LIFT

Low-Input Farming and Territories – Integrating knowledge for improving ecosystem based farming

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Drivers of farmers' up-take of ecological approaches – a conceptual framework with a behavioural focus

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About the LIFT research project

Ecological approaches to farming practices are gaining interest across Europe. As this interest grows there is a pressing need to assess the potential contributions these practices may make, the contexts in which they function and their attractiveness to farmers as potential adopters. In particular, ecological agriculture must be assessed against the aim of promoting the improved performance and sustainability of farms, rural environment, rural societies and economies, together.

The overall goal of LIFT is to identify the potential benefits of the adoption of ecological farming in the European Union (EU) and to understand how socio-economic and policy factors impact the adoption, performance and sustainability of ecological farming at various scales, from the level of the single farm to that of a territory.

To meet this goal, LIFT will assess the determinants of adoption of ecological approaches, and evaluate the performance and overall sustainability of these approaches in comparison to more conventional agriculture across a range of farm systems and geographic scales. LIFT will also develop new private arrangements and policy instruments that could improve the adoption and subsequent performance and sustainability of the rural nexus. For this, LIFT will suggest an innovative framework for multi-scale sustainability assessment aimed at identifying critical paths toward the adoption of ecological approaches to enhance public goods and ecosystem services delivery. This will be achieved through the integration of transdisciplinary scientific knowledge and stakeholder expertise to co-develop innovative decision-support tools.

The project will inform and support EU priorities relating to agriculture and the environment in order to promote the performance and sustainability of the combined rural system. At least 30 case studies will be performed in order to reflect the enormous variety in the socio-economic and bio-physical conditions for agriculture across the EU.

Project consortium

No.	Participant organisation name	Country
1	**INRA - Institut National de la Recherche Agronomique**	**FR**
2	VetAgro Sup - Institut d'enseignement supérieur et de recherche en alimentation, santé animale, sciences agronomiques et de l'environnement	FR
3	SRUC - Scotland's Rural College	UK
4	Teagasc - Agriculture and Food Development Authority	IE
5	KU Leuven - Katholieke Universiteit Leuven	BE
6	SLU - Sveriges Lantbruksuniversitet	SE
7	UNIBO - Alma Mater Studiorum - Universita di Bologna	IT
8	BOKU - Universitaet fuer Bodenkultur Wien	AT
9	UBO - Rheinische Friedrich-Wilhelms-Universitat Bonn	DE
10	JRC - Joint Research Centre - European Commission	BE
11	IAE-AR - Institute of Agricultural Economics	RO
12	MTA KRTK - Magyar Tudományos Akadémia Közgazdaság- és Regionális Tudományi Kutatóközpont	HU
13	IRWiR PAN - Instytut Rozwoju Wsi i Rolnictwa Polskiej Akademii Nauk	PL
14	DEMETER - Hellinikos Georgikos Organismos - DIMITRA	GR
15	UNIKENT - University of Kent	UK
16	IT - INRA Transfert S.A.	FR
17	ECOZEPT Deutschland	DE

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List of acronyms and abbreviations

AES: agri-environment scheme

CAP: Common Agricultural Policy

D1.1: LIFT Deliverable 1.1

EU: European Union

GIS: Geographic Information System

IT: Information Technology

IV: instrumental variable

MEC: Means-end chain

PEoU: Perceived Ease of Use

PU: Perceived Usefulness

RDT: Resource Dependence Theory

SEM: structural equation model

TAM: Technology Acceptance Model

TPB: Theory of Planned Behaviour

UK: United Kingdom

USA: United States of America

WP: workpackage

1 Summary

This deliverable D2.1 of the LIFT project presents the conceptual framework on farmers' up-take of ecological approaches across the supply chain. The framework combines behavioural theories on individual decision-making with drivers and methodological considerations related to economic decision-making. Furthermore, deliverable D2.1 presents a systematic map of previous literature related to farmers' up-take of ecological approaches. The purpose of D2.1 is to guide data collection through the LIFT survey to farmers and interview studies in WP (workpackage) 2 of LIFT.

The theoretical part of the framework departs from the Theory of Planned Behaviour (TPB) for understanding individual decision-making, extended by integrating the Technology Acceptance Model (TAM). Furthermore, the framework distinguishes between endogenous, as well as exogenous factors such as: (i) motivational factors; (ii) farmers' self-identity; (iii) farm characteristics; (iv) supply-chain characteristics; (v) institutional conditions (including policy framework); and (vi) consumers' preferences and demands. Factors serve to identify the main drivers of farmers' up-take of ecological approaches, and to enable comparison of different dimensions of up-take across territories. The decision to implement the up-take of ecological approaches is approached across four different dimensions, according to their: (i) timing; (ii) intensity/extensity; (iii) size of change, and (iv) type of practices adopted. These dimensions are important since the factors that affect the decision to adopt have been found to differ across them. The deliverable continues by presenting a systematic map of previous literature related to farmers' up-take of ecological approaches. Two methodological approaches for understanding the drivers of farmers' up-take of ecological approaches are suggested: psychometric methodology and qualitative interviews, using the means-end chain and laddering approach. The deliverable ends by concluding on implications for the LIFT farmers' survey.

2 Introduction

The aim of this deliverable (D2.1 of the LIFT project) is to present a conceptual framework for understanding the drivers of farmers' up-take of ecological approaches. We take a behavioural approach to the understanding of those drivers. This implies that the framework explicitly acknowledges the possible impact of psychological constructs including attitudes, values, perceptions and self-identity. In so doing, the conceptual framework acknowledges the role of human personal characteristics in economic decision-making. Furthermore, the framework builds on a supply-chain approach covering influencing factors throughout the supply-chain. Deliverable 2.1 also presents results of a systematic map of the scientific literature related to farmers' up-take of ecological approaches, to show the state-of-the art and to highlight areas in the conceptual framework that has so far not be sufficiently covered by the literature.

The purpose of the conceptual framework is to guide the data collection through the LIFT farmers' survey as well as farm interview studies in WP2 of LIFT. We conclude the deliverable by discussing the implications of the conceptual framework for the development of the LIFT farmers' survey.

In this deliverable we use the terms "up-take of ecological approaches" and "adoption of ecological approaches" as synonyms. Here, as in the LIFT project, "ecological approaches" are understood in a general meaning, namely environmentally-friendly or low-input farming, and not specifically referring to a type of farming system.

3 Components of the conceptual framework

The starting point for the conceptual framework is the understanding of the decision-model for individual farmers. We build on the Theory of Planned Behaviour (TPB) (Ajzen, 1991) for understanding individual decision-making, and extend the TPB-model by integrating the Technology Acceptance Model (TAM) (e.g. Davis, 1989, Davis, 1985), the notation of use and non-use values for understanding farmers' perceptions of economic value and farmers' self-identity (Burton, 2004).

We then turn to the decision-environment in which the farmer exists. In particular, we introduce drivers from the farm and the policy environment in which the farm sits which may function as drivers for adoption of ecological approaches. Furthermore, we highlight that decision-making of individual farmers is also determined from actors in the supply chain, as well as institutional conditions in which these farmers operate and explain how this may function as drivers for adoption of ecological approaches.

Finally, we characterise the decision to adopt ecological approaches itself, by introducing four dimensions that can be used to understand the decision.

3.1 Decision-model for individual farmers

3.1.1 Attitudes, subjective norm and perceived behavioural control: psychological constructs from the Theory of Planned Behaviour

The TPB (Ajzen, 1991) is one of the most widely used approaches for understanding determinants of behaviour by an in-depth modelling of the individual's beliefs about the behaviour of interest. The TPB framework has been applied in a number of agricultural settings to explain the different behaviours of farmers (e.g. Beedell and Rehman, 2000, Bergevoet, *et al.*, 2004, Gorton, *et al.*, 2008, Hansson, *et al.*, 2012, Läpple and Kelley, 2013, Sutherland, 2010), as well as in other areas related to human economic behaviour (e.g. Kautonen, *et al.*, 2015, Kautonen, *et al.*, 2013).

The TPB framework posits that human behaviour is determined from behavioural intent (e.g. to adopt ecological approaches), which in turn is a function of three central psychological constructs, namely attitude, perceived behavioural control and subjective norm. An attitude to a behaviour represents the individual's summary evaluation of the behaviour. As such it captures the individual's understanding of the value of that behaviour and the individual's level of appreciation of that behaviour. As a simple example, consider an individual's attitude to apply intercropping. This behaviour can be evaluated at a scale ranging from "do not like at all" to "like very much". The attitude ranges between these extreme points and the more the evaluation is orientated towards "like very much", the more positive the individual's attitude and vice versa. Each behaviour is associated with a specific attitude; individuals may thus hold numerous different attitudes, each associated with a specific behaviour (Grube, *et al.*, 1994). The TPB framework stipulates that an attitude is a function of the individual's behavioural beliefs, which are the subjective probabilities that a particular behaviour will lead to a specific outcome. Figure 1 summarises in a conceptual diagram attitudes to a behaviour.

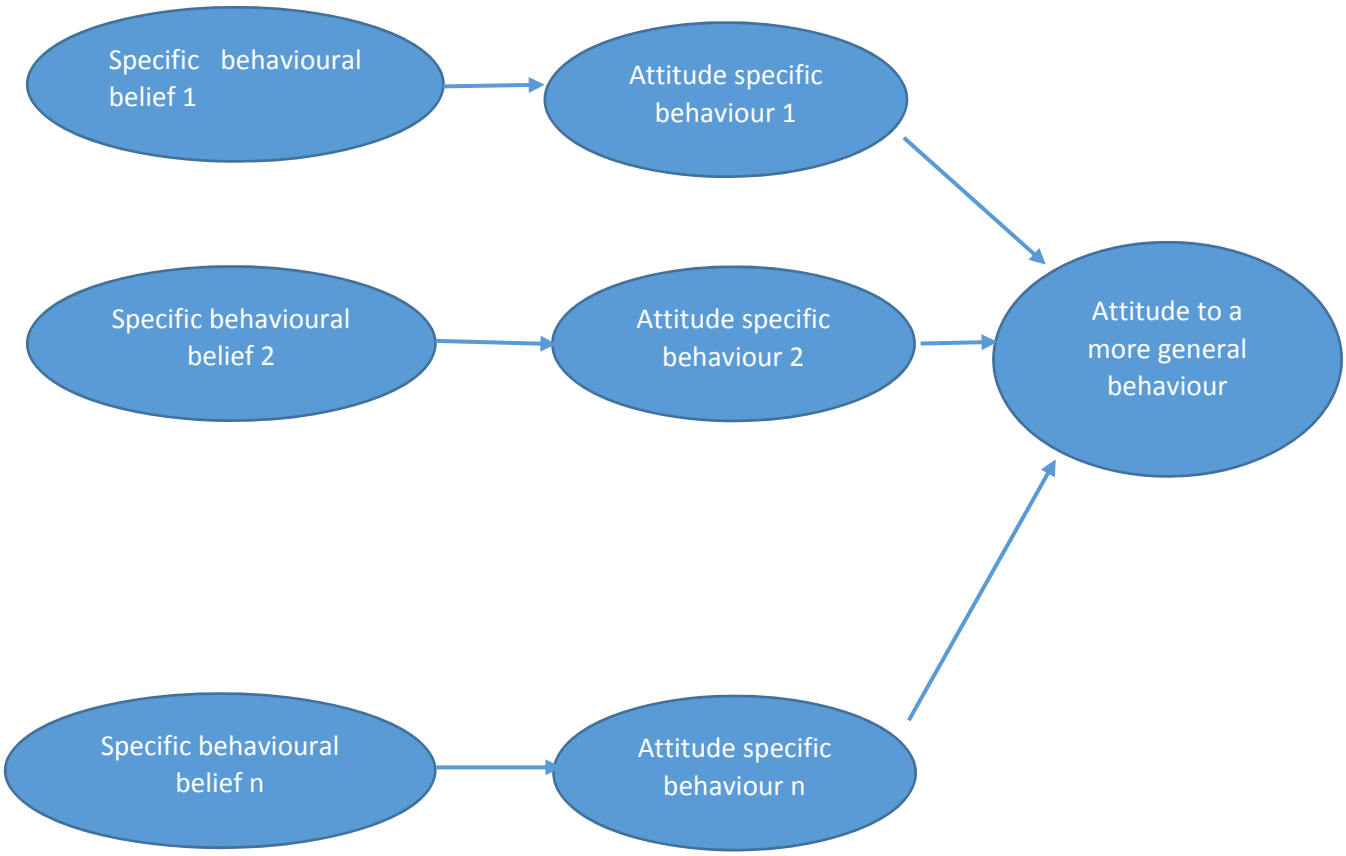

Figure 1: Conceptual diagram of attitudes. Source: Own compilation.

In the TPB framework, holding a positive attitude to an object (such as a specific behaviour) is not enough to create an intention to perform a particular behaviour. The individual also needs to perceive that others in his/her social network support the behaviour, namely the individual's subjective norm (Ajzen, 1991). Subjective norm is thus about the individual's belief that other individuals, whose beliefs are important to the individual, support that behaviour or put pressure on the individual to perform a particular behaviour. These originate from the perceived behavioural expectations of those others. Furthermore, the individual needs to hold a belief that he/she can influence and control the behaviour, this is the individual's perceived behavioural control (Ajzen, 1991). Consequently, perceived behavioural control reflects the individual's perception that he/she exhibits voluntary control over a behaviour and also accommodates the factors that may or may not support a particular behaviour.

