI: 10.1007/s11119-008-9101-1.

Reichardt, M., Jurgens, C., Kloble, U., Huter, J., and Moser, K. (2009). Dissemination of precision farming in Germany: acceptance, adoption, obstacles, knowledge transfer and training activities. *Precision Agriculture*, **10** (6): 525-545. DOI: 10.1007/s11119-009-9112-6.

Renborg, U. (2010). Research on agricultural research, rates of return to agricultural research in Sweden. Report 2010:166, SLU Department of Economics. Uppsala, Swedish University of Agricultural Sciences. Retreived from: https://pub.epsilon.slu.se/13254/1/renborg_u_160404.pdf [July 18, 2019].

Risgaard, M. L., Frederiksen, P., and Kaltoft, P. (2007). Socio-cultural processes behind the differential distribution of organic farming in Denmark: a case study. *Agriculture and Human Values*, **24** (4): 445-459. DOI: 10.1007/s10460-007-9092-y.

Rodrigo-Alarcon, J., Garcia-Villaverde, P. M., Parra-Requena, G., and Ruiz-Ortega, M. J. (2017). Innovativeness in the context of technological and market dynamism The conflicting effects of network density. *Journal of Organizational Change Management*, **30** (4): 548-568. DOI: 10.1108/jocm-04-2016-0068.

Rodriguez, J. M., Molnar, J. J., Fazio, R. A., Sydnor, E., and Lowe, M. J. (2009). Barriers to adoption of sustainable agriculture practices: change agent perspectives. *Renewable Agriculture and Food Systems*, **24** (1): 60-71. DOI: 10.1017/s1742170508002421.

Roep, D., Ploeg, J. D. v. d., and Wiskerke, J. S. C. (2003). Managing technical-institutional design processes: some strategic lessons from environmental co-operatives in the Netherlands. *NJAS - Wageningen Journal of Life Sciences*, **51** (1/2): 195-217. DOI: 10.1016/s1573-5214(03)80033-7.

Rogers, E., M. (2003). Diffusion of Innovations. New York, Free Press.

Rossi, V., Salinari, F., Poni, S., Caffi, T., and Bettati, T. (2014). Addressing the implementation problem in agricultural decision support systems: the example of vite.net (R). *Computers and Electronics in Agriculture*, **100**: 88-99. DOI: 10.1016/j.compag.2013.10.011.

Ruitenburg, R. J., Fortuin, F. T. J. M., and Omta, S. W. F. (2014). The role of prior experience, intellectual property protection and communication on trust and performance in innovation alliances. *Journal on Chain and Network Science*, **14** (2): 117-128. DOI: 10.3920/JCNS2014.x006.

Ryschawy, J., Debril, T., Sarthou, J. P., and Therond, O. (2016). Dairy farmers, agricultural experts, and the agroecological transition: a cross-analysis of agricultural and marketing practices in Aveyron. *Fourrages*, (228): 295-300.

Sabaté, J., Sranacharoenpong, K., Harwatt, H., Wien, M., and Soret, S. (2015). The environmental cost of protein food choices. *Public Health Nutrition*, **18** (11): 2067-2073. DOI: 10.1017/S1368980014002377.

Sandall, J., Cooksey, R., and Wright, V. (2011). A systems approach to identifying and managing opportunities and constraints to delivering innovation policy for agriculture: an analysis of the Australian Cooperative Research Centres (CRC) Program. *Journal of Agricultural Education and Extension*, **17** (5): 411-423. DOI: 10.1080/1389224x.2011.596418.

Sandrini, F., Durgiai, B., Aubert, S., and Meier, H. (2014). How to optimize agricultural extension for a successful farm management? *Agrarforschung Schweiz*, **5** (6): 240-247.

Seidel, J., Kelle, U. (1995). Different functions of coding in the analysis of textual data. In Kelle, U (Ed.), Computer-aided Qualitative Data Analysis: Theory, Methods and Practice. London, Sage.

Sewell, A. M., Hartnett, M. K., Gray, D. I., Blair, H. T., Kemp, P. D., Kenyon, P. R., Morris, S. T., and Wood, B. A. (2017). Using educational theory and research to refine agricultural extension: affordances and barriers for farmers' learning and practice change. *Journal of Agricultural Education & Extension*, **23** (4): 313-333. DOI: 10.1080/1389224x.2017.1314861.

Shea, B. J., Hamel, C., Wells, G. A., Bouter, L. M., Kristjansson, E., Grimshaw, J., Henry, D. A., and Boers, M. (2009). AMSTAR is a reliable and valid measurement tool to assess the methodological quality of systematic reviews. *Journal of Clinical Epidemiology*, **62** (10): 1013-1020. DOI: https://doi.org/10.1016/j.jclinepi.2008.10.009.

Shiri, G., Sauvee, L., and Abdirahman, Z. Z. (2015). Bridge and redundant ties in networks: the impact on innovation in food SMEs. *European Journal of Innovation Management*, **18** (3): 355-+. DOI: 10.1108/ejim-04-2014-0049.

