Utrecht University

Advancing agroecology through knowledge co-creation:

Exploring success conditions to enhance the adoption of agroecological farming practices, illustrated by the case of Chilean wineries.

Source: Arnaldo Rodriguez, Cono Sur Winery

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Abstract

Agroecology has been proposed as an alternative to conventional agriculture given that as it is based on ecological principles, it strengthens species interactions and generates synergies between ecosystem and agricultural systems. However, agroecological farming practices need to be adapted to farm and farmers' contexts and needs. Knowledge co-creation processes provide an environment where scientific and experiential knowledges can dialogue and thus supports the development of practices tailored to a particular set of circumstances or contexts. These processes have been linked to adoption of agroecological farming practices. However, their success in terms of achieving such adoption is limited and there is a need to engage a higher number of farmers to participate in them.

This Thesis aimed at exploring success conditions (SCs) in co-creation processes to enhance the adoption of agroecological farming practices, focusing on processes fostering scientist-farmer interactions. This study proposed three agroecology-relevant process outputs, namely, co-created knowledge meets credibility, salience and legitimacy criteria, development of social networks and capacity building which are theoretically expected to facilitate adoption of agroecological farming. Based on these outputs and by means of a literature review, this study selected and operationalized SCs in the co-creation process and in the context motivating farmers to participate in these. A conceptual framework of SCs was derived, including 17 SCs in the process and 11 in the context. This Thesis conducted a first test of the framework with the purpose of observing how the conditions manifest themselves in an empirical case and to further refine it. A case of co-creation between scientists and Chilean wineries was chosen for this purpose. Case analysis allowed a refinement of the framework and proved its usefulness for practitioners to analyze their previous co-creation projects and to design future ones. Further research could go into three directions. First, tailoring the framework and its operationalization to productive sectors different from wine production because, contexts and barriers faced by farmers and bigger scale producers are likely to differ between productive sectors. Second, development of detailed operationalization of SCs would allow a thorough assessment of the conditions, enhancing its usefulness for practitioners. Finally, the agroecology-relevant outputs and actual adoption of practices could be empirically tested to support the theoretical assumption central to this study.

Key concepts:

Agroecology, knowledge co-creation processes, success conditions, Chile

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1. Introduction

Conventional agricultural practices are characterized by the use of agrochemical inputs such as fertilizers and pesticides, and soil damaging techniques such as tillage, which cause a number of threats to the environment, namely, biodiversity loss and ecosystem degradation (IPCC, 2019). These practices decrease the ability of ecosystems to adapt and thrive when exposed to changing conditions, meaning that they reduce ecosystem resilience (Altieri, 1999; Perfecto et al., 2009). Agroecology has been proposed as a solution to improve agricultural systems by employing ecological principles and by bringing attention to ecosystem services such as natural pest control and cycling of nutrients to develop farming practices. For example improving soil fertility by minimizing the employment of artificial external inputs or substituting them with biofertilizers, implying the utilization of microorganisms on soil which can improve nutrient availability for crops (Wezel et al., 2014). Agroecology can also contribute to the development of equitable food systems and to alleviate social concerns by empowering and utilizing farmer and rural communities' knowledge, in addition to supporting their livelihoods (Altieri & Toledo, 2011). In this way, farmers no longer depend on the supply of mechanization technologies or agrochemical inputs (Altieri & Nicholls, 2017).

Promoting the development of agroecology is considered crucial to meet food demands, and to deal with increasing prices of inputs, such as agrochemicals and fuel, and technologies utilized in conventional agriculture (Altieri & Toledo, 2011; Calleros-Islas, 2017). Advancing agroecology requires the development of agroecological *knowledge and practices*. These can emerge from different sources, for example, they can be peasant or indigenous knowledge, can be co-produced or shared among farmers, or originate from the collaboration between farmers and researchers (Altieri & Nicholls, 2017; Loconto & Fouilleux, 2019). The latter relies on finding a balance between new technologies, and traditional agroecological knowledge from subsistence farms, including, for instance, farming practices that preserve resources. Additionally, experimentation and adaptation to local needs and contexts is required. Therefore, such knowledge and practices respond to the particular social, economic and ecological circumstances from which they emerge (Altieri & Toledo, 2011; Bellamy & Ioris, 2017; Compagnone, Lamine & Dupré, 2018).

The context-specificity and adaptation requirements of agroecological *knowledge and practices* present a challenge for advancing agroecology. More specifically, there is a need to co-create such practices and knowledge in a way that they are relevant for the context in which

they are developed, and for the actors, in this case farmers and scientists, whose needs are to be fulfilled. For this purpose, examples of participatory processes fostering co-creation of agroecological knowledge and practices have taken place in several countries (Altieri & Toledo, 2011; Loconto & Fouilleux, 2019). Such processes present an opportunity for collaboration and for bridging different knowledge systems, namely, scientific and experiential farmer knowledge (Méndez et al., 2013; Bellamy & Ioris, 2017). However, there is a question on how to effectively organize such processes in a way that they lead to a successful production of knowledge and practices relevant to all actors involved. Previous research has reported the need to study participatory approaches such as knowledge co-creation for enhancing agroecology (e.g., Méndez et al., 2017; Barrios et al., 2020). However, less is known about what conditions contribute to the success of these processes in terms of increasing the adoption of agroecological farming practices (Márquez-García et al., 2018; Bello Cartagena, 2019; Rossi, 2020). Therefore, an exploration of these success conditions is needed. This Thesis will perform a literature review to find such conditions and develop a framework to contribute to retrospective analysis of co-creation projects and design of future ones.

This section continues by describing knowledge co-creation processes in agroecology, followed by the need to study co-creation for agroecology. Finally, the research aim and questions, as well as an overview of the research and its scientific and societal relevance are presented.

1.1. Knowledge co-creation in the context of agroecology

To successfully generate agroecological knowledge and practices, input from both farmers and researchers is required. On the one hand, scientists consider traditional farmer knowledge crucial for the development of a more sustainable agriculture, as their efforts in adapting practices through trial and error makes them a good source of knowledge and proves their adaptive management abilities (Méndez et al., 2013; Orlando et al., 2020). On the other hand, farmers require scientific input since their observations on agroecosystems might not be complete and can lead, for instance, to a limited understanding of agroecosystem functioning (Van Asten et al., 2009; Bellamy & Ioris, 2017). The need for cooperation is further evidenced in that scientists are encouraged to convert their knowledge into farming techniques that could be used by farmers, while at the same time, farmers are requested to collaborate with scientists and experiment to develop these techniques and tailor them to their farm context (Ingram et al., 2016; Gliessman, 2018). Co-creation of knowledge and practices can present several

challenges related, for instance, to scientific uncertainties about yields when implementing farming practices, or to the type of knowledge that should be relied upon, for example, agricultural managers[1] in larger agribusinesses rely more on high scientific rigor and certainty when deciding about agricultural practices in the farm, while small scale farmers rely more on their traditional and experiential knowledge (Méndez et al., 2013; Ingram et al., 2016).

Transdisciplinary and participatory approaches such as knowledge co-creation processes have the potential to connect local and traditional knowledge with modern agricultural production practices (Méndez et al., 2013; Barrios et al., 2020). They do so by fostering co-creation and sharing of information among its participants, and by providing an opportunity to align interests of farmers, civil society actors, scientists, and policy makers. In this way, knowledge co-creation processes bridge different sources and systems of knowledge and enable actors to experiment and adapt agroecological farming practices to local needs and contexts (Méndez et al., 2017; Compagnone et al., 2018).

1.2. Problem and knowledge gap

Agroecology scholars recognize the importance of participatory approaches such as knowledge co-creation processes to advance agroecology in practice, meaning that farmers shift their conventional farming practices towards biodiversity conservation, or agroecological ones (Barrios et al., 2020; Wezel et al., 2020). Nevertheless, there is still a lot to be explored when it comes to optimizing knowledge co-creation processes in agroecology. When performing a literature review on scientific empirical cases of knowledge co-creation in the context of agroecology, Bello Cartagena (2019) found that only around one third of the cases were successful in reaching the adoption of agroecological farming practices. Additionally, there is a need to increase farmer participation in such processes as their engagement is linked to a higher adoption of agroecological farming practices (Márquez-García, Jacobson & Barbosa, 2019). Furthermore, practitioners highlight that these processes are still mostly unidirectional, in other words, scientists are mainly those sharing knowledge, and more horizontal interaction with other actors is a constant struggle. This brings attention to the need to create an inclusive and collaborative environment to foster dialogue between knowledges, cultures and disciplines

[1] Throughout this paper the term 'agricultural managers' will refer to a particular actor in medium to bigger scale farming, characterizing those actors who work closely with both farm workers and higher decision making positions in the agribusiness they work for. Agricultural managers are aware of how crops are developing and are in charge of decision making on which agricultural practices will be adopted in the farm. This concept will be recurrent in the empirical case (see section 4.2).

(Rossi, 2020) because, even though there is evidence of co-creation contributing to the adoption of agroecological farming, less is known about the conditions in the process which will reach better results in terms of a higher adoption of agroecological farming practices (Márquez-García et al., 2018; Bello Cartagena, 2019; Rossi, 2020). These findings support the notion stressed by agroecology scholars in that there is a call to increase the understanding of co-creation processes complexity, and to identify conditions within these processes that will encourage agrobiodiversity conservation behaviours, such as the adoption of agroecological farming practices (Laforge & Levkoe, 2018; Rossi, 2020).

Conditions in knowledge co-creation processes that would successfully lead to an increased adoption of agroecological farming practices will be referred to as *success conditions* (see section 2.1), and as the studies mentioned above have highlighted, there is a need to further investigate such conditions.