Applying the TPB framework in the context of understanding farmers' up-take of ecological approaches, posits that intentions to up-take are determined from farmers' attitudes to ecological approaches, their social norm related to ecological approaches and their perceived behavioural control related to those approaches. It should be noted that farmers are likely to hold one specific set of TPB constructs, i.e. attitude, subjective norm and perceived behavioural control, related to each type of ecological approach; thus understanding up-take of one particular approach requires understanding of the specific set of TPB constructs related to this activity.

The TPB framework has been extended in a number of ways to accommodate particular characteristics of the behaviours being explored by including additional psychological constructs that are particularly important in specific domains. For instance, Donald, *et al.* (2014) added habit to the model and extended the norm part of the model to also cover moral norm and descriptive norm, with the purpose of explaining commuters' use of transport mode, while Kautonen, *et al.* (2015) added age-based self-image to the TPB model to explain entrepreneurial behaviour. This type of extension may be useful for studying up-take of ecological approaches and opens the possibility to study mediating roles of other psychological constructs, such as values and motivation in the decision-making framework of TPB.

3.1.2 Perceived Usefulness and Perceived Ease of Use: psychological constructs from the Technology Acceptance Model

Adding to the TPB framework (Ajzen, 1991), where behavioural intent is predicted from attitudes, social norms and perceived behavioural control, research has shown that user's intended use of a certain technology is related the "usefulness" and the "complexity" of the technology. The Technology Acceptance Model (TAM) is a framework for predicting usage of technology, based on the Perceived Usefulness (PU) and the Perceived Ease of Use (PEoU) of the technology (Davis, 1985) as core variables. PU is defined as the potential user's subjective likelihood that the use of a certain system (e.g.: agroecological system) will improve his/her action; PEoU refers to the degree to which the user expects the system to be physically and mentally effortless (Davis (1989). PEoU represents the perception of difficulty to use or even to learn to use the technology (Ajzen, 1991). Following TAM the potential user who perceives the technology as "useful" and "easy to use" is more likely to adopt the technology.

From previous research, the validity of TAM has been well researched for explaining intentions to adopt and use of information technologies (IT) (e.g. Koul and Eydgahi, 2017, Lane and Coleman, 2012, López-Nicolás, *et al.*, 2008, Park, *et al.*, 2013, Yang, 2005). However, applications to agriculture studying ecological systems are rather limited, especially in terms of selection of ecological approaches. Furthermore, these approaches do not consider the degree or the extent of varietal uptake or technologies per se. For instance, Adrian, *et al.* (2005), Reichardt, *et al.* (2009), Rezaei-Moghaddam and Salehi (2010) studied attitudes and decisions to use precision agriculture; Flett, *et al.* (2004) and Schaak and Mußhoff (2018) studied the use of selected technologies and adoption of grazing practices in dairy farming respectively. Given these findings, PU and PEoU are directly related with technology acceptance and the users' behaviour, with PU seeming to have a greater effect (e.g. Flett, *et al.*, 2004). These authors have shown that, averaged across four different dairy farming technologies, PU and PEoU accounted for 69% of the total variance of a factor solution in a factor-analytical framework. PU and PEoU scores were significantly greater for farmers using the technologies, compared to non-adopters. Adopters consistently reported that technology use was easy, which is a consideration for the knowledge requirement or learning in technology.

Due to identified limitations of the TAM in terms of explanatory power, model modifications such as TAM2 (Venkatesh and Davis, 2000) have, besides PU and PEoU, included external variables such as: i) social influence processes with three interrelated forces: subjective norms, voluntaries, i.e. the extent to which potential adopters perceive the adoption decision to be "non-mandatory", and establish or maintain favourable image; and ii) cognitive instrumental processes with three cognitive instrumental determinants: job relevance, output quality, result demonstrability, all to explain PU. Similar extension by adding determinants to explain PEoU has been provided in TAM3 (Venkatesh and Bala, 2008). Borrowing from IT studies, Adrian, *et al.* (2005) proposed a structural model and path analysis including an attitude of confidence, perceived net benefits and demographic factors expected to influence the intention to adopt precision agriculture. In Adrian, *et al.* (2005) the confidence component is used to capture the assurance to learn and use precision agriculture technology.

In relation to the TPB framework, TAM can be considered an elaboration of the attitude construct in terms of the PU and PEoU which elaborate two dimensions of this component. This project (LIFT) has extended the application of TAM by including it within the entire TPB framework and by applying it to the behavioural intent and adoption behaviour related to a spectrum of ecological approaches, characterised by different degrees of complexity, as elaborated in Deliverable D1.1 of LIFT (see Rega, *et al.*, 2018). Understanding farmers' attitudes, and decisions for adopting ecological practices in terms of PU and PEoU, can help for developing easy to use technologies, and policies providing knowledge (for the usefulness, and the practice - know-how) that increase the actual adoptions, and predicting future adoptions.

3.1.3 Use and non-use values as motivational factors

Understanding the underlying values functioning as motivational factors of farmers' up-take of ecological approaches is useful for understanding their behaviour. In particular, the notion of 'economic value' is useful in this respect as it can be used to highlight the type of economic value farmers perceive from their up-take of ecological approaches. This can be expected to the extent that farmers' perceive economic value in application of practices and that this economic value is not off-set by costs associated with taking up ecological approaches. In this conceptual framework of LIFT, we view motivational factors as antecedents of the attitude construct in the TPB framework as they are likely to function as reinforcement of the individual's like or dislike of an object in relation to his/her goals.

The notion of economic value is appealing as it can be used to encompass all types of benefits farmers perceive from economic goods appropriated from up-take of ecological approaches. This acknowledges that there may be a diversity of different types of economic values that motivate behaviours around up-take. This notation has previously been used for understanding farmers' behaviours, in particular from working with their livestock (McInerney, 2004) and for their provision of farm animal welfare (Hansson and Lagerkvist, 2016, Hansson and Lagerkvist, 2015, Lagerkvist, *et al.*, 2011). This literature highlights that farmers may provide farm animal welfare because economic value is derived from such actions based on their effects on the production processes; referred to as use-values. Non-use values are used to explain farmers' provision of farm animal welfare beyond requirements related to the production processes and statutory requirements.

Relating the notation of use and non-use values to farmers' up-take of ecological approaches is therefore appealing as the notation acknowledges that motivation for doing so may not only be related to effects on production processes – which can generally be interpreted in monetary terms – but may also be related to other types of effects. Such effects may include that farmers experience economic value from knowing that soils are kept in a certain way, compliance with farmers' ethical codes, fulfilment of identity related to how a 'good' farmer should keep his/her soil, keeping the soil in good condition for future generations and avoiding possible discomfort from applying production methods that can be harmful to the eco-systems. Economic value of non-use type can also be derived from establishing more sustainable relationships with customers, from knowing that consumers are offered high quality food products and from obtaining recognition from actors in the food-supply chain.

3.1.4 Farmers' self-identity: a driver for adoption of ecological approaches

An individual's self-identity corresponds to his/her beliefs about him/herself. Apart from the 'non-use' value coming from fulfilment of self-identity as described above, the notion of self-identify can be useful as a separate construct in the conceptual framework of LIFT. Burton (2004) has described the identity of the 'good farmer' to being associated with fertile soils, high yields and thriving animals that yield high quality animal products. These are described as important clues around the identity of the

farmer and are associated with his/her status and self-esteem. The identity concept in itself has been important for understanding farmers' behaviours. For instance, Vesala and Vesala (2010) have investigated farmers' identities as entrepreneurs or producers and in what way those are present among conventional and diversified farmers. Niska, *et al.* (2012) have investigated farmers framing of farming in terms of a peasant livelihood or entrepreneurial activity. Brandth and Haugen (2011) found that farmers who renewed their businesses through starting up agritourism enterprise found themselves adopting a new type of identity, abandoning the identity of a conventional type of farmer. Hansson and Kokko (2018) used the concept of self-identity for explaining why farmers had not, to the extent expected, re-organized their farms to counter negative consequences of a significant change to the environment surrounding their farms (in their case the restoration of a wetland).

Self-identity may be an equally important driver for understanding farmers' adoption of ecological approaches. In particular, adopting ecological approaches may result in fields that, from a visual perspective, appear less fertile and more plagued by weed problems, and may thus hurt farmers' self-identity centred on fertile, high yielding soils. This makes them less inclined to adopt ecological approaches. For those who do adopt ecological approaches, this may have been preceded by a (possible gradual) self-identity change.

3.2 Decision context

3.2.1 Farm characteristics

Empirical work demonstrates that the variety of farm related factors such as structural characteristics (size, degree of fragmentation, type of land tenure, type of business, existing equipment), managerial features (degree of specialisation, type of production specialisation, economic size), farm family characteristics, spatial factors (proximity to urban centres, main roads, local markets, etc., location in Area Facing Natural Constraints/priority targeted regions), are identified as strong predictors for the up-take of ecological approaches. Furthermore, as ecological approaches differ in intensity (see Rega, *et al.* (2018)) the up-take of these practices might also be related to that intensity, in terms of workload and knowledge. However, common understanding of the influence of these attributes does not exist (Kumar, *et al.*, 2018). Differences in farm size (in physical, and economic terms) are related with the uptake of agroecological approaches; for instance, large farms can invest or have the buffer for experimentation to try agroecological approaches (Arslan, *et al.*, 2014, Blazy, *et al.*, 2011, Flaten, *et al.*, 2005, Khaledi, *et al.*, 2010, Pietola and Lansink, 2001), but it also implies higher labour costs (Blazy, *et al.*, 2011). Therefore, smaller farms are found to be more appropriate for labour intensive ecological approaches, especially when labour is unpaid. Differences in the effect of the location (in Areas Facing Natural Constraints or priority targeted regions for instance) can arise from differences in specific practices in public procurement, e.g. the specification of demand for organic food across municipalities (Lehner, 2010), a specific regions' eligibility for environmental support or soil quality (Kumar, *et al.*, 2018, Nachtman, 2015, Pietola and Lansink, 2001, Schmidtner, *et al.*, 2012).

Moreover, addressing how ecological approaches at various scales are related with farm characteristics, provides greater potential for strategic planning and sustainable development of these practices across the European Union (EU).

3.2.2 Supply chain drivers for adoption of ecological approaches

A significant part of the literature defining the influences on farmer decision-making, whether traditional or environmental, lies within the area of sustainable food supply chain management. The food supply chain is usually considered to start with the primary production at farm level, followed by

the processing industry such as dairies and slaughter companies, the retailing sector and finally the consumer who purchases the food products from actors in the retailing sector.

It is well-acknowledged that farmers' decision-making is influenced to a large extent by others in the supply chain in which they operate, and that, overall, the decision-making processes of all supply chain actors ultimately follow market demand. More recently market demand for food products has been shaped progressively by considerations other than price and food safety, namely the environmental footprint, animal welfare, socially 'fair' aspects, and this has been reflected increasingly in the food supplied and has affected the behaviour of all actors along the supply chain. In this section we analyse theoretical frameworks used to understand the influences on farmer behaviour from elsewhere in the supply chain on decision-making and, more specifically, on environmental management.

The sustainable supply chain management literature is considerable (Rajeev *et al.* 2017; Seuring and Müller, 2008; Ahi and Searcy, 2013) and includes a number of theories and corresponding methods applied to portray and estimate the linkages between the different chain segments and transfer or accumulation of effects leading to behavioural change. A large part of the literature analysing causalities along the supply chain builds on the TPB framework. Some of these approaches estimate supply chain influences on farmer decision-making mainly through the 'subjective norm' component of the framework. Other conceptual frameworks used to analyse influences on farmer decision-making originate from business management and organisational theory, such as the Resource Dependence Theory (RDT) introduced by Pfeffer and Salancik (2003). This is focussed on how organisations/supply chain stakeholders manage their relationships with others to thrive by reducing environmental uncertainty. There is an increasing number of analyses on the determinants of collaboration e.g. Inman, *et al.* (2018) who argue in favour of involving processing and retailing elements within the food supply chain in group-based learning processes with farmers to incentivise environmentally-friendly behaviour. Their analysis is based on buyers and food retailers' increasing interest in natural resource management and benchmarking within the farming sector, and how farmers perceive this influence. Inman, *et al.* (2018) analyse supply chain influences on farmer behaviour from the perspective that farmers 'consider the food supply chain to represent a professional network with whom an informed discussion might be conducted', which may have a different weight in explaining related changes in their decision-making.

Similarly, Dania, *et al.* (2018), Kottila and Rönni (2008) recommend collaboration among heterogeneous stakeholders to deal with the complex sustainability requirements in agrifood supply chains, as 'essential to collectively achieve a competitive advantage for better environmental, business and societal outcomes'. Fearne, *et al.* (2001) state that market share, market growth and margins within a collaborative system are higher, while Pomeroy, *et al.* (2007) argue that collaboration may help to reduce conflicts, abate individualistic and opportunistic behaviour of supply chain stakeholders (Lozano, 2007) and improve responsibility of each stakeholder in maintaining the sustainability of supply chains. Serra and Poli (2015) present other arguments in favour of supply chain collaborative efforts, namely that farmers' 'business skills, aspirations and system thinking' would improve through better access to resources and opportunities sometimes more readily available to other supply chain stakeholders. This may also lead to incentives for farmers to manage their farms in a more environmentally-friendly manner through development and implementation of innovative ideas and practices. Hamprecht, *et al.* (2005) state that effective communications between farmers and buyers lead to improved economic, environmental, and social standards throughout the supply chain.