Specht, K., Zoll, F., and Siebert, R. (2016). Application and evaluation of a participatory "open innovation" approach (ROIR): The case of introducing zero-acreage farming in Berlin. *Landscape and Urban Planning*, **151**: 45-54. DOI: 10.1016/j.landurbplan.2016.03.003.

Strong, R., Irani, T. (2011). The relationship of future agricultural extension educators' cognitive styles and change strategies for adult learners. *Journal of Extension*, **49** (2), n2. Retrieved from https://www.joe.org/joe/2011april/pdf/JOE_v49_2rb2.pdf [October 10, 2019].

Sun, X. H., Wang, Y., Li, M. S. (2016). The influences of different R&D types on productivity growth in OECD countries. *Technology Analysis & Strategic Management*, **28** (6): 651-663. DOI: 10.1080/09537325.2015.1130806.

Sutherland, L. A., Madureira, L., Dirimanova, V., Bogusz, M., Kania, J., Vinohradnik, K., Creaney, R., Duckett, D., Koehnen, T., and Knierim, A. (2017). New knowledge networks of small-scale farmers in Europe's periphery. *Land Use Policy*, **63**: 428-439. DOI: 10.1016/j.landusepol.2017.01.028.

Takoutsing, B., Tchoundjeu, Z., Degrande, A., Asaah, E., and Tsobeng, A. (2014). Scaling-up sustainable land management practices through the concept of the rural resource centre: reconciling farmers' interests with research agendas*. Journal of Agricultural Education and Extension*, **20** (5): 463-483.

Taplin, I. M. (2012). Innovation and market growth in a new 'New World' wine region: the case of North Carolina. *Journal of Wine Research*, **23** (3): 229-246. DOI: 10.1080/09571264.2012.690090.

Thompson, L. J., Reeve, I. (2011). Knowledge types used by researchers and wool producers in Australia under a workplace learning typology: Implications for innovation in the Australian sheep industry. *Journal of Agricultural Education and Extension*, **17** (5): 445-458. DOI: 10.1080/1389224X.2011.596707.

Tisenkopfs, T., Kunda, I., Sumane, S., Brunori, G., Klerkx, L., and 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 & Extension*, **21** (1): 13-33. DOI: 10.1080/1389224x.2014.991115.

Tokgoz, S. (2006). Private agricultural R&D in the United States. *Journal of Agricultural and Resource Economics*, **31** (2): 212-238.

Tveden-Nyborg, S., Misfeldt, M., and Boelt, B. (2012). Scientific knowledge dissemination in Danish seed communities of practice. *Journal of Science Communication*, **11** (3). DOI: https://doi.org/10.22323/2.11030202.

Vagnoni, E., Carrino, C., Dibenedetto, N., Pieragostini, E., and Consenti, B. (2016). The enhancement of native sheep's wool: Three case studies from some Italian regions. *Small Ruminant Research*, **135**: 85-89. DOI: 10.1016/j.smallrumres.2015.12.011.

Van Baalen, P., Bloemhof-Ruwaard, J., and Van Heck, E. (2005). Knowledge sharing in an emerging network of practice: The role of a knowledge portal. *European Management Journal*, **23** (3): 300-314. DOI: 10.1016/j.emj.2005.04.008.

Vanloqueren, G., Baret, P. V. (2009). How agricultural research systems shape a technological regime that develops genetic engineering but locks out agroecological innovations. *Research Policy*, **38** (6): 971-983. DOI: 10.1016/j.respol.2009.02.008.

Vazquez-Casielles, R., Iglesias, V., and Varela-Neira, C. (2013). Collaborative manufacturer-distributor relationships: the role of governance, information sharing and creativity. *Journal of Business & Industrial Marketing*, **28** (8): 620-637. DOI: 10.1108/jbim-05-2011-0070.

Vereijssen, J., Srinivasan, M. S., Dirks, S., Fielke, S., Jongmans, C., Agnew, N., Klerkx, L., Pinxterhuis, I., Moore, J., Edwards, P., Brazendale, R., Botha, N., and Turner, J. A. (2017). Addressing complex challenges using a co-innovation approach: Lessons from five case studies in the New Zealand primary sector. *Outlook on Agriculture*, **46** (2): 108-116. DOI: 10.1177/0030727017712321.

Vittersø, G., Tangeland, T. (2015). The role of consumers in transitions towards sustainable food consumption. The case of organic food in Norway. *Journal of Cleaner Production*, **92**: 91-99. DOI: https://doi.org/10.1016/j.jclepro.2014.12.055.

Vuylsteke, A., Gijseghem, D. v. (2012). Linking the agricultural knowledge and innovation system's subsystems: the case of the Flemish ornamental plant production. *Studies in Agricultural Economics (Budapest),* **114** (2): 79-85.

Wiersinga, R. C., Hiller, S. R. C. H., and Zimmermann, K. L. (2012). Towards consumer driven and innovative fruit supply chains. *Acta Horticulturae*, **930**: 209-216. DOI: 10.17660/ActaHortic.2012.930.27.

Wikstrom, S., Jonsson, H., and Decosta, P. L. (2016). A clash of modernities: Developing a new value-based framework to understand the mismatch between production and consumption. *Journal of Consumer Culture*, **16** (3): 824-851. DOI: 10.1177/1469540514528197.

Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., Garnett, T., Tilman, D., DeClerck, F., Wood, A., Jonell, M., Clark, M., Gordon, L. J., Fanzo, J., Hawkes, C., Zurayk, R., Rivera, J. A., De Vries, W., Majele Sibanda, L., Afshin, A., Chaudhary, A., Herrero, M., Agustina, R., Branca, F., Lartey, A., Fan, S., Crona, B., Fox, E., Bignet, V., Troell, M., Lindahl, T., Singh, S., Cornell, S. E., Srinath Reddy, K., Narain, S., Nishtar, S., and Murray, C. J. L. (2019). Food in the Anthropocene: the EAT2013 Lancet Commission on healthy diets from sustainable food systems. *The Lancet*, **393** (10170): 447-492. DOI: 10.1016/S0140-6736(18)31788-4.

Wood, B. A., Blair, H. T., Gray, D. I., Kemp, P. D., Kenyon, P. R., Morris, S. T., and Sewell, A. M. (2014). Agricultural Science in the Wild: A Social Network Analysis of Farmer Knowledge Exchange. *Plos One*, **9** (8). DOI: 10.1371/journal.pone.0105203.

Yakovleva, N., Flynn, A. (2009). Organic production: The adoption of a niche strategy by the mainstream food system. International *Journal of Innovation and Sustainable Development*, **4** (1): 43-60. DOI: 10.1504/IJISD.2009.024855.

Zanquetto Filho, H., Fearne, A., and Pizzolato, N. D. (2003). The measurement of benefits from and enablers for supply chain partnerships in the UK fresh produce industry. *Journal on Chain and Network Science*, **3** (1): 59-74. DOI: 10.3920/JCNS2003.x030.

Appendix 1

Search strings. Searches in databases were conducted on August 1, 2018.

1. WoS core collection
Language=English
Publication years: 1997-2017
Publication type=Article

2 **196,692** (TS=innovat*) *AND* **LANGUAGE:** (English) *AND* **DOCUMENT TYPES:** (Article)
Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan=1997-2017

# 4 **623,233** (TS=("agri food" OR "agro food" OR "agrifood" OR "agrofood" OR "agri-food" OR "agro-food" OR "agric*" OR food)) AND LANGUAGE: (English) ANDDOCUMENT TYPES: (Article)
Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan=1997-2017

# 5 **9,106** #4 AND #2
Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan=1997-2017

2. Scopus
Search string:
((TITLE-ABS-KEY ("agri food" OR agrifood OR agri-food OR "agro food" OR agrofood OR agro-food OR agric* OR food)) AND DOCTYPE (ar) AND PUBYEAR > 1996 AND PUBYEAR < 2018) AND (TITLE-ABS-KEY (innovat*) AND DOCTYPE (ar) AND PUBYEAR > 1996 AND PUBYEAR < 2018) AND (LIMIT-TO (LANGUAGE, "English "))

11,943 document results on August 1, 2018.

3. CABI

1 **1,422,128** ((TS=("agri food" OR "agro food" OR "agrifood" OR "agrofood" OR "agri-food" OR "agro-food" OR agric* OR food))) *AND* **LANGUAGE:** (English) *AND* **DOCUMENT TYPES:** (Journal article)
Indexes=CAB Abstracts Timespan=1997-2017

# 2 **38,923** (TS=innovat*) AND LANGUAGE: (English) AND DOCUMENT TYPES: (Journal article)
Indexes=CAB Abstracts Timespan=1997-2017

# 3 **20,502** #2 AND #1
Indexes=CAB Abstracts Timespan=1997-2017

Appendix 2

Supplementary material

Supplementary material is made open accessible through the Swedish National Data Service, a national digital repository for open research data. The material has received a digital object identifier (DOI) to provide a persistent link to its location on the Internet.

The dataset consists of two parts, including explanation and instructions:

Dataset SND 1116-001
Innovation at system level in agri-food. Excel sheet mapping and key-words identified in the literature (1997-2017)

Citation:
Fredrik Fernqvist, Sara Spendrup. Swedish University of Agricultural Sciences, Department of Work Science, Business Economics and Environmental Psychology (2019). *Innovation at system level in agri-food. Excel sheet*

mapping and key-words identified literature (1997-2017). Swedish National Data Service. Version 1.0. https://doi.org/10.5878/95pp-rx48.

Dataset SND 1116-002
Innovation at system level in agri-food. Meta-table of key elements categorized in mapping study (1997-2017)

Citation:
Fredrik Fernqvist, Sara Spendrup. Swedish University of Agricultural Sciences, Department of Work Science, Business Economics and Environmental Psychology (2019). *Innovation at system level in agri-food. Meta-table of key elements categorized in mapping study (1997-2017)*. Swedish National Data Service. Version 1.0. https://doi.org/10.5878/m9h7-6k80.

The data was uploaded to the Swedish National Data Service August 20th, 2019 and published September 2nd, 2019.

The data is available at the following Internet address:
https://snd.gu.se/en/catalogue/study/snd1116 (Retrieved 3 September, 2019).