Success conditions in knowledge co-creation processes have been studied in the context of climate change adaptation (Hegger, Lamers, Van Zeil-Rozema & Dieperinket al., 2012; Hegger, Van Zeil Rozema & Dieperink, 2014), and later in the context of agroecology (Bello Cartagena, 2019). They focused on the production of credible, salient, and legitimate knowledge (see Cash et al., 2003; Hegger et al., 2012), in this way conceptualizing successful co-creation as that which meets *credibility, salience* and *legitimacy* criteria. However, this Thesis argues that these criteria are not sufficient to deal with the context-specificity of the co-created *knowledge and practices* through farmer-scientist interactions, nor are able to enhance the adoption of agroecological farming practices on their own. When looking at challenges farmers face when adopting such practices, the need for a support network which encourages them to experiment with new practices, and skills development to allow an experimentation and adaptation of practices to local contexts are crucial. Therefore, as will be elaborated upon later (section 2.1), other aspects such as the development of social networks among farmers and capacity building are key for the adoption of agroecological farming. This paper will thus aim at broadening the scope to look for success conditions and explore those which will contribute not only to legitimacy, salience, and credibility criteria but also to create social networks and build capacities that lead to the adoption of agroecological farming practices.

1.3. Research objective, questions, and research framework

The aim of this research is to contribute to the study of knowledge co-creation processes that facilitate the adoption of agroecological farming practices by developing a conceptual framework including success conditions related to both the co-creation process *itself* and its *context*, which will be applied to a co-creation project with Chilean wineries for the purpose of refining the framework.

The empirical case refers to a co-creation project, offered by the Chilean Wine Climate Change and Biodiversity Program (WCCB) and the Joint Nature Conservation Committee (JNCC) from the UK. This project aimed at connecting ecological knowledge on ecosystem services and how they are affected by agricultural practices in the wine productive sector. The project brings together scientific and experiential knowledge to raise awareness on the effects current agricultural practices have on agrobiodiversity and ecosystem service provision, to ultimately encourage the adoption of agroecological practices by wineries. Further case specifications and justification are provided in section 3.1. Following the example by Kolhoff et al. (2013) and Schoonhoven & Runhaar (2018), the resulting *success conditions* framework will be tested on this case of knowledge co-creation with the aim of providing input for a refinement of the framework and recommendations for future co-creation projects.

To achieve the aim of this research, the following research question will be answered:

What are success conditions in knowledge co-creation processes that facilitate the adoption of agroecological farming practices, and how can these be assessed in practice?

To answer the main research question, the following sub-questions are proposed:

1. What success conditions in knowledge co-creation processes in the context of agroecology can be found in the literature of participatory processes in agroecology?
2. How can the success conditions be assessed in empirical cases of knowledge co-creation processes in the context of agroecology?
3. How do the SCs present themselves in the knowledge co-creation project with Chilean wineries, and what conclusions can be derived for other cases?

Research framework

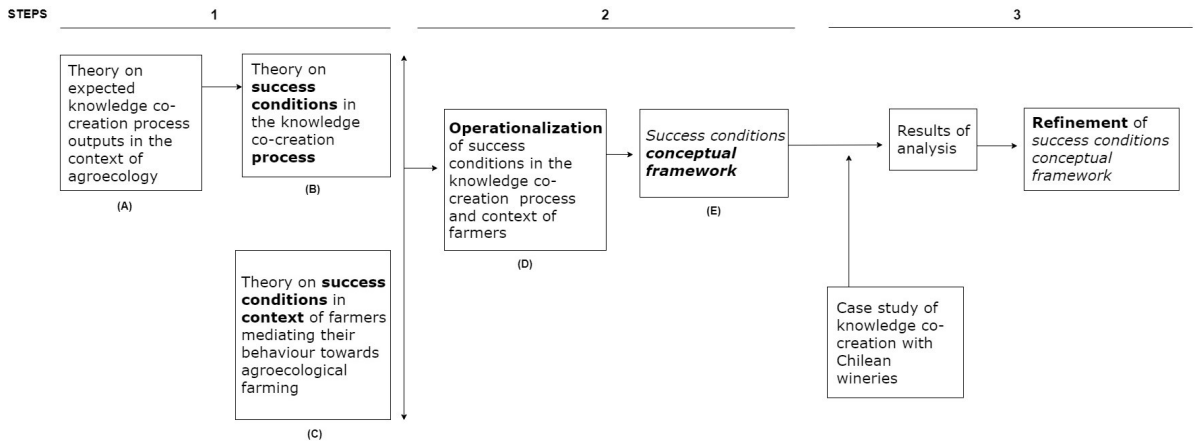

Figure 1 Research framework

The first step is concerned with a literature review on knowledge co-creation processes in the context of agroecology (See (A) in Figure 1) to explore co-creation process outputs (i.e., immediate results of the co-creation process) that would increase the chances of adoption of agroecological farming practices. Details on why this is required, and its relevance are presented in section 2.1. Success conditions will be explored in the literature of participatory processes in agroecology (B) as well as in the literature on the context of farmers mediating their behaviour towards agroecological farming (C). This review aims at finding and selecting success conditions in knowledge co-creation processes, hereby answering sub-question 1. Step 2 is concerned with the operationalization of success conditions in the knowledge co-creation processes literature, and those in the context of farmers mediating their behaviour towards agroecological farming, hereby answering sub-question 2. The description of how to assess the success conditions in an empirical case will complete the development of the conceptual framework which will be used for the next step. Finally, Step 3 focuses on the application of the framework to the empirical case of co-creation with Chilean wineries to subsequently provide input to refine it for future uses, thus answering sub-question 3.

1.4. Scientific and societal relevance

This Thesis explores success conditions for knowledge co-creation processes which can increase the adoption of agroecological farming practices. Such an approach contributes to both, the literature on agroecology, and on knowledge co-creation processes. Regarding the former, this Thesis will contribute to the need for further research on participatory processes (such as co-creation of knowledge) that positively contribute to advancing agroecology, as has been stressed by several scholars (Méndez et al., 2013; Altieri & Nicholls, 2017; Barrios et al., 2020; Wezel et al., 2020) . While for the latter, the success conditions that will be selected and operationalized expand on those that have been previously used in the context of agroecology (Bello Cartagena, 2019). Specifically, as the ones selected here aim at achieving broader process outputs, namely, the development of social networks and capacity building, and explore conditions mediating farmer participation in co-creation processes (see section 2.1). Thus, this Thesis' findings will serve as recommendations to effectively design and carry out co-creation processes, which can be particularly relevant for actors engaging in these processes such as research institutes, businesses, farmer organizations, and governmental institutions.

With the purpose of testing the success conditions (SCs) framework and to refine it, a knowledge co-creation project to advance agroecology in Chilean wineries has been selected (see section 3.1. for further justification). In this regard, the tentative analysis of SCs in the case will be relevant for the WCCB program and their future co-creation projects, but also for Chile in terms of their biodiversity conservation efforts in productive sectors. Firstly, since this region constitutes one of the few Mediterranean ecosystems in the world and its biodiversity is being extremely challenged by agricultural land uses (Viers et al., 2013), finding ways to improve these existing scientific and farmer collaborations can have a positive impact on the region's conservation efforts. Secondly, cooperation among researchers and the private sector can have a positive effect on biodiversity conservation given that legal frameworks enabling conservation on private land are currently lacking (Márquez-García et al., 2018).

This work also contributes to the broader context of achieving sustainable food systems. Particularly, the population growth expected for the next decades brings along a higher demand for food produce, which when produced through conventional methods, will continue to damage ecosystems and decrease agrobiodiversity (Wezel et al., 2014; IPCC, 2019). Thus, by providing insights on how to efficiently organize participatory processes in which knowledge

and practices can be co-created to help advance agroecology, this Thesis contributes to the conservation of agroecosystems while still meeting food produce needs.

1.5. Outline

So far, this paper has presented insights into how agroecology can be advanced through knowledge co-creation processes and has highlighted what this research will contribute to and how. The next chapter will provide the theoretical basis of the main argument of this Thesis and the search for success conditions for co-creation processes (section 2). Then section 3 elaborates on the Methods to carry out each step of the research as well as justifies and explains the empirical case. Section 4 will present the results of the literature review on success conditions by presenting the SCs conceptual framework, and the results from the test on the empirical case. Finally, section 5 discusses limitations of the research, usefulness of the framework, a suggestion for its refinement and presents recommendations for practitioners and further research.

2. Conceptual design

2.1. Conceptualization of successful knowledge co-creation processes to advance agroecology

To achieve the aim of this research several points need to be clarified, namely, a description of what constitutes a successful knowledge co-creation process in the context of agroecology, how this would be achieved in theory, and finally, what are the conditions that need to be met for a process to be successful. This section draws on the literature of knowledge co-creation processes in agroecology to identify aspects that make a co-creation process in the context of agroecology successful. The chapter starts by defining and exemplifying a knowledge co-creation process in agroecology and then elaborates on the different process results which need to be achieved for the process to be successful.

Knowledge co-creation processes can be defined as "iterative and collaborative processes involving diverse types of expertise, knowledge and actors to produce context-specific knowledge" (Norström et al., 2020, p.182), as well as the exchange and application of such knowledge (Hegger et al., 2012). These processes originate from a particular set of circumstances in which goals are set and interaction among participants takes place (Norström et al., 2020). Knowledge co-creation processes in the context of agroecology are based on direct collaboration between different actors, for instance, farmers[2] and scientists which connect traditional and experiential with scientific knowledge systems (Méndez et al., 2013; Rossi, 2020). A concrete example of such processes are participatory workshops in which farmers (or stakeholders from agribusinesses, for instance, agricultural managers) come together with scientists and assess the status of several ecosystem services on the farm, to at a later stage, understand which farming practices will allow the conservation of biodiversity and secure the availability of ecosystem services (Márquez-García et al., 2018). Figure 2 presents a visualization of this example of knowledge co-creation.