3.2.3 Institutional conditions as drivers of adoption of ecological approaches

Institutional conditions are understood to have an important influence on the decision to adopt ecological agricultural approaches (Edwards-Jones, 2006, Pretty, 2008, Tilman, *et al.*, 2002). They can narrow or widen the options available to farmers by requiring compliance with regulations or offering subsidies (Tey and Brindal, 2012) but also have important influences on individual's thought and behaviour, perhaps reinforcing (or challenging) farmers' social norms and identities (Dequech, 2009). Given the breadth of what may be termed an institution, conceptually it is useful to consider distinctions such as whether institutions are: informal or formal; public or private; voluntary or mandatory; operating vertically or horizontally in the supply chain, as well as the scale of activity (Armitage, *et al.*, 2009). Vertically we consider contractual relationships between the farmer and their suppliers or between the farmer and those who buy their products. Horizontally we consider membership of cooperatives or machinery rings where agricultural equipment might be shared. Within our framework we will consider both informal and formal institutions, primarily those that are voluntary rather than mandatory since LIFT research questions go beyond those of compliance; those that operate vertically in the supply chain are of particular interest; we could also consider local, national, and international scales.

Public institutions could be represented in the model by the policy environment. Understanding for example which agri-environmental schemes are available at the EU, national or regional funding will be important: evidence suggests that scheme characteristics account for some variance in adoption rates (Edwards-Jones, 2006, Knuth, *et al.*, 2018, Mozzato, *et al.*, 2018). Private institutions, on the formal end of the spectrum could be represented in the model by private standards or participation in certification schemes. This includes consumer facing e.g. organic (Quiedeville, *et al.*, 2017) and non-consumer facing e.g. good agricultural practices (Codron, *et al.*, 2014). Some have argued that formalisation of these institutions are important for increasing adoption rates (Quiedeville, *et al.*, 2017) whereas others have argued that some support the status quo and actually limit transitions to more sustainable practices (Konefal, 2015).

Informal institutions could be represented in the model by farmers' social networks. The importance of social networks such as interpersonal networks with near peers has long been highlighted in the diffusion of innovations theory (Rogers, 1983). Inclusion of social network information has become more common in economic literature although provides challenges (Maertens and Barrett, 2012). Who is in a network, the strength and position of the actors, may all be relevant to the adoption decision (Toma, *et al.*, 2016, Trabelsi, *et al.*, 2016).

3.2.4 Perception of consumers' attitudes and demand for ecological production as drivers for adoption of ecological approaches

Consumers increasingly care about the environmental impact of their consumption. 42% of the global consumers want more products in the market that are produced in a socially responsible and environmentally friendly way (Nielsen, 2015). According to the Sustainability Imperative (Nielsen, 2015), the number of consumers willing to pay more for brands committed to positive social and environmental impact continues to rise – reaching 66% in 2015 (up to 11% from 2014). This holds for different types of consumer goods, including agri-food products. Price and taste are (still) major determinants for food consumption choices. However, more and more consumers care about other aspects of food consumption and production (Farber, 2012). They are interested in consuming tasty, healthy, safe and high-quality foods that are produced in a way that respects the environment and animal welfare and stimulates local development.

While there is a positive attitude towards more sustainable food consumption and while consumers indicate that they are willing to pay a mark-up for more sustainably produced food products (Farber, 2012), market shares of, for example, organic products remain relatively low (Rousseau and Vranken, 2013). This difference between what people think, feel and say is also known as the attitude-behaviour gap (Farber, 2012, Vermeir and Verbeke, 2008) and can be attributed to many reasons. There is a lack of a commonly agreed definition of the food sustainability concept. It is also a multi-dimensional concept which makes it difficult to determine the overall sustainability of food consumption patterns and to signal this to consumers. While this attitude-behaviour gap still exists, consumers are also increasingly backing their values with their willingness to pay.

For the conceptual framework of LIFT, this means that farmers' perceptions of the development of consumer preferences will function as one important driver of adoption of ecological approaches.

3.3 Characterising decisions to implement and the up-take of ecological approaches

Four different dimensions across which decisions to implement ecological approaches have been identified in the literature: according to their timing, intensity (or extensity), the size of change, and the type of practices adopted. These dimensions are important since the factors that affect the decision to adopt have been found to differ across them. While many of these dimensions are relevant to the adoption of any technology or practice, they have particular nuances in the ecological approach adoption literature, particular with regards the size of change and differentiation between incremental and transformative changes. Disruption is another aspect worth mentioning. For various reasons implementation of ecological approaches may be disrupted and this may lead to what we consider as incremental changes, even though incremental changes may also originate from the farmers' original adoption plan.

3.3.1 Timing of adoption

The first way in which adoption decisions were found to be characterised, is according to their timing (e.g. Carlisle, 2016, Higgins, *et al.*, 2017, Liu, *et al.*, 2018, Läpple and Van Rensburg, 2011). Studies have found different factors affecting the decision to adopt depending on when the practice was adopted relative to the newness of the practice (Läpple and Van Rensburg, 2011). They have also identified that adoption is not a one-time decision, rather it is better understood as a process, from being aware of the practice, to being interested in, and ultimately adopting it (Carlisle, 2016). This has led to a two-step process of identifying first farmers most likely to adopt and then looking at how those farmers could be helped to adopt (Baumgart-Getz, *et al.*, 2012, Llewellyn, 2011). These observations are underpinned by the diffusion of innovations theory developed by Rogers (1983), and the S-shaped diffusion curve developed by Tarde (1903).

Studies have expanded on the timing dimension to highlight that farms move on many different trajectories (Kumar, *et al.*, 2018, Wilson, 2008), that we should therefore try to account for those that are "tinkering" (Higgins, *et al.*, 2017), in the process of conversion (Cakirli, *et al.*, 2017), or trialling and evaluating an approach (Liu, *et al.*, 2018). Others have argued that capturing those dis-adoption decisions can be useful for highlighting when drivers of adoption are transient - such as incentives and regulatory approaches that subsequently change (Mills, *et al.*, 2017).

3.3.2 Intensity or extensity of adoption

The second way in which adoption decisions were found to be characterised is by the intensity with which, or extensity to which a practice has been adopted. Examples include: Moore, *et al.* (2016), who found that the extensity (defined by acreage) and intensity (defined by diversity and complexity) of

cover cropping had different explanatory factors; Tey and Brindal (2012) who considered how frequently farmers used a particular precision agriculture technology; and Robert, *et al.* (2016) who distinguished between spatial scopes across which climate adaptive practices were implemented (plot, farm or plot and farm); Kumar, *et al.* (2018) studied the decision process and the factors influencing conversions to mixed or fully organic farming. Clearly there may be links between the time and intensity dimensions, however, as described by Moore, *et al.* (2016), Robert, *et al.* (2016) and Kumar, *et al.* (2018) there are reasons that farmers may choose to apply some practices on only parts of their land for relatively lengthy periods of time, and therefore considering the dimensions of time and intensity separately could provide useful insights. The degree of intensity of adoption may also be due to access to necessary farming equipment which through collaboration with other farmers may both drive and limit adoption.

3.3.3 Size of change

The number of practices adopted (relative to time passed) is the third way in which adoption decisions are characterised with a number of studies differentiating between incremental and transformational changes (Carlisle, 2016, Huet, *et al.*, 2018, Lamine, 2011, Sutherland, *et al.*, 2012). Transformational changes are seen to be qualitatively different from incremental changes (Carlisle, 2016) with different factors being found to influence transformational compared to incremental changes (Sutherland, *et al.*, 2012).

Changes are often characterised as transformational when large changes are made on farm, but also when the changes occur beyond the farm gate and extend into the supply chain (Hill and MacRae, 1996, van Mierlo and Beers, 2018). This can include the need to engage in organic supply chains or develop links with local food networks selling directly to customers. As a consequence, studies highlight economic or supply chain factors as factors that limit transformational changes (Carlisle, 2016, Cook and Hagey, 2003, Lamine, 2011). This is related to the notion of path dependency where at any moment of decision there are path-dependent boundaries which "reflect what is likely or possible" given everything about the position of the farm (Wilson, 2008, p. 368).

Theory in the sustainable transitions literature predicts that moves to a more sustainable agricultural system will occur where there is top-down pressure due to changes in the landscape (e.g. climatic change) and bottom-up pressure from coming from innovative niches (Konefal, 2015). However, how transformational change takes place at farm level is not well understood, at least in the quantitative literature which Huet, *et al.* (2018) argues has tended to focus on incremental change e.g. the adoption of single clusters of practices (Huet, *et al.*, 2018).

3.3.4 Type of practice adopted

The type of practice adopted is the fourth important way in which decisions to adopt are characterised. This dimension is highlighted by both the diffusion of innovation (Rogers, 1983) and TAM (Venkatesh, *et al.*, 2003). However, it is difficult to distinguish between the properties of the practice itself and farmer perceptions of the practice (Adusumilli and Wang, 2018). For example the type of practice has been theorised to affect adoption due to differing information requirements (Larson, *et al.*, 2008, Walton, *et al.*, 2008), observability of effects (McCann, *et al.*, 2015), and cost. However, each of these aspects might also be considered relative to the farmer/farm position.

Whether or not the type of practice is important is difficult to discern from review articles since many restrict themselves to one or two clusters of practices (as defined by Table 3 in D1.1 of LIFT, (see Rega, *et al.*, 2018)) or "bundles" (Rajendran, *et al.*, 2016). Of both the narrative and meta-analytic reviews found within this search the topics included: precision farming (Bramley, 2009, Pierpaoli, *et al.*, 2013);

conservation agriculture (Knowler and Bradshaw, 2007); best management practices relating to non-point source pollution (Liu, *et al.*, 2018); organic and integrated pest management (Rajendran, *et al.*, 2016). Baumgart-Getz, *et al.*'s meta-analysis of best management practice adoption within the United States of America (USA) (Baumgart-Getz, *et al.*, 2012) includes one of the widest ranges of practices and finds that access to and quality of information, financial capacity, and being connected to agency or local networks of farmers or watershed groups were categories that had the largest effect sizes across studies. While Baumgart-Getz, *et al.* (2012) observe that many studies on ecological approaches include variables measuring environmental attitudes and values, they argue that inclusion of these variables in the models are often not well justified – logically or by the data.

4 An integrated conceptual framework

In Section 2 we have introduced the components of the conceptual framework in LIFT. As indicated above, the conceptual framework characterises farmers' uptake of ecological approaches in three dimensions: i) the decision-process of individual farmers; ii) the decision-context in which the farm exists and iii) the adoption decision in itself. In Figure 2 we show how these dimensions can be merged into an integrated conceptual framework.

Our starting point is the TPB framework which characterises the decision-process of individual farmers. The TPB components attitude, perceived behavioural control and subjective norm are assumed to determine farmers' behavioural intent to adopt ecological approaches, which in turn is assumed to determine behaviour, i.e. actual adoption of ecological approaches. We extend the TPB framework by first extending the attitude construct by considering the PU and the PEoU of ecological approaches. Subjective norm is considered in terms of perceptions and demands of consumers and other supply chain actors. Furthermore, we extend the TPB framework by adding self-identity as an additional component which enters the model at the level of attitude, perceived behavioural control and subjective norm. The type of economic value (in terms of use and non-use values) experienced by farmers is considered a motivational construct which enters the integrated conceptual framework as an antecedent to the attitude component and the subjective norm component. The self-identity component is assumed to impact the types of use and non-use values perceived by farmers.

We consider the decision-process of individual farmers, described by an extended TPB-framework to be affected by the context in which the farm exists. In particular, we assume heterogeneity of the decision-process with respect to farm related factors, influences and information from supply chain actors, formal institutions, informal institutions, farm socio-demographics and the nature of practice. This is depicted to the left in the integrated conceptual framework in Figure 2.

Finally, we consider the adoption decision in itself. According to the literature review, the decision can be characterised along the dimensions of the time or process characteristics of adoption, the intensity of adoption, whether adoption is incremental or transformational and finally in terms of the type of ecological approach(es) adopted. In LIFT, we extend the TPB framework by considering adoption behaviour along these dimensions. Furthermore, as it is reasonable to assume that any behaviour would induce a learning process in the individual, through any experience obtained from the adoption process, we posit that current adoption behaviour will have an indirect impact on future adoption behaviour through a hypothesised feedback loop on attitude and perceived behavioural control.

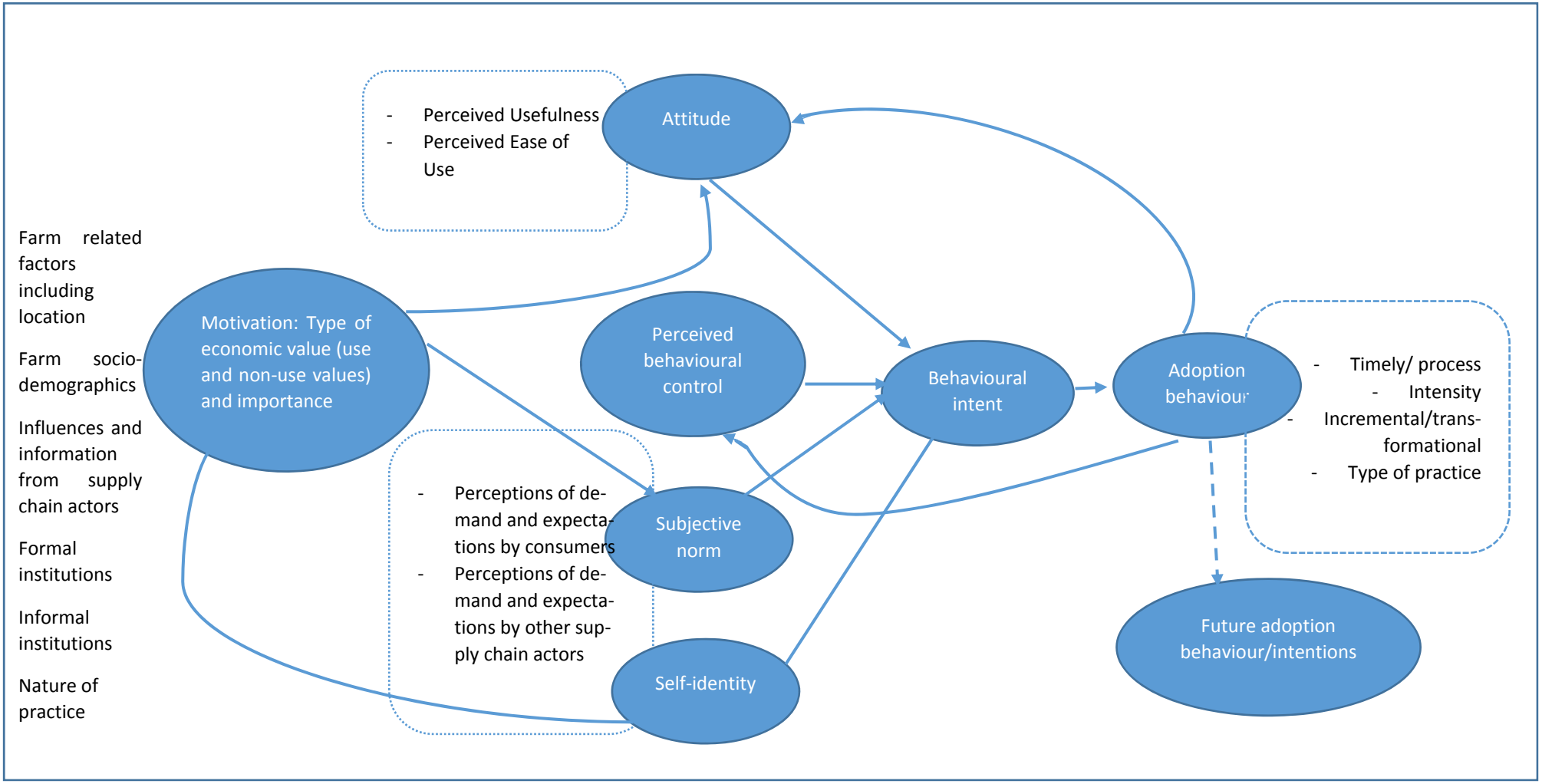

Figure 2: Integrated conceptual framework. Source: Own compilation

5 A systematic map of previous literature

To obtain a systematic understanding of the current knowledge related to farmers' up-take of ecological practices and the extent to which determinants of adoption behavior as outlined in the conceptual framework have been investigated in previous literature, we conducted a systematic map of literature found in Web of Science and Scopus between years 2008 – 2019. The starting year 2008 is consistent with the Common Agricultural Policy (CAP) "Health Check" reform, which implied increased potential spending on, and therefore uptake of, agri-environmental measures. We focused only on literature which has collected own empirical material.

The search string was based on previous reviews of the farmer behaviour literature and D1.1 of the LIFT project. The first part of the string defines our population of interest. We included terms that would pick up where either farmers or agriculture were the subject. This enabled us to capture the "agricultural transitions" literature described in section 2.3 and the more traditional individual decision maker literature e.g. "farmer behaviour" literature described in section 2.1. This breadth was important since the LIFT project is concerned with the whole spectrum of ecological practices. The second part of the string defines the actions in which we are interested. Again here we included terms such as "transition" as well as terms common in the individual decision-maker literature such as "attitude". The third part of the string defined the practices or systems that we were interested to understand the adoption of. This section was derived from D1.1 and includes the terms for the ecological farming typologies as well as the individual practices described. The final list of practices and farming typologies included in the query was developed iteratively to remove redundant terms. We also included additional terms such as "best management practices", "sustainab*", and "environment" based on previous reviews of the farmer behaviour literature. We limited our geographic scope to Europe, USA, Canada, Australia or New Zealand, where agriculture is generally equipment intensive and where the economic systems are similar. We did this by specifying countries to exclude rather than include. By this we avoided excluding relevant studies as the country of origin is not always included in the title, keywords or abstract. We also excluded studies that referred to mammals since this helped us to exclude a large number of natural science papers that were not relevant to our search. The query can be found in Table 1.

After an initial screening of the literature based on title and abstract, a total of 467 individual articles were retained. The exclusion criteria used were:

- Wrong country: where these had not been caught by exclusion criteria.
- Wrong outcome: the dependent variable of the study was not the adoption of a listed practice or system, intention to engage in a practice, attitude or belief about a practice. For example, those studies that evaluated the efficiency of a practice or its environmental results were excluded unless the study also considered whether those findings affected the adoption of the practice. We use the term dependent variable loosely since we include both qualitative and quantitative studies.
- Wrong population: the population studied was not farmers/growers e.g. asked only the opinion of consultants.
- Wrong study design: the study modelled adoption so results were projected not actual. We did allow theoretical or conceptual papers given the nature of this deliverable.

- Duplicate between Web of Science and Scopus.
- The study is a review or theoretical study (typically based on informal reviews).

These 467 studies were read more carefully by the authors. This process has resulted in the further exclusion of 150 records which, after more careful reading, were considered not to fit with our purposes based on any of the exclusion criteria listed above. This left us with a total of 317 studies which were further analysed. The framework we used to analyse the studies can be found in Appendix A.

Table 1: Search string

TI =	farm* OR agri* OR agro*
AND TI =	adopt* OR adapt* OR behavio* OR behavio*change OR decision* OR transition* OR intention* OR participation OR attitude* OR perception* OR determinant* OR conversion OR willingness* OR preference
AND TS =	agro*ecology OR biodiversity OR diversity OR diversification OR ecological OR ecology OR organic OR integrat* OR mixed OR low-input OR extensive OR low-intensity OR permaculture OR conservation OR silvopastoral OR agri-environment* OR ecosystem service* OR agroforestry OR intercrop* OR polyculture OR *rotation* OR integrated pest management OR IPM OR cover crop OR bio-control OR best management practice" OR BMP OR *fixation OR transhumance OR fallow OR mulch* OR precision OR set-aside OR sustainab* OR crop residue management OR environment*
NOT TS =	Argentina OR Bangladesh OR Brazil OR Cambodia OR Chile OR Colombia OR Africa OR Guatemala OR India OR Iran OR Kenya OR Lebanon OR Malawi OR Mexico OR Nepal OR Nigeria OR Pakistan OR Senegal OR South Africa OR Tanzania* OR Thailand OR Uganda OR Vietnam OR Zambia OR Zimbabwe OR Bolivia OR Uzbekistan OR China OR Ethiopia* OR Philippine OR Honduras OR Costa Rica OR Mozambique OR Laos OR Malaysia* OR Ghana
NOT TS	mammal*

The remainder of this section presents an overview of these studies categorised in terms of geographical scope, definition of ecological approach used in the study, considered drivers of ecological approaches, type of data and type of analytical methods used.

5.1 Study location

We found that just over half of all the studies were based on research in EU countries (*Figure 3*). In terms of other regions 4% were from European countries outside the EU, 31% were based on research from North America, 9% from Australasia, and 2% were multi-region studies.

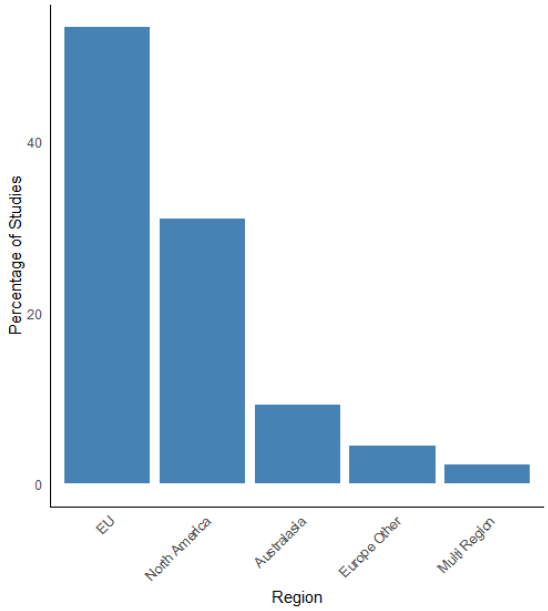

Figure 3: Percentage of studies by region (n = 317)

Figure provides information on which EU countries the studies came from. The United Kingdom (UK), France, Germany, and Italy were the most common single country studies, followed by studies which covered multiple countries.

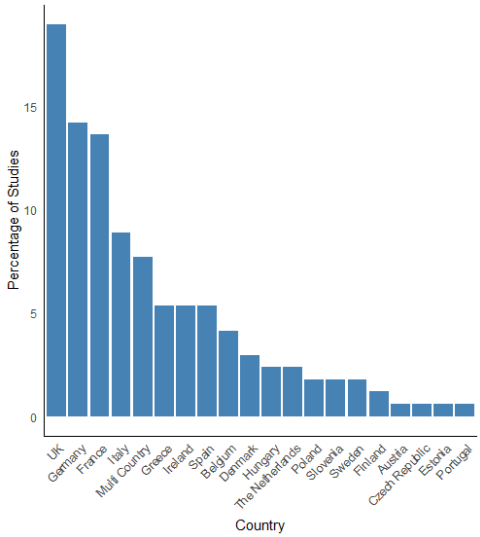

Figure 4: Percentage of EU based studies by country (n = 169)

5.2 Study data type and dependent variable

The most common type of study was survey based with just over 64% being of this type (*Figure*). Interviews were the next most common although only 26% employed an interview technique. Mixed studies, those that incorporated some quantitative and qualitative analysis were fairly uncommon at just over 4% of studies found.

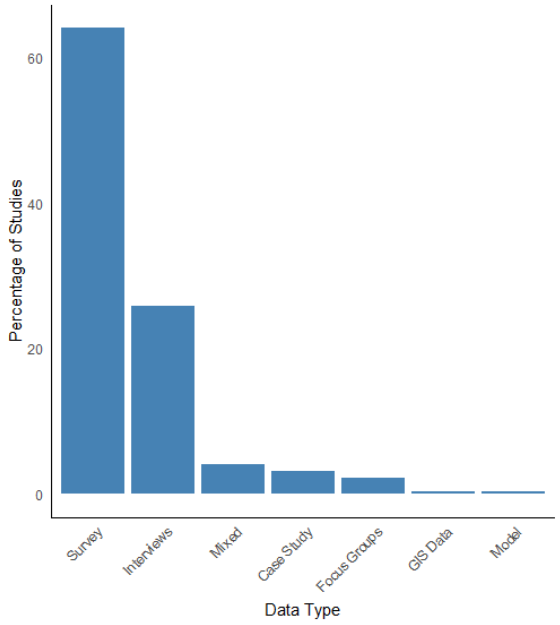

Figure 5: Percentage of studies by data type (n = 317)

Within the studies that used a survey (n = 203) we also considered the analytical methods used (**Erreur ! Source du renvoi introuvable.**). Other methods including structural equation models (SEM), instrumental variable (IV) approach or cluster and latent class models are much less common. Further analysis will also consider the type of regression whether the studies use a binary "use/do not use" dependent variable or use other measure that show the extensity or intensity of adoption.

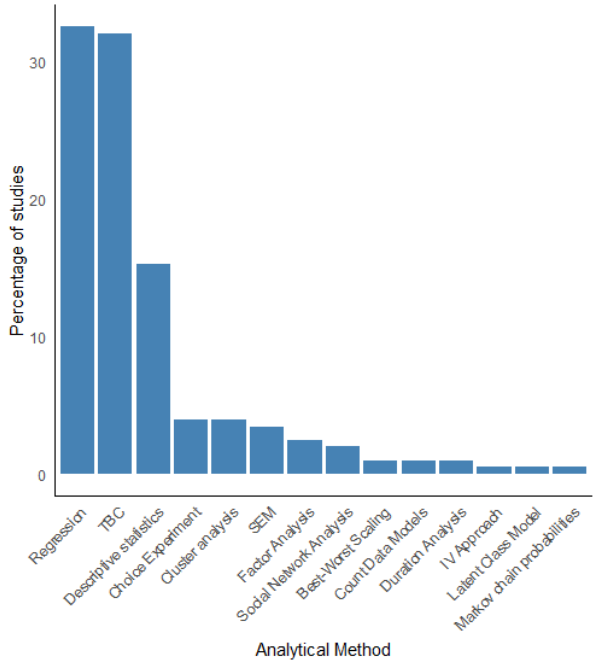

Figure 6: Percentage of survey studies by analytical method (n = 203)

We further considered whether there was any pattern to the studies by region. Surveys comprised around 70% of studies from North America, Australasia, and Multi-Region studies. They comprised around 60% of studies in the EU but a lower proportion in studies from other European countries (43%), the same proportion as were based on interviews. In EU studies, interviews were 29% of the total whereas they were 20% or under in North America and Australasia. These results are presented in *Figure* . For the number of studies per region refer back to *Figure 3*.

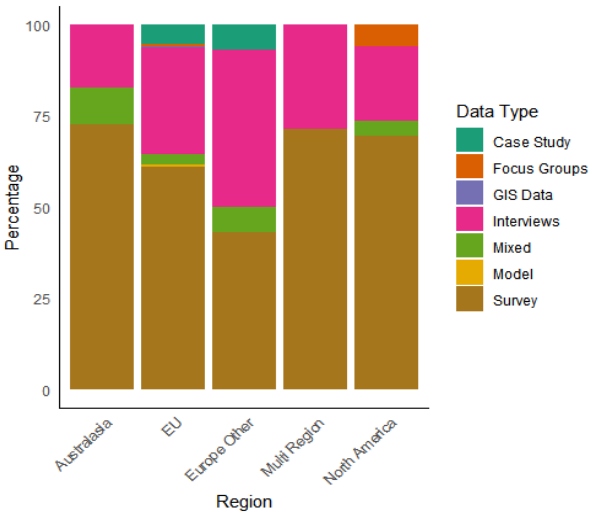

Figure 7: Proportion of studies by region and data type

Another criterion of interest was whether the study investigated behaviour or the actual adoption of a practice as opposed to either intentions to adopt or attitudes towards adoption. We found that studies investigating actual behaviour were the most common, closely followed by attitudes towards adoption (Figure 8).