[2] In the literature farmers are the main holders of traditional and experiential knowledge as they are those directly working in the fields and experiencing how crops react when facing external pressures and inputs. However, later in this paper (section 4.2), other actors representing a particular productive sector will be those possessing experiential knowledge which they will share with academic actors in co-creation processes.

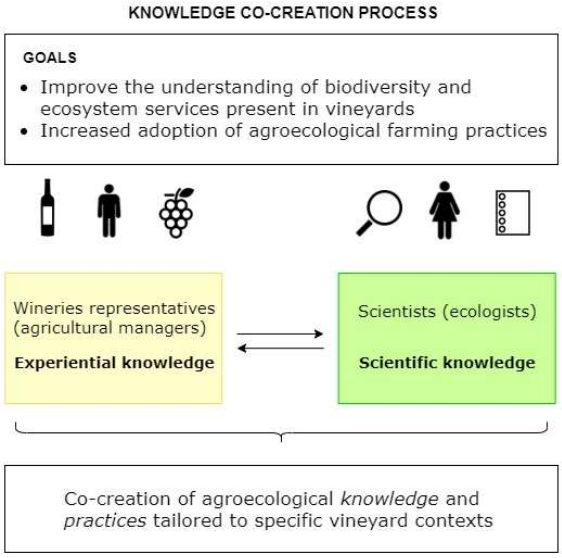

Figure 2. Example of a knowledge co-creation process

Success in knowledge co-creation processes[3] broadly refers to the achievement of desired effects of the process on the issue of interest, which can be measured at different levels. These levels vary from most immediate results, namely outputs, that lead to outcomes, which are the potential short- and medium- term effects that outputs will have. While, in the longer term, outcomes are expected to lead to impacts (Schuck-Zöller et al., 2017). Different scholars define success at different levels framing it, for instance, within short-term effects focusing on the relevance of the co-created knowledge for the diversity of actors involved (Hegger et al., 2012), while others conceptualize success in the more distant goal of sustainability transformations (Norström et al., 2020). Particularly for agroecology, adoption of agroecological farming practices is considered to form the basis for broader change in agricultural systems (Gliessman, 2018; Mier & Terán Giménez Cacho et al., 2018), and this will therefore be the main characteristic of successful knowledge co-creation processes in the context of agroecology. Adoption of such practices will be considered as the outcome of co-creation processes leading to impacts in terms of broader changes in agroecosystems and agroecological transformations (see Figure 3). This Thesis will zoom into outputs, which are process results preceding the adoption of agroecological farming practices and, as this Thesis argues, they are a precondition for such changes to occur. The focus will then be on searching conditions which lead to such

[3] Throughout this paper knowledge co-creation processes might also be referred to as 'co-creation processes'. While 'co-creation projects' will refer to bigger co-creation instances where more than one co-creation process is included. This will be the case in sections 3.1 and 4.2 where the empirical case is addressed.

outputs and therefore contribute to the adoption of agroecological farming practices. These will be referred to as *success conditions*. Figure 3 presents successful co-creation process results, highlighting the adoption of agroecological farming practices as the main aim. How outputs are expected to lead to the outcome will be discussed later in this section.

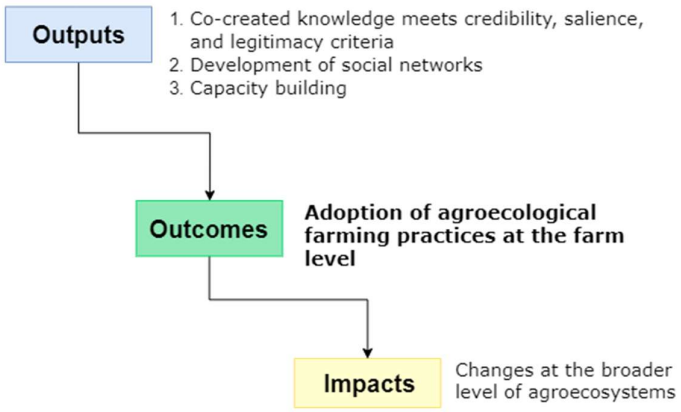

Figure 3. Final products of knowledge co-creation processes. Process outcome as the main determinant of the co-creation process success is marked in bold.

The following sub-sections elaborate on the three levels of process results, namely outputs, outcomes, and impacts, and their interrelationships. This is done for the purpose of developing a logical line of argument linking these process results to later explore success conditions that will (theoretically) positively contribute to achieving these results. However, they will not be empirically measured as this is out of the scope of this Thesis.

Process outcomes and impacts

Advancing agroecology in practice refers to enhancing agroecological farming to reach a production of food that delivers lower environmental, social and economic burdens (Gliessman, 2018, 2019). In practical terms and for the purpose of this Thesis, it will refer to increases in the adoption of agroecological farming practices at the farm level (Figure 3). Agroecological farming practices present an alternative to conventional agricultural production methods, such as tillage, synthetic fertilizer, and pesticide use, for instance by substituting them with agroecological practices, such as direct seeding, organic fertilization of crops and biological pest control, respectively. These practices are based on ecological processes and promote the conservation of ecosystems by enhancing beneficial interactions between species.

Hereby achieving synergies between ecosystems and agricultural systems (Wezel et al., 2014), which enhances agroecosystem sustainability and resilience (Altieri & Toledo, 2011).

Farmers changing their conventional farming practices to agroecological practices, for instance, by reducing artificial chemical inputs or substituting them, are considered the first level of change towards the transformation of food systems through agroecology (Gliessman, 2016, 2018). The adoption of agroecological farming practices is considered to set the foundations for broader changes in agricultural systems (Mier & Giménez Cacho et al., 2018), and will therefore constitute the co-creation process outcome (i.e., short- and medium-term results of co-creation processes) as shown in Figure 3. When such practices are widely present, then the development of further changes or impacts is fostered. Impacts involve the redesign of agroecosystems based on ecological principles, and at a later stage, the inclusion of actors such as consumers to develop inclusive and just food systems that conserve biodiversity and other life supporting systems (Gliessman, 2018).

Process outcomes and impacts can be measured in practice, in fact, the *Tool for Agroecology Performance Evaluation* is currently being used to assess the adoption of agroecology and its impacts on agroecosystems (FAO, 2019; Gliessman, 2020). However, since the focus of this Thesis is placed only on success conditions in knowledge co-creation processes leading to the achievement of outputs, an assessment of the adoption of agroecological practices and of further impacts at the agroecosystem level and food systems are out of the scope.

Agroecology-relevant process outputs

After consultation of agroecology and knowledge co-creation literature (Step 1A Figure 1), several knowledge co-creation process outputs were identified as relevant for the adoption of agroecological farming practices. These are first, the production of knowledge that meets *credibility, salience, and legitimacy* criteria. Second, the development of *social networks*. Third, *capacity building* among co-creation process participants. These outputs will be referred to as 'agroecology-relevant' process outputs. The present section elaborates on these outputs and provides evidence on how they can be linked to enhancing the adoption of agroecological farming practices as described in the literature. It is important to mention that these links are assumed from the literature, as the design of this research does not include testing causality between process outputs and outcome. While, as mentioned above, the relationship between co-creation process outcomes, in terms of adoption of agroecological farming, and impacts, in terms of generating broader changes in agroecosystems has been described in the literature

(Gliessman, 2016; Mier & Giménez Cacho et al., 2018). Therefore, this Thesis will solely focus on first, linking process outputs to outcome (later in this section), and second, finding success conditions that will lead to the achievement of outputs (section 4.1). In this way, a theoretically substantiated argument will be made connecting success conditions to all co-creation process results, ranging from outputs to impacts.

The first agroecology-relevant process output is co-creation of knowledge that meets *credibility, salience,* and *legitimacy* criteria. This output has been described in the literature as a requirement for successful co-creation and transference of knowledge between different knowledge systems or actor groups (Cash et al., 2003; Hegger et al., 2012; Norström et al., 2020). Particularly in the context of agroecology, *legitimacy* would be evidenced when all participants, scientists, and farmer's knowledge and beliefs have been considered and respected in the process of producing new knowledge and practices. While *salience* would mean that knowledge and practices are scientifically and practically relevant. The former can be observed in the fact that results can be published by scientists in academic journals, while the latter in that farmers develop a set of skills which allows them to implement a farming practice, for example, biological pest control in their farm. Regarding the *credibility* criteria, knowledge sources should be considered as believable by all participants, namely, farmers trust in scientific knowledge about biodiversity in their farm and how it relates to the ecosystem services provided by it, as well as scientists trust in farmer empirical knowledge on how they perceive biodiversity in their farms. Co-created agroecological knowledge that meets these criteria supports the required dialogue between different knowledge systems and is more likely to be accepted by farmers (Altieri & Toledo, 2011; Méndez et al., 2013; Méndez et al., 2017). Hence, these criteria should be met to allow an adequate transference and co-creation of agroecological knowledge and practices among co-creation process participants.

Secondly, *social networks* are a heterogeneous group of actors which interact and serve as a knowledge-sharing platform (Wood et al., 2014). In such networks scientists and farmers interact and work together to produce agroecological knowledge and practices, for instance, they work together to determine the inclusion of adequate allelopathic plants[4] within crops that will allow a chemical input-free weed, and pest control in the field. Multi-actor knowledge networks, for instance, those including farmers and scientists, empower farmers and make them

[4] Allelopathic plants are characterized by the production and secretion of certain compounds in some stages of their life cycle which have a negative effect, for instance, on weed seeds by impeding their germination and therefore contributing to an artificial pesticide-free pest control in the fields. Some examples of allelopathic plants are sunflower and rye (Wezel et al., 2014).

co-creators of knowledge together with scientists increasing the chances of adoption of agroecological farming (Šūmane et al., 2017). In fact, the need for collaboration and integration of scientific and traditional experiential knowledge required for the successful production of knowledge and practices, challenges the previous idea that innovative farming practices should be unidirectionally shared from scientists to farmers. In contrast, a co-creation of knowledge and practices increases farmer willingness to learn and enhances collaboration with other farmers to disseminate the practices and knowledge which they have tested and already adapted to their local circumstances and needs. Then *social networks* become crucial as farmers value the experience of other farmers and when they see practices applied in one farm they are more likely to trust it, apply it in their own farms, and share them with other fellow farmers in their network (Reyes-García et al., 2013; Wood et al., 2014). Therefore, the development of social networks both between scientists and farmers, and among farmers, becomes a relevant knowledge co-creation output towards the adoption of agroecological farming practices.

Thirdly, *capacity building* in the context of agroecology has been described as a key component of participatory approaches, such as knowledge co-creation processes, as it plays a crucial role in the dissemination of agroecological principles and practices (Altieri & Nicholls, 2017; Laforge & Levkoe, 2018). *Capacity building* basically refers to training individuals to develop a particular skill. Specifically for agroecology, capacity building would focus on the transference of biodiversity conservation agricultural practices (or agroecological practices), which can occur between agroecologists (scientists) and farmers or among farmers (Laforge & Levkoe, 2018). Knowledge co-creation processes can take the form of participatory educational workshops offering training in technical skills, for instance, farmers and scientists jointly identifying biodiversity and the ecosystem services present in their farm, and at a later stage follow up activities provide training on agroecological practices aiming at preserving those ecosystem services (Márquez-García et al., 2018). In this way capacity building provides an opportunity for experimentation and adaptation of farming practices to the farm's context, and it can therefore enhance the adoption of agroecological farming practices.

As shown in this section, each of the three agroecology-relevant outputs have been linked to knowledge co-creation processes and positively contribute to the adoption of agroecological farming practices. Interestingly, synergies among outputs are also found, for instance, *capacity building* activities that foster learning agroecological knowledge and practices positively contribute to the formation of *social networks*. The latter serve as farmer support systems, which are crucial for developing trust among farmers and enhances information sharing

(McGuire et al., 2015; Laforge & Levkoe, 2018). While, as mentioned before, when co-created knowledge among farmers and scientists is perceived as *credible, salient,* and produced in a *legitimate* environment, then farmers are more inclined to trust it. Thus, as these outputs contribute to enhancing the adoption of agroecological farming practices, they will be used as a filter when exploring success conditions in the literature. Figure 4 schematically presents the links between the success conditions which will be later explored in the literature, and the agroecology-relevant outputs and outcome. It is important to note that only the first output here described has been considered in previous studies in the context of knowledge co-creation and agroecology (see Bello Cartagena, 2019). Therefore, the success conditions that this study will find (Step 2 of this research, see Figure 1), will contribute to expand theory on success conditions in co-creation processes in the context of agroecology.

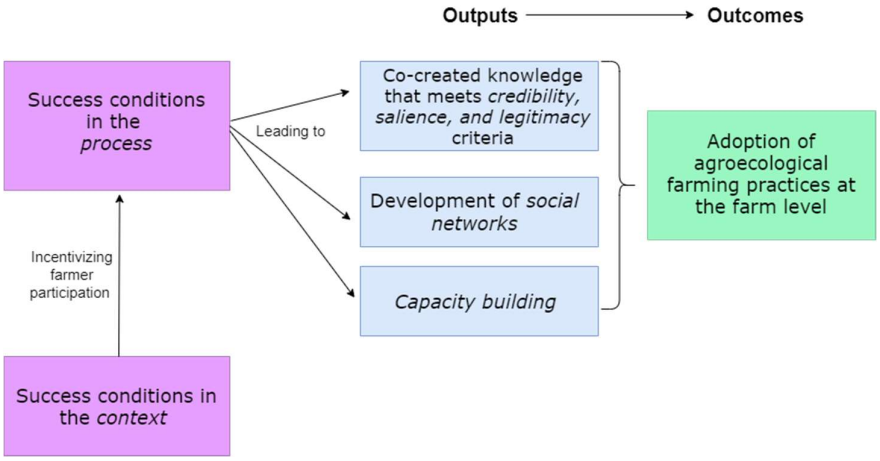

Figure 4. Conceptual design

2.2. Success conditions

As defined in the previous section, successful knowledge co-creation processes in the context of agroecology are those that will produce the three agroecology-relevant process outputs, namely, *credible, salient, and legitimate* knowledge, development of *social networks*, and *capacity building*, which are expected to facilitate the adoption of agroecological farming practices at the farm level (see Figure 4). The conditions enabling successful knowledge co-creation processes to occur will be referred to as *success conditions (SCs)*. To answer sub-question 1, these conditions will be explored in both the process of co-creation *itself* as well as in the *context* which influences farmer participation in such processes. The logic behind

selecting two sets of SCs is that first, there is a need to ensure the co-creation process is organized in an optimal manner to enhance interaction between actors and produce the three agroecology-relevant process outputs, and second, to increase participation of farmers, who in the end take on the task of adopting agroecological farming practices, conditions in their context which motivate them to participate are interesting to study. This section further expands this argument and provides the theoretical lens for selection of SCs in the next step of this research.

Knowledge co-creation process

Finding success conditions in the knowledge co-creation process *itself*, particularly in process organization is relevant as this can directly affect process results, and hence, the co-creation process success (Schuck-Zöller et al., 2017). To explore success conditions in the knowledge co-creation process, certain dimensions should be considered. For instance, the group of actors involved who represent different knowledge systems, and the patterns guiding interactions among actors, which will be shaped by the type of activity they engage in. Furthermore, aspects related to the context in which the process takes place, for instance, availability of resources, and finally, the goals set for the process. Since the adoption of agroecological farming practices resulting from knowledge co-creation is assumed to be dependent on the achievement of three outputs, this Thesis will explore success conditions in the literature which lead to such outputs. In this way providing insights into what conditions should be present in co-creation processes so that they lead to the three agroecology-relevant process outputs. To present these SCs in the results section in a clear and organized manner, they will be categorized using the framework by Norström et al. (2020). These scholars propose that co-creation processes should be context-based, pluralistic, goal-oriented, and interactive (Figure 5), and further argue that when processes comply with the principles, then it has higher chances of contributing to all three agroecology-relevant process outputs.

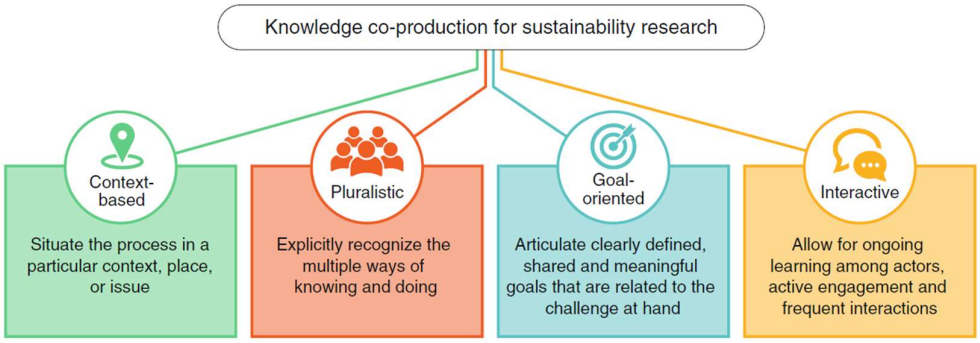

Figure 5. Principles of knowledge co-production for sustainability research. Source Norström et al. (2020)

Context

The context in which knowledge co-creation processes develop entails, for instance, social, economic and ecological aspects of a particular place (Norström et al., 2020), however, a co-creation process is also affected by the context in which its participating actors are inserted. This Thesis builds on agroecological literature on farmer behaviour towards agroecological farming to argue that since farmers are those who take action, and ultimately change their farming practices, conditions enabling their participation in co-creation processes are relevant to explore.

The participatory approach of co-creation processes and the need for knowledge systems to dialogue and develop new, context-adapted knowledge and practices requires participation of farmers who are the actors which will adopt the agroecological farming practices emerging from these proceses. Co-creation processes are usually organized by actors other than farmers, therefore, how to engage them into participating becomes a relavant question. Especially because increased participation has been linked to a higher adoption of agroecological farming practices (Márquez-García et al., 2019). To explore SCs which play a role motivating producers to engage in co-creation processes, previous research in conditions influencing farmer behaviour towards agroecology exemplified by the adoption of agroecological farming practices becomes relevant. In this regard, scholars have highlighted several conditions that influence farmer behaviour towards agroecology, for instance, Runhaar et al. (2017) presented conditions referring to the motivation of farmers and demand for them to change their behaviour towards biodiversity conservation practices (or agroecological practices). Additionally, these scholars propose that farmers are required to have the necessary skills, knowledge, and access to resources to adopt such practices (Runhaar et al., 2017). With

financial incentives being crucial to encourage small and family farmers to engage with agroecological practices and innovations (Altieri & Toledo, 2011). Finally, governance arrangements towards nature conservation should allow farmers to participate (Runhaar et al., 2017). The latter has been highlighted by both scientists and farmers who have identified a key role of policies enabling farming, education and market development as crucial to enable the adoption of agroecological farming practices (Mier & Giménez Cacho et al., 2018). These studies present evidence of a range of conditions mediating change in farmer behaviour in relation to agroecology, specifically towards the adoption of agroecological farming practices.

This Thesis builds upon this body of literature and argues that such conditions could play a role in mediating farmer participation in knoweldge co-creation processes in agroecology because, if such conditions positively influence farmers to change their behaviour and adopt agroecological farming, then they will also have an effect on whether these actors are inclined to participate in co-creation processes aiming at facilitating adoption of these practices. In this sense, success conditions in the *context* (Figure 4) will be those that mediate farmer behaviour towards adoption of agroecological farming. At this point it is important to note that these success conditions are not intended to directly contribute to successful co-creation processes in terms of the achievement of agroecology-relevant outputs as presented in the previous section, but only to ensure farmer participation in such processes.