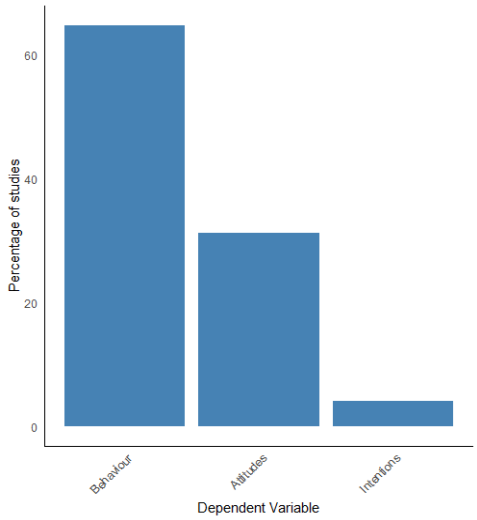

Figure 8: Percentage of studies by dependent variable (n = 317)

The high number of studies on attitudes is related to the inclusion of studies on the topic of climate change perceptions. Choice experiment studies that investigate willingness to pay or participate were also classified as having attitudes as their dependent variable. The number of studies using intentions as their dependent variable was very low. This result may be somewhat misleading as studies which include both intentions and behaviour have for simplicity here been classified as having behaviour as their dependent variable. Understanding more about which studies include both and whether they have a gap between the measurement of intentions and behaviour is something to consider in a more in-depth analysis.

5.3 Ecological practices

Figure presents our findings on the type of practices covered by the studies in our sample. These have been tokenised meaning that where a study covered more than one practice category these are counted separately. Practice categories were defined in line with D1.1 (Rega *et al.* 2018) with a couple of additions. We use labels for systems of practices where applicable e.g. organic or agroecology. We also use labels for practice groups e.g. *Fertilisation and soil management*. These practice labels are consistent with the labels used in the LIFT survey. We use the additional label *agri-environment scheme (AES)*. While this can cover a range of practice groups, given that AES are associated with specific contracts and payments, the decision to adopt is likely to be different for the same practice when associated with an AES than when it is not. We use the label *climate change perceptions* as a number of studies covered this topic despite the fact that they do not specify a practice change. It should be noted that the label *organic* is different from the others in that what counts as organic is defined according to certification regulations.

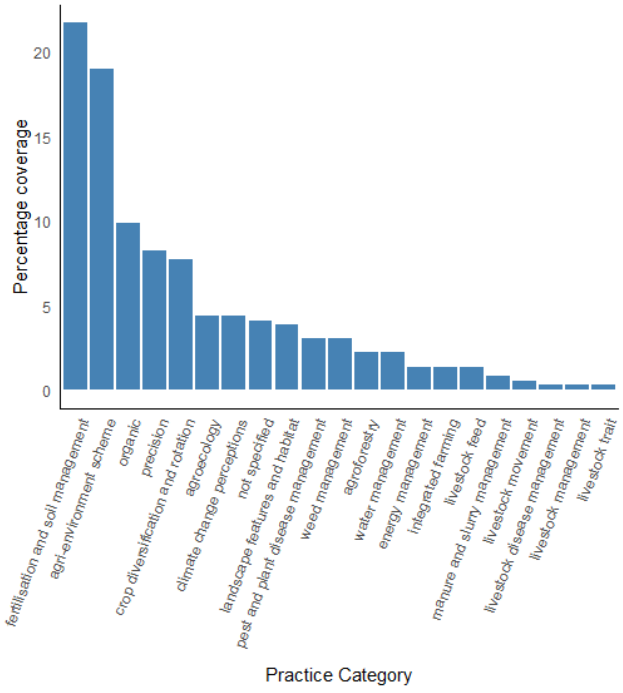

Figure 9: Percentage of practices by practices covered (n = 364)

Figure 10 describes the number of practices covered by the studies. We count those that consider the adoption of whole systems (organic, agroecology) and those that consider the adoption of AES separately. It appears to be most common for studies to cover a narrow practice category such as

Fertilisation and soil management followed by those which consider the uptake of AES or a whole system (predominantly organic). One curious finding is that a number of studies do not clearly specify which behaviours or practices they are studying. Studies categorised as such tend to use loose terms such as conservation or environmental behaviours but nowhere in the text are definitions of those behaviours provided. Also of interest to the LIFT project is that very few studies have considered a wide range of practice categories without specifying a particular system. Four was the largest number of practice categories covered.

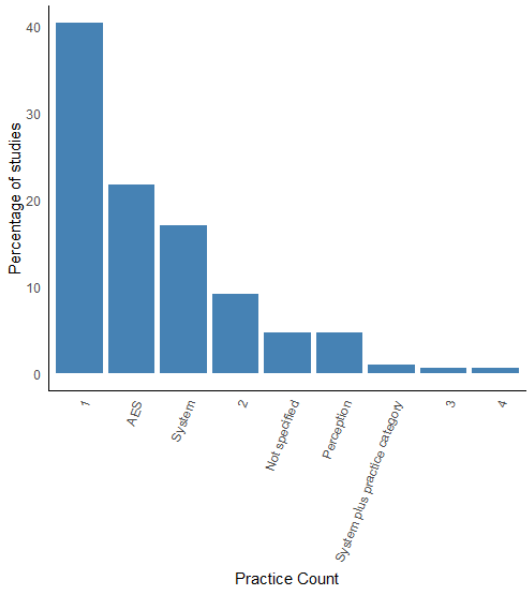

Figure 10: Percentage of studies by practice count (n = 317)

5.4 Influential factor categories

A set of five broad categories for factors considered to have an influence on the adoption of ecological farming practices was established. These categories were developed based on those identified in existing review papers and can be seen in Appendix B. The categories and their abbreviations used in subsequent figures are:

1. *Farmer Socio Demographics (Socio Dem)*
2. *Farm Factors (Farm Struc)*
3. *Farmer Personal Factors (Personal)*
4. *Informal Institutional Factors (Inf Inst)*

*Formal Institutional Factors (F Inst)*Table ***2*** presents the top ten most common categories of influential factors studied. The most commonly studied category of influential factors was Farmer Personal Factors. This was followed by studies that only focussed on Farm Factors. Studies that focussed on only Informal Institutional or Formal Institutional Factors were also in the top ten indicating that it is very common for studies to focus on only one factor category (*Figure* further supports this assertion). Studies that included formal institutional factors alongside other factors were not very common. A copy of the full table can be found in Appendix C.

Table 2: Combinations of influential factors studied

Socio Dem	Farm Struc	Personal	Inf Inst	F Inst	Count
		■			82
	■				31
		■	■		25
	■	■			20
			■		18
				■	17
■	■	■			17
■	■				13
	■		■		11
■	■	■	■		10

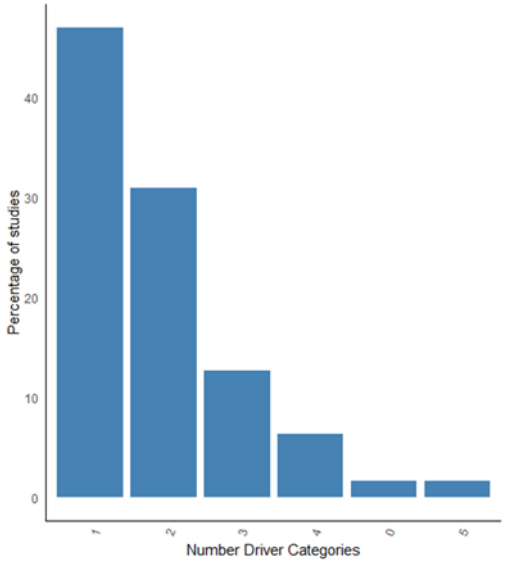

Figure 11: Percentage of studies by number driver categories investigated (n = 317)

5.5 Deep dive into farming systems and practices of particular interest to LIFT

As described in the beginning of Section 4, the search terms for this review included both farming system and farming practice terms as outlined by D1.1 (Rega *et al.* 2018). However, as described in section 4.3, only two of the farming systems were found as the practice category of interest: Agroecology (number of studies = 16) and Organic (number of studies = 34). The remainder of our studies referenced the up-take of one or two practice categories. One point to note is that while Conservation Agriculture was not a common term used to describe the practices under consideration, the most commonly investigated category of practices was fertilisation and soil management, often in combination with crop diversification and rotation. Both of these are elements of Conservation Agriculture and this could therefore be considered an issue of terminology, as Conservation Agriculture is not a term used in higher-income countries even if the practices themselves are of interest.

5.5.1 Agroecology

At present, agroecology as a system has been studied in a qualitative way, with studies comprising of interviews, case studies and focus groups. These studies mainly appear in the EU, in particular France which has 8 studies (the same number of studies from all other countries together) (*Figure*). The adoption of agroecology was mainly considered as a consequence of personal and informal institutional factors. Due to the nature of the studies socio-demographic factors were not considered (*Figure*).

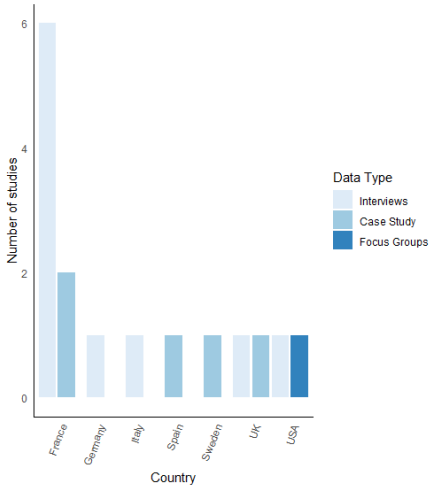

Figure 1: Agroecology studies by country and data type (n = 16)

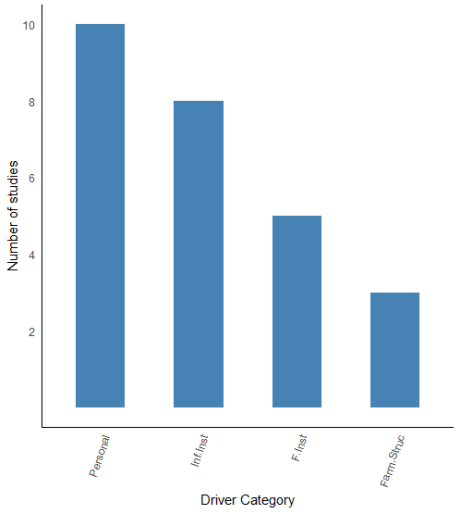

Figure 2: Drivers of uptake of agroecology

5.5.2 Organic

Organic studies were more common than those on agroecology with 34 studies found. They came from a broader range of countries, and regions (although only one from New Zealand and none from Australia). Surveys were also the most common method of data collection (*Figure*). In contrast to agroecological studies we find that informal institutional factors were the least considered categories for organic. While some of the differences in drivers considered are attributable to the study data type, it is interesting to note the differences in the relative emphasis placed on different driver types. For

example why do many studies on agroecology choose not to consider farm structural factors that might make this system more or less applicable to the farm, equally why do many studies on organic choose not to consider informal institutional influences? From the perspective of LIFT, including a balance of these elements could provide new insights.

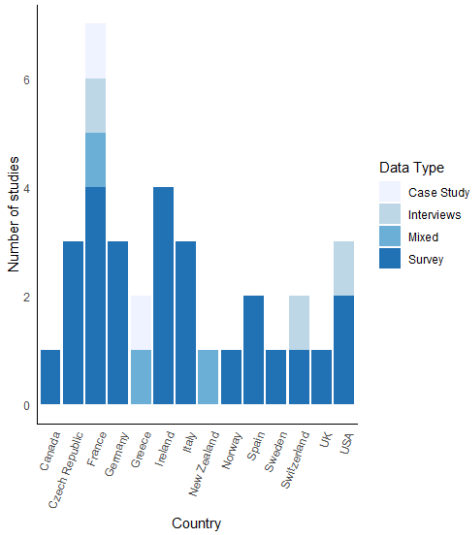

Figure 3: Organic studies by country and data type (n=34)

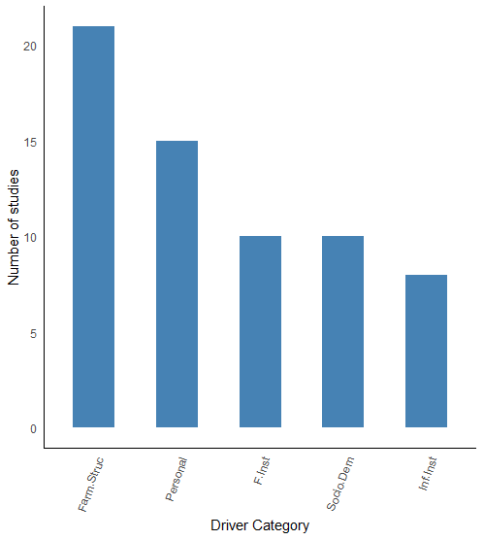

Figure 4: Drivers of uptake of organic (n = 34 – multiple drivers per study)

5.5.3 Three and four practice category studies

As highlighted in section Figure 10 we found that there were very few studies (4 in total) that explored a wide range of practices categories. This suggests that LIFT already contributes to a gap in the literature. *Figure* shows the breadth of practices covered by these four studies.

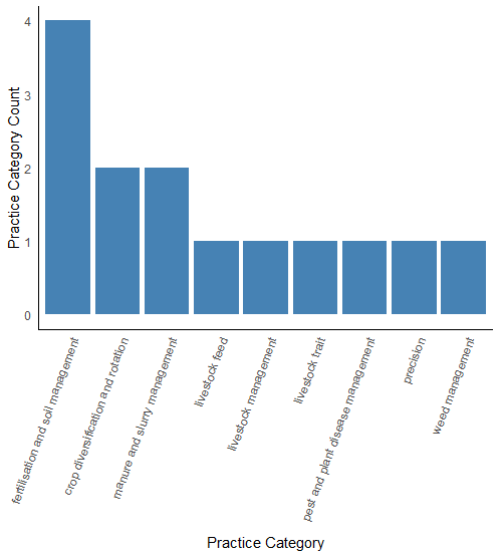

Figure 5: Multi practice category studies - practice categories covered

5.5.4 Single practice category studies: fertilisation and soil management

At the other end of the spectrum we find those studies that consider only one practice category. Within this category the most common was fertilisation and soil management (n = 47) (*Figure*).

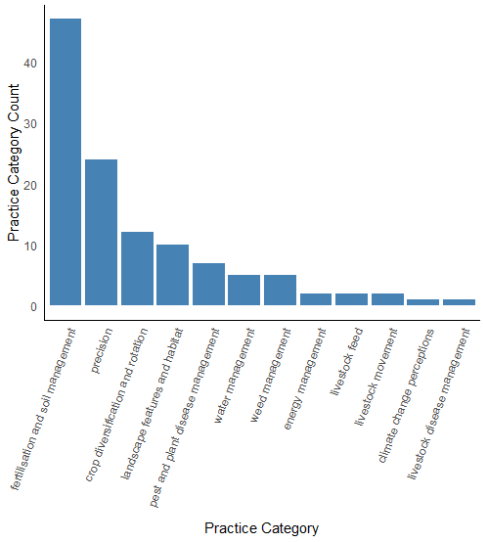

Figure 6: Count of studies of a single practice category

We find that this practice category is dominated by studies based on surveys (*Figure*) and that personal and farm structural factors are the most common factors investigated (*Figure*). Formal institutional factors were rarely studied, with fewer considering these system level factors than in organic studies. LIFT can therefore add to the literature by including this type of factors in its study of practice adoption.

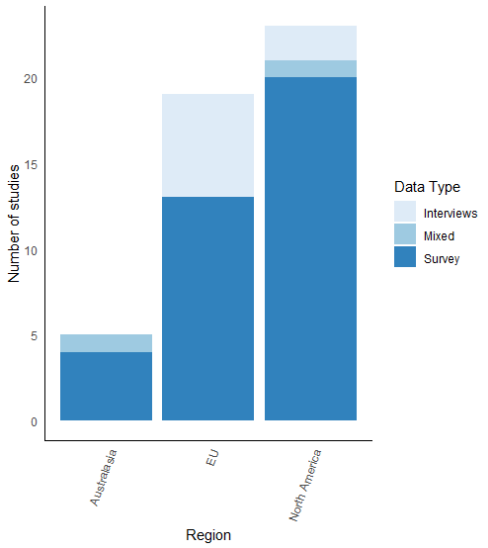

Figure 7: Fertilisation and soil management studies by region and data type

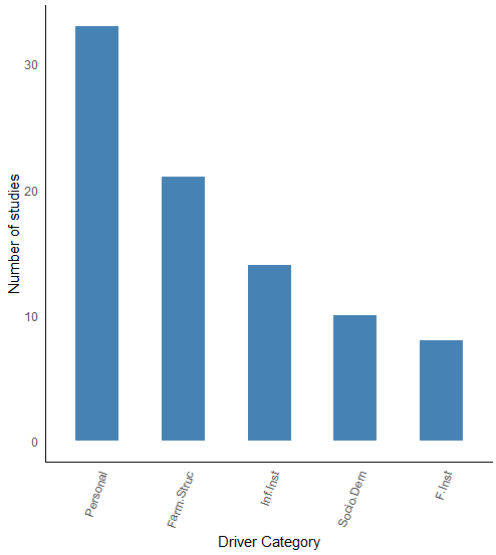

Figure 8: Drivers of uptake of fertilisation and soil management practices

5.6 Factor sub-category: farmer socio-demographics

Age, gender, education level and income, or more specifically dependence of household on farm income, were the four most common socio-demographic factors considered across the studies. The effects of many of these factors were found to be mixed when considered in review studies and in many cases varied by the specific practice type (Mozzato *et al.* 2018; Tey *et al.* 2012; Lastra-Bravo *et al.* 2015; Liu *et al.* 2018). Education level appeared to have the most consistently positive influence on adoption (Mozzato *et al.* 2018; Lastra-Bravo *et al.* 2015; Tey *et al.* 2012; Liu *et al.* 2018) although some find that extension training rather than formal education is more important (Baumgart-Getz *et al.* 2012). One reason for these mixed results is that factors such as age are difficult to separate from factors such as succession (Giannakis *et al.* 2014), another is that the causal pathways between these factors are not well specified particularly when personal motivational factors such as attitudes are not

included in the study (Burton 2014). This can also be related to general interest in ecological practices and pro-environmental attitudes.

5.7 Factor sub-category: farm factors

There were three main sub-categories of farm factors: business, biophysical and spatial, and management. The first and most common sub-category considered relates to the *farm business*. This includes the availability of (skilled or relevant) labour, size of the farm, land tenure, and some measure of its current financial position (income or profitability). The second sub-category includes *biophysical and spatial effects.* The idea being that the location of the farm, in particular variables relating to its climate and soil are likely to have an effect on practice adoption. Spatial effects are closely related but also might consider where the farm is located in relation to other farms. The third sub-category relates to *farm specialisation and current farming practices*, including the current machinery or technology used. As described in section 2 current practices, machinery and technology contribute to the concept of path dependency. It is also likely that the degree of access to specific equipment for ecological farming practices can drive or limit adoption of ecological approaches.

5.8 Factor sub-category: informal institutional factors

Informal institutional factors as described in section 2.2.3 are included in existing studies in two main ways: through understanding norms and through understanding the farmers' information seeking behaviour and the networks they are engaged in. At a variable level these are related since who farmers engage with in the networks is likely to affect define their reference group.

There are three main type of norms included in studies. Descriptive norms seek to understand the influence of other observed behaviour on farmers' behaviour. Subjective norms seek to understand the farmers' perceived social pressure to behave in a certain way. Closely related to this is the concept of a group norm which also seeks to understand perceived social pressure but for a specific reference group. It is therefore normally found in surveys to be combined with a measure of group identity.

From whom farmers' seek information and with whom they engage on a regularly basis are two factors that those studies looking at informal institutional conditions tend to focus on.

5.9 Factor sub-category: farmer personal factors

Farmer personal factors cover the widest range of factors about the farmers' individual motivations and attitudes. This is perhaps reflective of the fact that studies considering only personal factors were the most common.

The studies in our sample frequently include *attitudes* towards the environment but also towards risk. Attitudes towards the adoption of any practice tend to be formed by an understanding of the benefits or limitations that adopting those practices will bring. Here qualitative as well as quantitative studies provide useful insights into the range of benefits and limitations perceived by farmers of ecological practices. *Self-identity* has only been covered by one study.

Likely to inform benefits and limitations, along with factors associated with farm are the farmers' *objectives* or *motivational* factors. Studies have also included farmers' *climate change perceptions* and experience of local changes. Also, studies have included individual *knowledge* and *skills* (or access to them), which is important for being able to make change on the farm. Related to knowledge and skills but also to farm business factors and support network is the concept of *self-efficacy*. This captures the farmer perception of their capacity to make changes on the farm.

5.10 Factor sub-category: formal institutional factors

While many studies have *AES scheme participation* as their dependent variable, others consider it as factor that may influence the adoption of other ecological practices. The type of scheme, funding and associated training are considered across these studies. Furthermore, availability of and participation in *certification schemes* is likely to influence the type of practices adopted.

Other factors of importance in relation to formal institutional factors are *supply chain relationships and contracts*. As noted by two other reviews of the ecological farming practices literature (Mozzato *et al.* 2018; Bartkowski and Bartke 2018) factors relating to the supply chain are rarely considered. However, we know from the wider green supply chain literature that these factors are important in moving towards production practices that are understood to be less harmful to the environment.

Economy, markets and infrastructure are important to describe formal institutional factors. The majority of factors considered by studies in our sample fall under this sub-category, and include variables such as prices (inputs and outputs) as well as internet connectivity. While prices are clearly related to contracts the distinction from contracts is that price is here considered on its own and not related to contract type or buyer/supplier relationship.

5.11 Comparing current knowledge with the latent behavioural variables of the integrated conceptual framework

In relation to the latent behavioural variables in the integrated conceptual framework suggested in this deliverable, what drivers for up-take of ecological practices have been studied? After comparing the latent behavioural variables of the integrated conceptual framework with the findings from the systematic mapping of the literature, we would like to highlight the following aspects, which should be prioritised in future research:

- *Behavioural intent, adoption behaviour and future adoption behaviours*: Studies of actual behaviour were the most common, followed by attitudes towards adoption. Only very few studies considered intentions to future adoption. In relation to the conceptual framework presented here, we note that it would be useful to characterise the adoption process according to its timely/process-characteristics, intensity, whether it is incremental or transformational, and type of practice. However, based on our systematic mapping of the literature, such an in-depth characterisation of the adoption behaviour appears not to have been in focus so far. Furthermore, in the integrated conceptual framework we propose to investigate the impact of actual adoption behaviour on intentions for future adoption. This appears not to have been covered by previous literature but would add by further our insights into how a trajectory of up-take of ecological practices can spur further up-take. From a behavioural perspective, it would also be useful to study the actual steps from behavioural intent to actual adoption behaviour in a longitudinal approach.
- *Theory of planned behaviour variables: Attitudes* were studied as an influential factor, mostly in terms of respondents' understanding of the benefits or limitations adoption of ecological practices would bring. From the literature review, it appears that the TAM-components of the attitude construct have not been previously studied. However this would further our understanding of farmers' attitudes towards ecological practices in terms of assessing their PU and PEoU. The TPB variables *perceived behavioural control* and *subjective norm* have also been studied, although subjective norm only in two studies.

- *Self-identity:* The impact of self-identity on farmers' up-take of ecological approaches has only been study once in the literature we reviewed. Including the self-identity construct in studies of farmers' adoption behaviours would add significantly by allowing us to understand the extent to which up-take of ecological approaches can be obstructed because it is not perceived as compatible with farmers' self-identity.
- *Motivation:* Previous literature has considered farmers' goals but has not been interested in farmers' motivation in terms of the type of economic value they perceive in ecological practices.

6 Methodological considerations based on the integrated conceptual framework

Given the conceptual framework developed for the purposes of understanding drivers of farmers' up-take of ecological approaches, two approaches may be considered; psychometric methodology and qualitative interviews using the means-end chain and laddering approach. In this section, we introduce these methodological approaches and highlight how they can be useful for analysing drivers of farmers' up-take of ecological approaches.

6.1 A psychometric framework

Several variables defined in the conceptual framework are theoretical constructs that are not possible to measure directly. Examples include attitudes, subjective norms, perceived behavioural control, motivational constructs and self-identity. These are viewed as latent constructs. This leads to measurement complexity, which can be handled with psychometric methodologies to capture latent constructs through measurement indicators. Generally, respondents are asked to self-report on measurement scales targeting the latent constructs of interest, capturing for instance the degree of importance or agreement. Responses to such scales are taken as respondents' measurement items of particular latent constructs (DeVellis, 2003, Hair, *et al.*, 2010, Podsakoff, *et al.*, 2003).

6.1.1 Type of measurement models

After measurement indicators for the latent constructs of interest, one important decision is the type of causality implied between the measurement indicators and the latent construct (Jarvis, *et al.*, 2003, Podsakoff, *et al.*, 2003, Rossiter, 2002). This will guide the choice of measurement model and type of scale development technique to use in assessing the latent construct. Measurement models can be categorised as reflective or formative. A reflective measurement model assumes causality from the latent construct to the measurement indicators. This implies that the latent construct causes the type of responses to the measurement indicators. A formative measurement model assumes causality from the measurement indicators to the latent construct. Measurement indicators together constitute the latent construct.

Jarvis, *et al.* (2003) provided a set of useful criteria for assessing what type of measurement model should be used in a specific case. In particular, they advised researchers to consider the following criteria:

1. Causality between construct and measurement indicator

This is based on the theoretical understanding of the construct. For instance, an attitude is generally considered to cause responses to self-reported bipolar scales used as measurement indicators. This implies that a change in attitude is assumed to cause changes in the measurement indicators and not the other way around.

2. Interchangeability between indicators

This is about whether or not indicators are derived from the same theme. Covariation between indicators considers whether the theoretical meaning of the construct would change if one particular measurement indicator was removed, and whether a change in one indicator would also lead to a change in another indicator. The nomological network of measurement indicators refers to their antecedences and consequences; that is to say whether they can be assumed to share antecedences and lead to the same consequences.

3. Covariation between indicators

Reflective measurement indicators covariate with each other by construction. Formative measurement indicators do not need to covariate.

4. The nomological network of indicators

For reflective measurement indicators the nomological networks of the indicators are the same. For formative measurement indicators this need not be the case.

Measurement indicators which are caused by the latent construct, which are derived from the same theme, have a high degree of covariation and share nomological network, are recommended to be modelled in a reflective framework. Measurement indicators, which on the other hand are assumed to create the latent construct, and which are not necessarily derived from the same theme, are not expected to covary, and, if they do not share nomological network, are recommended to be modelled in a formative framework.