3. Method

3.1. Case description and justification

The empirical case is "The natural capital approach to landscape planning: a pilot project in Colchagua Valley", from here onwards the WCCB-JNCC project. Is a co-creation project resulting from a collective effort by the Wine, Climate Change and Biodiversity program (WCCB), based in Chile, and the Joint Nature Conservation Committee (JNCC), based in the UK, in which knowledge from wine producers is combined with ecosystem science in an attempt to understand how wineries' agricultural practices interact with the provision of ecosystem services relevant for their businesses. This project contributes to advancing agroecology through knowledge co-creation by fostering interaction between scientific and experiential knowledge resulting in the development of models to inform future decision making at wineries. Specifically, by providing information about how wineries' agricultural practices, such as herbicide use, tillage, and buffer strips, affect the provision of ecosystem services sustaining wine production. In this way, as wineries are aware of the damaging effects of their conventional practices to biodiversity and ecosystem services provision, they are encouraged to shift their farming practices to agroecological ones and hereby contribute to advancing agroecology in practice.

The project entailed three knowledge co-creation processes carried out in a period of five months, resulting in the development of interactive tools to help inform wineries on how their agricultural practices are affecting the ecosystem services in their field and broader region (see Figure 8). The WCCB-JNCC project is considered an adequate unit of analysis to test the success conditions framework in practice, as its participatory nature fosters the bridging of scientific knowledge in ecology and biodiversity conservation with experiential knowledge from wine producers in the Colchagua Valley to ultimately encourage them to shift their agricultural practices towards agroecological ones.

The case is not intended to be representative of participatory processes in agroecology, but rather it constitutes an interesting example of how co-creation induces adoption of agroecological farming practices. As an empirical case to test the success conditions conceptual framework it contributes to build theory on success conditions in knowledge co-creation processes in the context of agroecology. Specifically, by providing insights on how conditions manifest themselves in practice, and their interrelations, hereby, contributing to refine the

framework for its application in co-creation projects in different contexts and production sectors.

Although there is no formal internship with the WCCB research program, communication has been in place since November 2020 and fruitful conversations have been held with them in terms of their experience and what they would consider useful for the development of future co-creation projects. Considering this information, this Thesis relied on a certain degree of collaboration for the realization of Step 3 of the research (Figure 1). Involving, for example, interviews with the researcher team, provision of program reports and project minutes which are not publicly available and establishing contact with researchers and wineries to receive the necessary input for the empirical case analysis.

3.2. Step 1- Literature review for success conditions

Sub-question 1 was addressed by means of a literature review on peer-reviewed work from different bodies of literature and data sources. Initially, a review of the theory on agroecology and participatory processes in the context of agroecology was performed to explore process outputs that could be theoretically linked to the adoption of agroecological farming practices. This was covered in Step 1A (Figure 1) which constitutes part of the Conceptual Design presented in section 2.1. For this purpose, data was collected via key word search in engines such as Google Scholar and Scopus using terms such as: 'agroecological knowledge and practices', 'participatory approaches in agroecology'. Additionally, other articles were found following the snowball method.

Step 1B continued with a review of scientific literature on theory and practice of knowledge co-creation processes or participatory processes in agroecology. This step explored success conditions in co-creation processes in the literature on participatory processes in agroecology. The consulted search engines were Google Scholar and Scopus, and the review was performed using combinations of the following groups of keywords: 1. 'knowledge co-creation/co-production', 'agroecological knowledge'; 2. 'good practices', 'success conditions'; 3. 'social networks', 'capacity building' (see Figure 6 for a summary). The main inclusion criteria for selecting an article were that the knowledge co-creation process included and/or focused on scientist or researcher and farmer interactions to enhance agroecological farming behaviour. Success conditions were selected based on whether they were directly linked to the achievement of one or more agroecology-relevant process outputs, namely, creation of

knowledge that meets *credibility, salience* and *legitimacy* criteria, development of *social networks*, and *capacity building*. This follows the argument made in section 2.1. which states that co-creation processes achieving these outputs contribute to increase the adoption of agroecological farming practices at the farm level. Following this argument, some articles looking at co-creation in the context of sustainability which presented SCs leading to one or more outputs, were also considered.

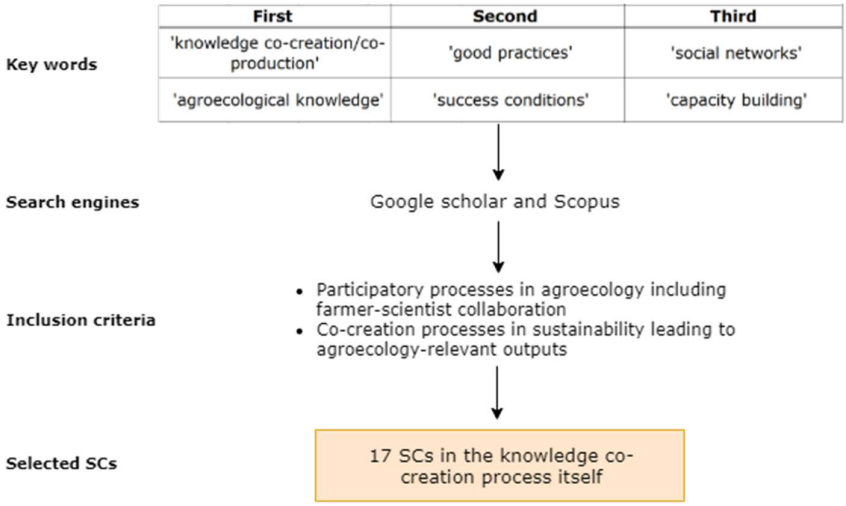

Figure 6. Steps followed for literature review for SCs in the co-creation process.

Secondly, literature on the context mediating farmer behaviour towards agroecological farming, in this case considered to mediate farmer participation in co-creation processes (see section 2.2), was consulted using the same search engines as mentioned above and key terms such as 'agroecological farming behaviour' in addition to the snowball method.

Furthermore, literature search for Step 1 (Figure 1) included other data sources such as grey literature (e.g., websites, repositories, and reports) from research institutes, as participatory approaches in the context of agroecology are performed by different groups of stakeholders. The inclusion of these data sources is based on the work of Schuck-Zöller et al. (2017) and Wall et al. (2017) when describing the selection of quality criteria for knowledge co-creation processes. Figure 6 presents a summary of the consulted sources and bodies of literature for this review.

3.3. Step 2- Operationalization of success conditions

Step 2 was concerned with the operationalization of the success conditions found in Step 1, this means that the conditions found in the literature from participatory processes in agroecology and from co-creation in general were translated into indicators which allow a preliminary assessment on how SCs manifest themselves in an empirical case. The operationalization was based on the literature consulted in Step 1 and was tailored for the empirical case as it is relevant for the next Step of the research. However, when an approximation on how to assess the conditions in practice was not present, it was developed by the author of this Thesis. The operationalization led to the development of a *success conditions* conceptual framework (Step 2 (E)) which by providing indicators to observe the success conditions in practice it allows testing of the framework in the empirical case. Table 3 in the results section presents the conditions and indicators to test the framework in the WCCB-JNCC project.

3.4. Step 3- Empirical case analysis

The degree of success of the WCCB-JNCC co-creation project evidenced by the extent of adoption of agroecological farming resulting from the project was not measured, as such results can only be observed sometime after the project has finished, and therefore, such analysis is beyond the scope of this Thesis. In fact, the idea was to assess the conditions in the empirical case based on the theoretical link described above, namely, 'SCs will lead to the agroecology-relevant outputs which increase the chances of adoption of agroecological farming practices'. Thus, it was assumed that the presence of SCs will lead to successful co-creation in the context of agroecology.

The empirical case analysis relies on the *success conditions* conceptual framework developed in the previous steps. With the aim of testing and further refining the framework, the operationalization of success conditions allowed a tentative assessment by means of document analysis and interviews with project participants. More specifically, for the SCs in the process *itself*, projects results such as reports by the WCCB and JNCC, and scientific publications derived from the project were analysed using the indicators developed in the operationalization from Step 2. For instance, to assess SCs related to interaction among participants, sections of the documents describing these interactions were analysed to finally derive conclusions on how

the condition manifested itself in the case. Secondly, input to assess this set of SCs mainly came from interviews with members of the WCCB researcher team as they were in charge of organizing and carrying out the three participatory processes entailed in the case, and therefore held knowledge that could inform the assessment of this set of SCs. For this purpose, semi structured interviews were performed with four researchers, inquiring about their experience in this project, about the decisions they made in terms of goal setting, or who to invite to participate as well as details on how the activities performed during workshops were designed and developed. The selected SCs in the process itself and their operationalization (section 4.1.1) guided the interviews. The interviews had an average duration of 1 hour and were performed by the author of this Thesis. For the assessment of this set of SCs, representatives from wineries (agricultural managers) who participated in the processes did not provide direct input as their experience was deemed more relevant for assessing the other set of conditions. Nevertheless, they did share some general impressions about their participation in the co-creation project and these will be reflected upon in the discussion of this paper.

To assess SCs in the *context*, meaning those mediating farmer participation in co-creation processes, semi structured interviews with representatives from wineries in the Colchagua Valley were performed. These representatives were agricultural managers as they are the ones who participated in the WCCB-JNCC project and are those in charge of decision making in terms of agricultural practices. The interviews had a length of around 40 minutes and were performed by the author of this Thesis. They were guided by a questionnaire (see Annex 1) inquiring about SCs in the conceptual framework such as their skills in agroecological farming, peer pressure or whether they have access to financial incentives to adopt agroecological farming practices. Additionally, for triangulation purposes, policy documents and grey literature were consulted to explore financial incentives and other relevant policies farmers are subject to in the Colchagua Valley region. Together, the input from interviews as well as the additional documents consulted for this step contributed to a tentative assessment of whether the conditions were present in this case and how they affected wineries' participation in the WCCB-JNCC project. Hereby, also contributing to refining the success condition framework.

Finally, while the first and second steps of the research are based on literature reviews, the third one is based on document analysis as well as on input from knowledge co-creation process participants, including both academic and non-academic actors. This is expected to enhance the validity of the results by adding to the relevance of this framework, its practical usefulness

for practitioners and the future co-creation processes they engage in and make the recommendations that result from it more valuable.

Research ethics

For the interviews contemplated in Step 3 (Figure 1) a few actions were taken regarding the confidentiality of information shared with this Thesis' author. First, agricultural managers representing the different wineries were formally invited through an invitation letter explaining in detail what the research was about, why their contribution was required and how the information they provided would be shared and published. Additionally, they were asked to sign an 'Informed Consent Form' which was based on the template provided by Utrecht University and contained some modifications as suggested by the WCCB researcher team. Finally, the four researchers from the WCCB team also agreed to participate and share their experiences as they believed this research will prove useful for their future work.

4. Results

4.1. Success conditions and their operationalization

To answer the first and second sub-questions, this section elaborates on the success conditions found in the literature and presents an approximation on how to observe them in an empirical case of co-creation, which will be utilized at a later stage of the research. The results presented in this section constitute the conceptual framework this Thesis aims at developing based on the literature review performed in Steps 1 and 2. To situate this result in the argument of this Thesis, Figure 7 shows where the SCs conceptual framework is placed in the conceptual design. The section begins by presenting success conditions in the knowledge co-creation process *itself* and is then followed by success conditions in the *context*. The former will be referred to as 'SC-P' indicating *process*, while the latter will be 'SC-C' indicating the *context*.

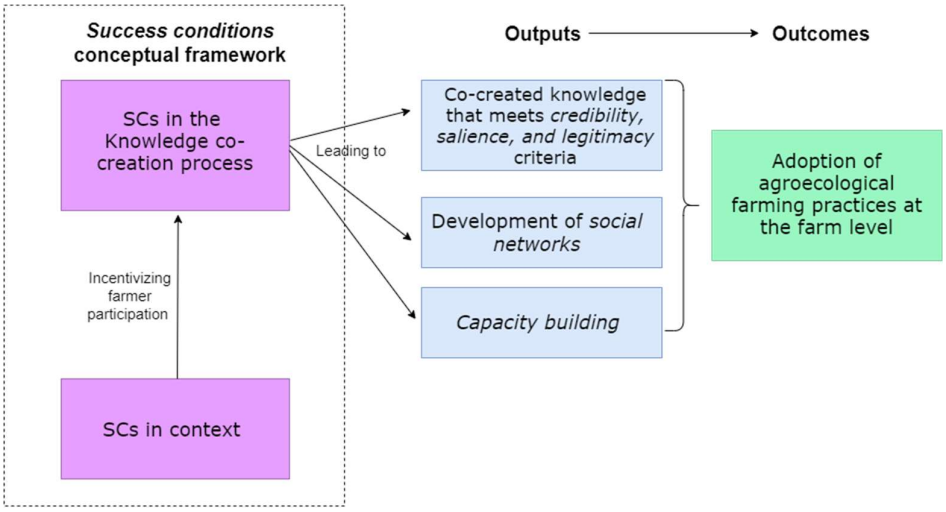

Figure 7. Conceptual design and SCs framework, the latter is demarcated by the dotted box.

4.1.1. Knowledge co-creation process

A total of 17 success conditions were selected from the literature review following the methodology described in section 3.2. The focus for success conditions selection was on scientist-farmer participatory approaches, in which farmers are the main decision makers when choosing the agricultural practices they will perform in their farms. As the literature review progressed, some articles addressing knowledge co-creation for sustainability in general (not

necessarily in the context of agroecology) were also included in the review as they appeared in the search even after the key words filter, and because the SCs presented by them led to one or more of the three agroecology-relevant process outputs.

Table 1 presents all SCs identified in the co-creation process *itself* as well as the process output, they contribute to as it was found in the literature. The following paragraphs elaborate on the success conditions, presenting a description for each SC, their operationalization and how they are expected to contribute to the agroecology-relevant process outputs. Finally, as mentioned in section 2.2, success conditions are categorized within the principles for knowledge co-creation as presented by Norström et al. (2020), this categorization is rather flexible as it could be argued that some conditions are related to more than one principle, nevertheless it is considered suitable to present the SCs in an organized manner.

Context-based principle

This principle states that co-creation processes should emerge within specific social, ecological, and economic contexts. They should further consider the variety of interests, beliefs, and demands of participating social groups. In turn, context-based co-creation processes will contribute to previously agreed upon goals and objectives of those actors involved in the issue (Norström et al., 2020). Success conditions in this category describe considerations project organizers should take regarding the context in which the knowledge co-creation process is embedded.

Firstly, *awareness on knowledge governance* (SC-P1) broadly refers to understanding how the co-created knowledge is governed, it implies clarity on the rules that shape how knowledge is shared, used and its accessibility (Clark, Van Kerkhoff, et al., 2016). The need to know and acknowledge knowledge governance comes together with the fact that, as it has been emphasized earlier, different actors and knowledge systems are brought together in knowledge co-creation processes. Therefore, the way information is presented, for instance, through academic publications, will not have the same value for actors outside of the academic world.

Table 1. Success conditions in the knowledge co-creation process itself. Output 1: Credibility, salience, legitimacy of co-created knowledge; Output 2: development of social networks; Output 3: capacity building. See Figure 2 for a general overview of process outputs.

Principles	Success conditions	References	Process output the success condition relates to
Context-based	SC-P1: Awareness on knowledge governance	(Clark, Van Kerkhoff, et al., 2016)	1
	SC-P2: Matching farmer and researcher needs and wills	(Orlando et al., 2020)	1
	SC-P3: Availability of sufficient resources to sustain long-term collaborations	(Lucas et al., 2019; Méndez et al., 2017)	2,3
	SC-P4: Connection between proposed activities and existing ones	(Bezner Kerr et al., 2019)	3
Goal-oriented	SC-P5: Project is oriented towards addressing existing problems of farmers	(Albicette et al., 2017)	1
	SC-P6: Participatory design of goals and desire for change	(Lacombe et al., 2018)	1,3
	SC-P7: Allow flexibility to incorporate lessons learned and to make adjustments throughout the project	(Albicette et al., 2017)	3
Pluralistic	SC-P8: Selection of actors based on whose behaviour or beliefs need to change, those with the know-how, and those who would be (in)directly affected by the issue	(Clark, Tomich, et al., 2016; Fernández González et al., 2021)	1
	SC-P9: Establishment of communicative competence (e.g., communicating science in a relevant and accessible way to non-specialists)	(O'Connor et al., 2019)	1,3
Interactive	SC-P10: Effective communication	(Méndez et al., 2017; Posner et al., 2016)	2,3
	SC-P11: Collaboration and interaction should be sustained in time	(Fernández González et al., 2021; Orlando et al., 2020)	1,2
	SC-P12: Construction of a common vocabulary regarding agroecology	(Orlando et al., 2020)	1
	SC-P13: Researchers are trained in transdisciplinary research	(Clark, Van Kerkhoff, et al., 2016; Fernández González et al., 2021; Tandon et al., 2016)	1
	SC-P14: Collaborative decision of research priorities and execution of research	(Henfrey, 2018; Mediterra, 2016; Méndez et al., 2017)	1,2,3
	SC-P15: Experiential learning should be core to the project	(Bezner Kerr et al., 2019; Moncure & Francis, 2011)	3
	SC-P16: Learning processes should be through trial and error together with other farmers	(Laforge & Levkoe, 2018)	2,3
	SC-P17: Choosing methods that simultaneously further both academic and practical aims.	(Henfrey, 2018)	2

On the other hand, non-academic actors are more likely to recognize knowledge as more relevant when it comes from people within their network, or from people they look up to, which can then also be different for different cultural settings. Thus, understanding how co-created knowledge is governed is crucial for enhancing legitimacy, salience and credibility of the process results (Clark, Van Kerkhoff, et al., 2016). This success condition can be observed in practice when all project participants are aware of how knowledge and practices originating from the co-creation process will be recognized and shared. More specifically, the organizers should make sure that there is an understanding on the form and language used when making knowledge available and sharing it, for instance, production of co-authored reports with language which is understandable to all participants.

Secondly, *farmer and researcher needs and wills should be coordinated* (SC-P2), which can be observed, for instance, when farmers have an interest in organic farming and take the initiative to learn how to change their agricultural farming practices. Whereas researchers have an interest in the effects of such practices on ecosystems and seek to improve the present knowledge in this respect. Such complementary needs bringing these two actors together contribute to increasing the salience of the knowledge and farming practices derived from the co-creation process (Orlando et al., 2020).

Thirdly, *sufficient resources need to be available to sustain long-term collaborations* (SC-P3). There needs to be an important investment of resources such as time and effort, human and monetary resources, to maintain longer term collaborations among project participants (Méndez et al., 2017). Collaboration sustained in time, for example in periods of three to four years, brings farmers together and enhances the development of networks between them (Lucas et al., 2019). Additionally, given the secured availability of resources over time, capacity building activities can be sustained for longer periods of time, and this has a positive influence on training activities. To observe this success condition in actual knowledge co-creation projects, funding possibilities from project related institutions and actors, namely, research institutes and private actors, should be explored to assess the feasibility of sustaining the collaborations in longer periods of time.