Consequently, one important task in analysing drivers of farmers' up-take of ecological approaches relates to defining measurement model for each theoretical construct used.

6.1.2 Exploratory and confirmatory approaches to measurement

Apart from the reflective and formative considerations described above, psychometric approaches to measuring latent constructs can generally be based on exploratory analysis of confirmatory measurement models. Major differences between the two kinds of models relate to whether or not it is possible to specify the latent construct in terms of dimensionality and measurement indicators. If little or no theory exists to guide this, for instance when previous measurement scales are under-developed, Podsakoff, *et al.* (2003) recommend an exploratory approach, e.g. exploratory factor analysis.

On the other hand, in situations where theory and prior scale development exist, the measurement model can be specified beforehand and confirmatory approaches can be used, e.g. confirmatory factor analysis (Hair, *et al.*, 2010, Podsakoff, *et al.*, 2003). This is useful for hypothesis testing related to construct dimensionality and content. Confirmatory factor analysis can be used in structural equations modelling to enable use of latent constructs in such models. This is likely useful in analysing drivers of farmers' up-take of ecological approaches.

6.2 A means-end chain approach

We are interested in identifying drivers of farmers' up-take of ecological approaches. Apart from the psychological framework outlined above, farmers' drivers can also be mapped by qualitative interviews. In particular, we consider the laddering interview technique (Olson, 1989, Reynolds and Gutman, 1988) useful for these purposes. The laddering technique allows mapping of farmers' mental models with respect to the causal effects from attributes to consequences, and to values. In this way we can understand how farmers represent their decisions to adopt ecological approaches, the perceived consequences from doing so and the values that drive their behaviour. This allows us to understand drivers of farmers' behaviours. Conceptually, the laddering approach builds on the means-end chain (MEC) model (Gutman, 1982, Reynolds and Gutman, 1988), which has originally been developed to explain consumer behaviour. The MEC model posits that consumers choose particular products because of the values product attributes serve to fulfil, not for the products themselves. Thus, products are described by consumers to possess certain attributes, these are perceived to lead to certain consequences, and these are in turn associated with certain values. Behaviour is driven by the desire to fulfil these values. Although developed to explain consumer behaviour, MEC and laddering has recently been adopted to study farmers' decision-making in various settings (Hansson and Kokko, 2018, Hansson and Lagerkvist, 2015, Lagerkvist, *et al.*, 2012, Okello, *et al.*, 2014), but never in relation to farmers' adoption of ecological approaches.

Farmers can be asked to characterise a decision (to adopt certain ecological approaches) with a number of attributes (e.g. Hansson and Lagerkvist, 2015). These attributes can be used as a starting point for a laddering interview by probing interviewees about why each attribute is important to them, until they can no longer articulate why. This stage is taken as the end-stage of the "ladder" connected to each attribute. Laddering interviews can be summarised into hierarchical value maps (Reynolds and Gutman, 1988) which highlight the dominant ways in which interviewed farmers view their decisions to adopt ecological approaches, what it means to them, the consequences of the attributes and finally the values farmers try to satisfy from adopting ecological approaches.

7 Conclusions

In this deliverable, we have developed a conceptual framework for understanding farmers' adoption of ecological approaches. We have taken a behavioural approach, meaning that psychological concepts such as attitudes, perceptions, motivation, values, and self-identity are recognised as important drivers for farmers' adoption decisions. This further means that farmers' decisions to adopt ecological approaches are not considered merely dependent on profitability concerns, but the outcome of a net of influencing factors where profitability concerns are one underlying dimension among others. We also introduce methodological considerations for further empirical work in WP2 of LIFT.

In conclusion, we would like to highlight implications for the LIFT farmers' survey. In particular, we suggest the LIFT farmers' survey to focus on the following areas:

- Attitudes to ecological approaches (the approaches are described in D1.1 of LIFT (see Rega, *et al.*, 2018)), possibly measured in terms of PU and PEoU of ecological approaches;
- Social norms, including farmers' perceptions of actors in the supply chain and their attitude towards adopting ecological approaches, but also perceptions of farmers' significant others, such as family and friends;

- Perceived behavioural control;
- Motivational factors in terms of use and non-use values; scale can be adopted by adapting the scale developed by Hansson and Lagerkvist (2016) to the adoption of ecological approaches;
- Farmers' self-identity, including the important symbols/cues farmers perceive in agriculture;
- Farm structural characteristics, including size, degree of fragmentation, tenure, specialisation, spatial characteristics, access to equipment; access to resources and skills via collaboration;
- Supply chain characteristics, including farmers' perceptions of expectations of the food supply chain;
- Institutional conditions, including the type of support farmers' benefit from and their perceived stability and ease of managing the support from an administrative point of view, participation in private certification schemes, perceptions of collaboration with neighbouring farmers, access to farmers' and advisors' networks including skills and equipment through such networks;
- Farmers' perceptions of consumers' demand and preferences;
- Characteristics of the decision to adopt ecological approaches (applicable for those who have already adopted ecological approaches).

In addition, the LIFT farmers' survey should inquire about the type of ecological approach adopted (or planned to be adopted), as classified by D1.1 of LIFT (see Rega, *et al.*, 2018).

We also suggest that the LIFT survey recognises the psychological constructs as latent constructs and thus uses measurement scales to capture those constructs. As a rule-of-thumb, about four – five measurement indicators should be used to capture each latent construct. We also suggest that drivers for farmers' up-take of ecological approaches can be mapped using MEC theory and the laddering approach. This would be a useful way to elicit farmers' mental models of how they represent ecological approaches and what they would like them to lead to.

Finally, comparisons between the integrated conceptual framework as suggested here and the systematic mapping of the scientific literature review enables suggestions for key areas to focus further empirical analyses of drivers for farmers' adoption of ecological approaches and the publications that will follow from those.

8 Deviations or delays

None.

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10 Appendix A: Analysis template

Reference	Country of emprical data	Type of farm	Definition of ecological approaches used in the study	Type of dependent variable (actual adoption, willingness to adopt, intention to adopt)	Considered drivers of ecological approaches (included in the conceptual framework suggested here)	Considered drivers of ecological approaches (not included in the conceptual framework suggested here)	Type of data	Analytical methods	Main results
			If possible, indicated according to the LIFT typology in D1.1.		*List the drivers considered in the paper, which are also part of our conceptual framework.*	*List the drivers considered in the paper, which are not part of our conceptual framework.*	*Indicate the type of data used, e.g. survey data, interviews, secondary data etc.*	*Name the analytical methods used, such as SEM, regression analysis etc.*	*Briefly summarize (1 – 2 sentences) the main results of the study.*

11 Appendix B: Influential factors: category development

Yhe table shows the category development of influential factors based on categories identified in existing review papers.

Author	Author classification	Author variable	Our categorisation	Sub category
Tey et al. 2012	Socio-economic factors	Age	Farmer socio-demographic factors	Age
Tey et al. 2012	Socio-economic factors	Years of farming experience	Farmer socio-demographic factors	Experience
Tey et al. 2012	Socio-economic factors	Formal Education	Farmer socio-demographic factors	Education
Tey et al. 2012	Agroecological factors	Land tenure	Farm structural factors	Business
Tey et al. 2012	Agroecological factors	Farm specialisation	Farm structural factors	Business
Tey et al. 2012	Agroecological factors	Farm size	Farm structural factors	Business
Tey et al. 2012	Agroecological factors	Farm sales	Farm structural factors	Business
Tey et al. 2012	Agroecological factors	Variable fertilizer rates	Farm structural factors	Management
Tey et al. 2012	Agroecological factors	Livestock sales	Farm structural factors	Business
Tey et al. 2012	Agroecological factors	Debt-to-asset ratio	Farm structural factors	Business
Tey et al. 2012	Agroecological factors	Production value	Farm structural factors	Business
Tey et al. 2012	Agroecological factors	Owned land minus rented land	Farm structural factors	Business
Tey et al. 2012	Agroecological factors	Yield	Farm structural factors	Biophysical
Tey et al. 2012	Agroecological factors	Part-owner farmers	Farmer personal factors	Business
Tey et al. 2012	Agroecological factors	Full-owner farmers	Farmer personal factors	Business
Tey et al. 2012	Agroecological factors	Farm income/profitability	Farm structural factors	Business
Tey et al. 2012	Agroecological factors	Soil quality	Farm structural factors	Biophysical
Tey et al. 2012	Agroecological factors	Percentage of main crop in total farmland	Farm structural factors	Biophysical
Tey et al. 2012	Agroecological factors	Percentage of farmland as county land	Farm structural factors	Biophysical
Tey et al. 2012	Agroecological factors	Percentage of farmland as large farms	Farm structural factors	Biophysical
Tey et al. 2012	Agroecological factors	Off-farm employment	Farmer personal factors	Business
Tey et al. 2012	Institutional factors	Distance from fertiliser dealer	Formal institutional factors	Value chain

Tey et al. 2012	Institutional factors	Use of forward contract	Formal institutional factors	Value chain
Tey et al. 2012	Institutional factors	Region	Farm structural factors	Biophysical
Tey et al. 2012	Institutional factors	Development pressure	Formal institutional factors	Economy
Tey et al. 2012	Informational factors	Use consultant	Informal institutional factors	Information
Tey et al. 2012	Informational factors	Perceived usefulness of extension services	Informal institutional factors	Information
Tey et al. 2012	Farmer perception	Perceived profitability of using precision ag	Farmer personal factors	Beliefs and perceptions
Tey et al. 2012	Behavioural factors	Willingness to adopt precision ag	Farmer personal factors	Intensions
Tey et al. 2012	Technological factors	Yield mapping	Farm structural factors	Management
Tey et al. 2012	Technological factors	Farm has irrigation facility	Farm structural factors	Management
Tey et al. 2012	Technological factors	Use of computer	Farm structural factors	Management
Tey et al. 2012	Technological factors	Generated own map-based input prescription	Farm structural factors	Management
Lastra-Bravo et al. 2015	Economic factors	Income	Farm structural factors	Business
Lastra-Bravo et al. 2015	Economic factors	Tenure	Farm structural factors	Business
Lastra-Bravo et al. 2015	Economic factors	Farm labour	Farm structural factors	Business
Lastra-Bravo et al. 2015	Economic factors	Business criteria	Farm structural factors	Business
Lastra-Bravo et al. 2015	Farm structure	Farm size	Farm structural factors	Business
Lastra-Bravo et al. 2015	Farm structure	Location	Farm structural factors	Biophysical
Lastra-Bravo et al. 2015	Farm structure	Farm specialisation	Farm structural factors	Business
Lastra-Bravo et al. 2015	Farmer characteristic	Education level	Farmer socio-demographic factors	Education
Lastra-Bravo et al. 2015	Farmer characteristic	Age	Farmer socio-demographic factors	Age
Lastra-Bravo et al. 2015	Farmer characteristic	Opinion on farm's future	Farmer personal factors	Beliefs and perceptions
Lastra-Bravo et al. 2015	Farmer attitudes	Previous experience	Nature of practice	Previous use
Lastra-Bravo et al. 2015	Farmer attitudes	Ease of implementation	Farmer personal factors	Beliefs and perceptions
Lastra-Bravo et al. 2015	Social capital	Technical advice and training	Informal institutional factors	Information
Lastra-Bravo et al. 2015	Social capital	Extension services	Informal institutional factors	Information
Lastra-Bravo et al. 2015	Social capital	Farming magazines	Informal institutional factors	Information
Lastra-Bravo et al. 2015	Social capital	Participation in organisation	Informal institutional factors	Networks
Lastra-Bravo et al. 2015	Social capital	Trust in government	Farmer personal factors	Attitudes

Lastra-Bravo et al. 2015	Social capital	Institutional policy	Formal institutional factors	Policy and regulation
Pierpaoli et al. 2013	Socio-economic factors	Age	Farmer socio-demographic factors	Age
Pierpaoli et al. 2013	Socio-economic factors	Computer confidence	Farmer personal factors	Knowledge
Pierpaoli et al. 2013	Socio-economic factors	Information	Informal institutional factors	Information
Pierpaoli et al. 2013	Socio-economic factors	Education level	Farmer socio-demographic factors	Education
Pierpaoli et al. 2013	Financial Resources	Income	Farm structural factors	Business
Pierpaoli et al. 2013	Financial Resources	Ownership and tenure	Farm structural factors	Business
Pierpaoli et al. 2013	Financial Resources	Full time farmer	Farm structural factors	Business
Pierpaoli et al. 2013	Contingent factors	Geography	Farm structural factors	Biophysical
Pierpaoli et al. 2013	Contingent factors	Size	Farm structural factors	Business
Pierpaoli et al. 2013	Contingent factors	Soil quality	Farm structural factors	Biophysical
Liu et al. 2018	Information and awareness	Access to information	Informal institutional factors	Information
Liu et al. 2018	Information and awareness	Networks	Informal institutional factors	Networks
Liu et al. 2018	Information and awareness	Opinion of others	Informal institutional factors	Norms
Liu et al. 2018	Information and awareness	Education programs	Informal institutional factors	Information
Liu et al. 2018	Information and awareness	Internet access	Formal institutional factors	Internet access
Liu et al. 2018	Information and awareness	Social media	Informal institutional factors	Information
Liu et al. 2018	Financial Incentives	Government subsidies	Formal institutional factors	Policy and regulation
Liu et al. 2018	Financial Incentives	Credits or loans	Farm structural factors	Business
Liu et al. 2018	Financial Incentives	Lack of cash or credit	Farm structural factors	Business
Liu et al. 2018	Financial Incentives	Cost of adoption	Nature of practice	Type
Liu et al. 2018	Financial Incentives	Maintenance cost	Nature of practice	Type
Liu et al. 2018	Financial Incentives	Time and other expenses	Nature of practice	Type
Liu et al. 2018	Social norms	Social conformity	Informal institutional factors	Norms
Liu et al. 2018	Social norms	Neighbours acceptance	Informal institutional factors	Norms
Liu et al. 2018	Social norms	Adoption by neighbours	Informal institutional factors	Norms
Liu et al. 2018	Social norms	Encouragement of important others	Informal institutional factors	Norms
Ahnstrom et al. 2008	Context	Education level	Farmer socio-demographic factors	Education