Finally, in line with considering the existing needs of participants, there should be a *connection between proposed activities and existing ones* (SC-P4). As Bezner Kerr et al. (2019) argue, this connection is founded in process organizers seeking and valuing commonalities between

the co-creation process proposed activities and their goals, and activities currently taking place in the farm. The link between these activities is important to enhance capacity building because co-creation process activities can reinforce and add to previous knowledge acquired in existing activities (Bezner Kerr et al., 2019). This success condition can be observed in practice by assessing whether the knowledge co-creation process under study incorporates activities that present a certain level of connection with, or are a continuation of, existing activities aiming at shifting farming practices towards agroecological ones.

Goal oriented

This principle highlights that co-creation processes should be problem-focused and have clear and shared goals among its participants. Furthermore, they should have explicit ways of how to measure process success (Norström et al., 2020), as setting clear goals in knowledge co-creation processes will contribute to protect the progress and legitimacy of the co-production process by preventing agendas pointing at directions different from the process' aims (Moser, 2016).

To ensure a co-creation process is in line with its participants' interests and goals, there should be a focus on *addressing existing problems of farmers* (SC-P5). In this regard, Albicette et al. (2017) argue that exploring the issues or problems farmers are facing is not necessarily responsibility of the researchers, rather it should be a joint effort in collaboration with farmers, field agronomists and researchers. This collaborative step in defining the goals of the process increases the legitimacy of the process as farmer concerns are considered by other participants and are, hopefully, incorporated at the core of the project (Albicette et al., 2017). In practice, this success condition could be assessed asking whether there was a stage at the beginning of the co-creation process allowing farmers to raise their concerns about issues they had observed in their farms and were interested in tackling. Building up on the success condition just described, there should be a *participatory design of goals and desire for change* (SC-P6) which will allow participants to tackle the issue motivating the co-creation process. This condition refers to the involvement of farmers from the beginning of the co-creation process, where they take a role of co-designers when they are involved in tasks such as defining what should change in relation to their needs (Lacombe, Couix & Hazard, 2018). During this time, there should be consideration of farmer history in the field and their ideas for change based on their observations and experiential knowledge, in this way there is a higher chance of tailoring the process to their needs and expectations. This early involvement characterized by collaboration

between scientists and farmers increases the chances of the co-created knowledge to be relevant to the context and needs of both actors (i.e., co-created knowledge is salient), in addition to experimenting with new practices and adapting them to their context, hereby increasing capacity building (Lacombe et al., 2018). When observing this success condition in practice, attention should be paid to whether the goal setting and activity design tasks are jointly created between academic and non-academic actors.

Finally, contextual conditions in which the knowledge co-creation process is embedded should not only be considered at the initial stages of design, rather the project should allow *flexibility to incorporate lessons learned* and make adjustments throughout the duration of the project (SC-P7). In practice, a strategy to incorporate changes while the process is on-going is to keep minutes documenting the process results, as well as allowing participants to make suggestions in real-time about what they consider to be project strengths and weaknesses. Such close monitoring favour swift and effective modifications that will increase the quality of the project (Albicette et al., 2017). Furthermore, participatory processes which make adjustments based on lessons learned while the project is on-going inherently present a higher performance in capacity building (Albicette et al., 2017).

Pluralistic

This principle refers to who is allowed to participate, including academic, namely, scientific researchers from different disciplines, and non-academic actors such as government, local communities, and businesses, to create knowledge and initiate change. Considerations should be taken so that a broad range of skills and knowledge are represented in the group of participants. Such diversity is expected to generate a comprehensive understanding in terms of social, ecological, economic and technical aspects that the sustainability challenge entails (Tengö et al., 2017). To measure this principle in practice, the inclusion of actors from various sectors, disciplines, and regions should be assessed, as well as procedural justice examining the final use of actors' input throughout the process (Norström et al., 2020).

Selection of key actors should be based on three considerations (SC-P8), firstly, actors whose behaviour and beliefs would change with the co-created knowledge, so as to tackle the issue motivating the co-creation process. Secondly, actors with the know-how, meaning those who possess knowledge with the potential to be transformed into action or that already possess a set of skills relevant to the issue at hand should be included as this will increase capacity building

among participants (Clark, Tomich, et al., 2016). Finally, selection of participants should also include individuals who are directly or indirectly affected by the issue (Fernández González et al., 2021), for instance, consumers, farmers, communities in the region who deal with externalities of a particular crop. The selection task should not necessarily be taken by the organizing scientists, but rather by a sort of mediator who is able to map actors and incorporate them iteratively through a series of knowledge co-creation projects. When involving all actors whose behaviour would need to transition towards agroecological principles, the *salience* of the co-created knowledge is expected to increase. In practice, a clear and transparent selection of actors can be evidenced, for instance, through a comprehensive mapping of actors involved in the issue from which the co-creation project emerges (Clark, Tomich, et al., 2016).

Once the selection of actors is completed, *communicative competence should be established* (SC-P9) so as to ensure that input from actors is considered and used. Communicative competence is observed when participants skilfully use language to communicate and share understandings of the issue of concern and are able to make sense of each other's opinions (O'Connor et al., 2019). Equal communicative competence between academic and non-academic actors can be achieved through an inclusive dialogue which is necessary to foster understanding of all participant perspectives. This equality is also key for *legitimacy* of the co-creation process and acceptance of the produced knowledge (O'Connor et al., 2019). In practice, the fact that all participants are allowed and respected when sharing their knowledge and experiences will be considered as evidence of communicative competence.

Interactive

The interactive principle is concerned with the frequency and type of interactions experienced by the participants at all stages of the process. Including, for example, collaborative framing and designing of research agenda, or jointly carrying out research. Such an interaction enhances the possibility that the knowledge created is perceived as credible (i.e., scientifically robust), salient (i.e., pertinent to user requirements), and legitimate in terms of whether it is regarded as respectful and fair knowledge (Norström et al., 2020).

When describing interactions in a knowledge co-creation process, *effective communication* among partners is a goal in and on itself (SC-P10). As Méndez et al. (2017) argue, an expectation for transparency on decision making throughout the process, and the information resulting from it, should be agreed upon by all participants. Additionally, potential biases from

any participant should be acknowledged, and dissemination of the knowledge co-creation process results in multiple formats should be prioritized, as these will increase the accessibility of results and in turn increase the legitimacy of the process (Méndez et al., 2017). Making process results such as reports available in an understandable format, the *capacity building* ability of the co-creation process is enhanced, as such reports can provide useful information to participants after the activity has ended in this way prolonging both the learning process, and experimentation and adaptation of agroecological practices. An additional consideration to allow effective communication among knowledge co-creation process partakers is the need to clearly define methods, assumptions and limitations of the approach followed by the co-creation process (Posner et al., 2016). As well as increasing the capacity building ability, such considerations allow farmers to feel a closer relationship with the project organizers which strengthens their network and relationships (Méndez et al., 2017). When assessing this success condition in practice, any attempts from the organizers to discuss details of the process, to clarify interests from all partners and explicitly state how the information will be considered is present. Moreover, when information obtained in the co-creation process is published in different formats making it accessible to both academic and non-academic actors, then the success condition will be fulfilled.

Continuing with the characterization of interactions for a successful co-creation process, *collaboration and interaction should be sustained in time* (SC-P11). As Fernández González et al. (2021) argue, building relationships among knowledge co-creation participants is a process that develops over time and therefore, collaboration between academic and non-academic actors should be sustained in time. Particularly for farmers, such long interactions among participants results in relationships built in trust and increases cohesion among farmers (Orlando et al., 2020). Thus, increasing the chances of developing strong social networks. When observing this success condition in practice, attention should be paid to whether there are projects that extend for longer periods of time or that have different stages in which the same stakeholders are able to participate so as to prolong interaction.

Another crucial condition for interaction in successful co-creation processes is the construction of a *common vocabulary regarding agroecology* between scientists and farmers (SC-P12). This condition relates to actors being able to speak the same language (Orlando et al., 2020), which is evidenced when concepts are approached in an audience-tailored manner allowing diverse participants to understand each other and the issue that brings them together. For instance, researchers approaching farmers as peers, spending time in their farms and working towards

building a common vocabulary helps understand the importance of building researcher-farmer relationships based on respect and trust. Consequently, this contributes to enhance legitimacy of the co-creation process and increases the chances of social cohesion networks by facilitating dialogue and participation (Orlando et al., 2020). When observing this success condition in practice, efforts should be directed towards understanding where conceptions about biodiversity, ecosystems, agroecological practices or other related concepts differ among farmers and researchers, so as to subsequently reach a common understanding.

A condition which specifically addresses the qualifications of the co-creation process organizing team and which will play a key role both in planning and execution of activities is that *researchers are trained in transdisciplinary research* (SC-P13). Scholars argue that when researchers explore beyond their fields of expertise or disciplines they are able to find commonalities with other disciplines and in turn are more open to collaborate in transdisciplinary contexts (Fernández González et al., 2021). This provides researchers with the necessary tools and skills to approach other societal actors as peers which fosters an environment of openness and increases the legitimacy of the process (Clark, Van Kerkhoff, et al., 2016). In practice, this success condition is evidenced in whether researchers received training in transdisciplinary research, learning for example how to interact with actors from different backgrounds, for instance, academics from the natural and social sciences, and non-academics coming from different contexts namely public or private sectors.