Ahnstrom et al. 2008	Context	Politics	Formal institutional factors	Policy and regulation
Ahnstrom et al. 2008	Context	Social norms	Informal institutional factors	Norms
Ahnstrom et al. 2008	Context	Economy	Formal institutional factors	Economy
Ahnstrom et al. 2008	Context	Extension	Informal institutional factors	Information
Ahnstrom et al. 2008	Context	Other farmers	Informal institutional factors	Information
Ahnstrom et al. 2008	Context	Farm history	Farm structural factors	Business
Ahnstrom et al. 2008	Context	Farm interest	Farm structural factors	Business
Ahnstrom et al. 2008	Context	Agricultural policy	Formal institutional factors	Policy and regulation
Ahnstrom et al. 2008	Context	Heir	Farm structural factors	Business
Ahnstrom et al. 2008	Context	Technique	Farm structural factors	Management
Ahnstrom et al. 2008	Subjective Norms	Subjective Norms	Informal institutional factors	Norms
Ahnstrom et al. 2008	Attitudes	Attitudes	Farmer personal factors	Attitudes
Ahnstrom et al. 2008	Agri-environmental scheme	Type of scheme	Formal institutional factors	Agri-environment scheme
Ahnstrom et al. 2008	Nature	Observed effect of action	Nature of practice	Observability
Mozzato et al. 2018	Farm factors - Structural	Farm size	Farm structural factors	Business
Mozzato et al. 2018	Farm factors - Structural	Degree of fragmentation	Farm structural factors	Business
Mozzato et al. 2018	Farm factors - Structural	Type of land tenure	Farm structural factors	Business
Mozzato et al. 2018	Farm factors - Structural	Type of business	Farm structural factors	Business
Mozzato et al. 2018	Farm factors - Economic	Farm specialisation	Farm structural factors	Business
Mozzato et al. 2018	Farm factors - Economic	Type of farming	Farm structural factors	Business
Mozzato et al. 2018	Farm factors - Economic	Economic size of farm	Farm structural factors	Business
Mozzato et al. 2018	Farmer factors - Socio	Age	Farmer socio-demographic factors	Age
Mozzato et al. 2018	Farmer factors - Socio	Education level	Farmer socio-demographic factors	Education
Mozzato et al. 2018	Farmer factors - Socio	Gender	Farmer socio-demographic factors	Gender
Mozzato et al. 2018	Farmer factors - Socio	Number of family members	Farmer socio-demographic factors	
Mozzato et al. 2018	Farmer factors - Socio	Number of active family members	Farmer socio-demographic factors	
Mozzato et al. 2018	Farmer factors - Socio	Full-time farmer	Farmer personal factors	Business
Mozzato et al. 2018	Farmer factors - Socio	Total family income	Farmer personal factors	Business

Mozzato et al. 2018	Farmer factors - Att/Motiv	Attitude to innovation	Farmer personal factors	Attitudes
Mozzato et al. 2018	Farmer factors - Att/Motiv	Attitude to risk	Farmer personal factors	Attitudes
Mozzato et al. 2018	Farmer factors - Att/Motiv	Profit orientation	Farmer personal factors	Objectives
Mozzato et al. 2018	Farmer factors - Att/Motiv	Personal motivation to adopt practice	Farmer personal factors	Attitudes
Mozzato et al. 2018	Farmer factors - Att/Motiv	Environmental attitudes	Farmer personal factors	Attitudes
Mozzato et al. 2018	Farmer factors - Att/Motiv	Awareness of negative enviro impact on farming	Farmer personal factors	Beliefs and perceptions
Mozzato et al. 2018	Informational factors	Affiliation to farmers organisation	Informal institutional factors	Networks
Mozzato et al. 2018	Informational factors	Information availability and participation in training courses	Informal institutional factors	Information
Mozzato et al. 2018	Informational factors	Farmers familiarity with practices	Informal institutional factors	Information
Mozzato et al. 2018	Social factors	Social pressure	Informal institutional factors	Norms
Mozzato et al. 2018	Social factors	Farmer's participation in social and/or environmental organisation	Informal institutional factors	Networks
Mozzato et al. 2018	Social factors	Trust in public institutions	Farmer personal factors	Attitudes
Mozzato et al. 2018	Value chain factors	Consumers price premium	Formal institutional factors	Value chain
Mozzato et al. 2018	Value chain factors	Value-chain structure and characteristics	Formal institutional factors	Value chain
Mozzato et al. 2018	Spatial factors	Proximity to urban areas	Farm structural factors	Biophysical
Mozzato et al. 2018	Spatial factors	Localisation of the farm in less favoured area	Farm structural factors	Biophysical
Mozzato et al. 2018	Spatial factors	Localisation of the farm in priority/target area	Farm structural factors	Biophysical
Mozzato et al. 2018	Spatial factors	Neighbouring farmers' effect	Informal institutional factors	Norms
Lyle 2015	Hazardscape	Hazardscape	Farm structural factors	Biophysical
Lyle 2015	Community Typology	Community Typology	Informal institutional factors	Norms
Lyle 2015	Community	Community	Informal institutional factors	Norms
Lyle 2015	Farm and Farmer Typology	Farm and Farmer Typology	Farmer personal factors	NA
Lyle 2015	Farm	Farm	Farm structural factors	Biophysical
Lyle 2015	Household	Household	Informal institutional factors	Norms
Lyle 2015	Individual	Individual	Farmer personal factors	NA
Bartowski and Barke 2018	Farm characteristics	Age	Farmer socio-demographic factors	Age

Bartowski and Barke 2018	Farm characteristics	Education level	Farmer socio-demographic factors	Education
Bartowski and Barke 2018	Farm characteristics	Household size	Farmer socio-demographic factors	
Bartowski and Barke 2018	Farm characteristics	Gender	Farmer socio-demographic factors	Gender
Bartowski and Barke 2018	Farmer characteristics	Size	Farm structural factors	Business
Bartowski and Barke 2018	Farmer characteristics	Environmental conditions	Farm structural factors	Biophysical
Bartowski and Barke 2018	Farmer characteristics	Technological facilities	Farm structural factors	Business
Bartowski and Barke 2018	Behavioural factors	Attitudes	Farmer personal factors	Attitudes
Bartowski and Barke 2018	Behavioural factors	Awareness	Farmer personal factors	Beliefs and perceptions
Bartowski and Barke 2018	Behavioural factors	Knowledge	Farmer personal factors	Knowledge
Bartowski and Barke 2018	Behavioural factors	Beliefs	Farmer personal factors	Beliefs and perceptions
Bartowski and Barke 2018	Behavioural factors	Perceptions	Farmer personal factors	Beliefs and perceptions
Bartowski and Barke 2018	Social institutional environment	Legal institutional framework	Formal institutional factors	Policy and regulation
Bartowski and Barke 2018	Social institutional environment	Peers	Informal institutional factors	Norms
Bartowski and Barke 2018	Economic constraints	Credits or loans	Farm structural factors	Business
Bartowski and Barke 2018	Economic constraints	Cost of adoption	Nature of practice	Type
Bartowski and Barke 2018	Economic constraints	Financial incentives	Formal institutional factors	Policy and regulation
Bartowski and Barke 2018	Decision characteristics	Goodness of fit	Nature of practice	Type
Baumgart-Getz et al. 2012	Capacity	Farm Size	Farm structural factors	Business
Baumgart-Getz et al. 2012	Capacity	Age	Farmer socio-demographic factors	Age

Baumgart-Getz et al. 2012	Capacity	Capital	Farm structural factors	Business
Baumgart-Getz et al. 2012	Capacity	Education level	Farmer socio-demographic factors	Education
Baumgart-Getz et al. 2012	Capacity	Farming experience	Farmer socio-demographic factors	Experience
Baumgart-Getz et al. 2012	Capacity	Income	Farm structural factors	Business
Baumgart-Getz et al. 2012	Capacity	Information availability and participation in training courses	Informal institutional factors	Information
Baumgart-Getz et al. 2012	Capacity	Farm structure / organisation	Farm structural factors	Business
Baumgart-Getz et al. 2012	Capacity	Networking	Informal institutional factors	Networks
Baumgart-Getz et al. 2012	Capacity	Tenure	Farm structural factors	Business
Baumgart-Getz et al. 2012	Attitudes	Environmental	Farmer personal factors	Attitudes
Baumgart-Getz et al. 2012	Attitudes	Profitability of practice (reason for adoption)	Farmer personal factors	Beliefs and perceptions
Baumgart-Getz et al. 2012	Attitudes	Heritage	Farmer personal factors	Attitudes
Baumgart-Getz et al. 2012	Attitudes	Perceived quality of current environment	Farmer personal factors	Beliefs and perceptions
Baumgart-Getz et al. 2012	Attitudes	Regulatory (gov can or should regulate)	Farmer personal factors	Beliefs and perceptions
Baumgart-Getz et al. 2012	Attitudes	Risk	Farmer personal factors	Attitudes
Baumgart-Getz et al. 2012	Attitudes	Scientific	Farmer personal factors	Attitudes
Baumgart-Getz et al. 2012	Attitudes	Receiving payments for conservation programmes	Formal institutional factors	Agri-environment scheme
Baumgart-Getz et al. 2012	Environmental awareness	Awareness environment general	Farmer personal factors	Beliefs and perceptions
Baumgart-Getz et al. 2012	Environmental awareness	Cause - impact agriculture on environment	Farmer personal factors	Beliefs and perceptions
Baumgart-Getz et al. 2012	Environmental awareness	Consequences of degraded system	Farmer personal factors	Beliefs and perceptions

Baumgart-Getz et al. 2012	Environmental awareness	Knowledge - facts relating to environmental quality	Farmer personal factors	Knowledge
Baumgart-Getz et al. 2012	Environmental awareness	Program	Farmer personal factors	Beliefs and perceptions
Knowler and Bradshaw 2007	Farmer and farm household	Farmer and farm household	Farmer socio-demographic factors	
Knowler and Bradshaw 2007	Farm biophysical	Farm biophysical	Farm structural factors	Biophysical
Knowler and Bradshaw 2007	Farm management	Farm management	Farm structural factors	Management
Knowler and Bradshaw 2007	Exogenous factors	Exogenous factors	Formal institutional factors	NA
Bijttebier et al. 2018	Communication and Extension	Regulation	Formal institutional factors	Policy and regulation
Bijttebier et al. 2018	Communication and Extension	Education	Farmer socio-demographic factors	Education
Bijttebier et al. 2018	Communication and Extension	Social pressure	Informal institutional factors	Norms
Bijttebier et al. 2018	Communication and Extension	Economic incentives	Formal institutional factors	Agri-environment scheme
Bijttebier et al. 2018	Communication and Extension	Tools	Farm structural factors	Management
Bijttebier et al. 2018	TPB	Belief strength	Farmer personal factors	Beliefs and perceptions
Bijttebier et al. 2018	TPB	Outcome evaluation	Farmer personal factors	Beliefs and perceptions
Bijttebier et al. 2018	TPB	Normative belief	Farmer personal factors	Beliefs and perceptions
Bijttebier et al. 2018	TPB	Motivation to comply	Farmer personal factors	Attitudes
Bijttebier et al. 2018	TPB	Control belief	Farmer personal factors	Beliefs and perceptions
Bijttebier et al. 2018	TPB	Control power	Farmer personal factors	Beliefs and perceptions
Bijttebier et al. 2018	TPB	Attitude	Farmer personal factors	Attitudes
Bijttebier et al. 2018	TPB	Subjective norm	Informal institutional factors	Norms
Bijttebier et al. 2018	TPB	Perceived behavioural control	Farmer personal factors	Beliefs and perceptions
Bijttebier et al. 2018	TPB	Intention	Farmer personal factors	Intensions

12 Appendix C: Influential factors full table

The table indicates the frequency with which different influential factors have been combined.

Combination type	*Farmer Socio Demographics*	*Farm Factors*	*Farmer Personal Factors*	*Informal Institutional Factors*	*Informal Institutional Factors*	Frequency
1	0	0	1	0	0	82
2	0	1	0	0	0	31
3	0	0	1	1	0	25
4	0	1	1	0	0	20
5	0	0	0	1	0	18
6	0	0	0	0	1	17
7	1	1	1	0	0	17
8	1	1	0	0	0	13
9	0	1	0	1	0	11
10	1	1	1	1	0	10
11	0	1	0	0	1	9
12	0	0	1	0	1	8
13	0	1	1	1	1	6
14	1	1	0	0	1	6
15	0	0	0	0	0	5
16	1	0	1	0	0	5
17	1	1	1	1	1	5
18	0	0	0	1	1	4
19	1	1	0	1	0	4
20	0	0	1	1	1	3
21	0	1	1	1	0	3
22	1	1	1	0	1	3
23	0	1	0	1	1	2
24	0	1	1	0	1	2
25	1	0	0	0	1	2
26	1	0	1	0	1	2
27	1	0	0	0	0	1
28	1	0	0	1	0	1
29	1	0	1	1	0	1
30	1	1	0	1	1	1