Another key element of interaction among participants found in the review is the *collaborative decision of research priorities and execution of research* (SC-P14). Building up on the previously discussed condition of including all relevant actors to the issue motivating the co-creation process, this success condition highlights that decision on research priorities and execution should be based on a discussion and agreement among all participating actors (Mediterra, 2016). When delineating the research and then carrying it out in a collaborative manner, namely, actors are free to provide input by questioning all stages of the process from the design of the process and activities that will take place to the goals it aims at achieving, the interactions observed are expected to be greater in number and meaningful in terms of connecting scientific and practical knowledge (Henfrey, 2018). Hence when collaborations are fostered in an environment where all relevant voices are heard, legitimacy, credibility and salience of the created knowledge is more likely to occur as well as the development of social networks (Mediterra, 2016). Additionally, as learning interactions are enhanced under collaborative environments, the chances of developing skills among the actors involved which

will allow them to tackle the issue of concern are greater (Henfrey, 2018). In practice, this condition could be observed when participants take an active role in contributing to the development of research questions as well as data collection and analysis, and finally taking actions derived from the knowledge and practices created in the participatory process (Méndez et al., 2017).

When characterizing fruitful interaction among knowledge co-creation participants *experiential learning* (SC-P15) stands out. Taking an experiential approach to education means that teaching strategies are prepared around a set of specific skills that are to be learned by participants. Such strategies incentivize participants to reflect and discuss among themselves while actively participating in the activity (Moncure & Francis, 2011; Bezner Kerr et al., 2019). Strategies in experiential education are also called 'hands-on activities' and can be, for instance, scenario development for land-use management techniques (Márquez-García et al., 2018), or field studies and site measurements (Fernández González et al., 2021). Taking such an approach to education aims at training participants on certain abilities of interest, which in turn inspires the design and execution of activities, increasing the chances of building capacities among participants. Particularly for agroecology, these activities can help clarify abstract concepts such as ecosystem services, by building the co-creation process around activities like on-site visits to the field and observation of ecosystem services, or scenario development to examine connections between agricultural management practices and ecosystem services. Therefore, when activities similar to the aforementioned are present, then the success condition will be evidenced in practice. In line with experiential learning, *the trial and error* (SC-P16) feature of learning processes takes up a prominent role. Laforge & Levkoe (2018) argue that activities allowing farmers to work side by side experimenting and making mistakes helps them to adapt the knowledge and practices to their farm's context. Which is a crucial aspect of agroecology as was mentioned in the introductory chapter. This approach to learning increases their practical skills while at the same time fosters the development of support systems among farmers. Additionally, these authors in their study about farmer training on agroecology in Canada, highlight that farmers value trial and error learning experiences with their peers as this gives them more confidence about their skills and helps them make future decisions in their farms (Laforge & Levkoe, 2018). This success condition can be observed in practice when co-creation process activities involve an aspect of experimentation and trial and error with other farmers that will allow them to adapt the agroecological practices to their own farm conditions.

Finally, contributing to the achievement of co-creation processes academic and practical aims, the *methods chosen should further both ends* (SC-P17). Methodologies employed that are aligned with research aims of the co-creation project while at the same time focus on reaching practical objectives, in this case activities that aim at development of agroecological farming practices, contribute to reconcile and achieve synergies between academic and practical knowledge (Henfrey, 2018). Additionally, in achieving both types of aims, there is a higher chance that interests from all participants (academic and non-academic) are addressed and this increases farmer credibility in the work from researchers while, at the same time, it fosters the creation of relationships based in trust and networks among participants (Henfrey, 2018). To assess the condition in practice a researcher should ask whether research methods, contained for instance in the activities carried out by the co-creation process, lead to both answering research questions and training on the specific set of skills that the project aims at achieving.

4.1.2. Context mediating farmer participation in co-creation processes

Moving on to the second set of success conditions, the analytical framework on conditions that contribute to change farmers' behaviour towards agroecological farming, developed by Schoonhoven & Runhaar (2018) will be utilized to explore success conditions in terms of what motivates farmers to participate in knowledge co-creation processes. Although their work focused on adoption of agroecological farming practices, as argued in section 2.2, conditions mediating farmer behaviour towards agroecological farming, evidenced in their willingness to adopt such practices are considered relevant to also mediate their participation in co-creation processes to fulfil the same end. Schoonhoven & Runhaar (2018) identified a set of contextual conditions that either negatively or positively influence the adoption and implementation of agroecological farming practices. For instance, the presence of subsidies was found to positively contribute to changing farmer behaviour towards agroecological farming. On the other hand, a lack of community trust and support, and of finance and investment possibilities were found to have a negative contribution in agroecological behaviour. It is logical to think that such conditions may also positively or negatively contribute to farmer participation in co-creation, because if there are subsidies available for them to shift practices, then they may be more inclined to co-create practices and adapt them to their farm context through co-creation processes. While, if there is a lack of support in their community about agroecological farming, then they may be less inclined to stand out from their peers and participate in co-creation processes aiming at adoption of agroecological farming. This framework was chosen because

it is considered to represent an overview of aspects affecting farmers. This is because it results from a literature review leading to a framework encompassing economic, social, direct, and indirect conditions mediating farmer behaviour.

With the aim of finding conditions which would incentivize farmer participation, the conditions presented in the framework by Schoonhoven & Runhaar (2018) were slightly altered and rephrased so that when they are present, they positively influence farmers to take part in co-creation processes in the context of agroecology. For instance, from the original 'no market or limited demand for agroecological products', this Thesis will use 'sufficient market demand for agroecological products' as a success condition. Table 2 presents the selected SCs in the *context* mediating farmer participation in co-creation.

The remainder of this section presents an operationalization of the success conditions which will be required for the next step of the research. These are presented following a simple categorization developed for clarification purposes, the categories are: *knowledge of the agroecosystem, financial aspects, intrinsic motivation,* and *external pressures*.

Table 2. Proposed success conditions in the context influencing farmer participation in co-creation processes. Modified from the framework by Schoonhoven & Runhaar, 2018.

Category	Success condition
Knowledge of the agroecosystem	SC-C1: Good understanding of the ecosystem
	SC-C2: Farmers hold a certain level of skills and knowledge about agroecological practices
Financial aspects	SC-C3: Cost-benefit ratio is acceptable for farmers
	SC-C4: Availability of subsidies to implement new practices
	SC-C5: Availability of resources to invest in new practices
Intrinsic motivation	SC-C6: Values and norms motivate farmers to shift practices
	SC-C7: Felt responsibility to future generations
External pressures	SC-C8: Existing community of practitioners
	SC-C9: Peer pressure incentivizes a transition towards agroecological farming
	SC-C10: Sufficient market demand for agroecological products
	SC-C11: Favourable political context

Knowledge of the agroecosystem

Firstly, relating to the knowledge of the agroecosystem, *understanding of the ecosystem* (SC-C1) can be assessed in practice by inquiring whether there is clarity on the concepts of biodiversity, the interactions among species, and the provision of ecosystem services that derives from it. Furthermore, this condition entails whether farmers are aware of how specific

characteristics of the ecosystem are affected by their agricultural practices. Farmers might be more inclined to participate in co-creation projects aiming at increasing the adoption of agroecological farming practices when they hold a certain level of *skills and knowledge about agroecological farming* practices (SC-C2), illustrated in whether farmers know different types of agricultural practices and farming styles.

Financial aspects

In relation to financial aspects of farmers' context, there are three main aspects to be considered: cost-benefit ratio, subsidies, and finance and investment opportunities. First, *cost-benefit relationship of agroecological practices should be acceptable for farmers* (SC-C3). This means, for instance, that the benefits, either economic, social, or ecological benefits that can be translated into monetary terms, are perceived as sufficient in comparison to the costs of shifting agricultural practices in the farm. Second, *subsidies for implementing agroecological practices should be available to farmers* (SC-C4). This financial instrument can be offered by either national or regional government or private actors (Runhaar et al., 2017).Thus, when observing this condition in practice financial incentives offered by all these actors should be looked at. Third, farmers should have *availability of resources* to invest in adopting new, in this case agroecological, farming practices and to continue to do so over time (SC-C5).

Intrinsic motivation

Other potential success conditions arise from farmers' intrinsic motivation, for instance, their *values and norms which motivates them to change their practices* (SC-C6) and their sense of *responsibility for future generations* (SC-C7). Although both are closely related, the former can be assessed in practice when there is an intrinsic motivation of farmers (Runhaar et al., 2017) expressed, for instance, in their concern about preserving the landscape and biodiversity in the area where their farm is located. While the latter is evidenced when farmers feel a responsibility to preserve the living environment in the region so that future generations have access to and enjoy the benefits the ecosystem can provide.

External pressures

While the last two conditions referred to farmers' inherent motivation towards protecting the environment, the next few refer to various external inputs which favour agroecological behaviour, specifically involving the community and the broader socio-political context in which the farmer is embedded. First, there is an existing *community of practitioners* (SC-C8),

evidenced in the fact that farmers in the neighbouring lands or part of a network of farmers promote changes in conventional farming, hereby enhancing knowledge exchange and facilitating shifts in practices within their network. Second, this *community of practitioners pressures other farmers into transitioning towards agroecological farming* (SC-C9). This can be evidenced when farmers perceive that other farmers within their network start to change their agricultural practices to ecologically based ones. Third, is the need for a *sufficient market demand for agroecological products* (SC-C10), or in other words, consumers are interested in buying goods that have been produced through practices based on ecological principles, or in a broader sense that have been sustainably produced. In practice, farmers could be asked whether they perceive that consumer demand for sustainably produced goods is present, and if so, to what extent. Finally, the *political context should provide a favourable environment for the adoption of agroecological farming* (SC-C11). More specifically, this can be observed in practice when governments and NGOs exert pressure on producers to preserve biodiversity and adopt certain practices such as integrated pest management (Schoonhoven, 2017).

Table 3. Success conditions conceptual framework and indicators to assess conditions in the empirical case.

Success conditions	Indicators
In the knowledge co-creation *process*	
SC-P1: Awareness on knowledge governance	Project participants are aware of how knowledge and practices created during the process will be recognized and shared
SC-P2: Matching farmer and researcher needs and wills	The co-creation project is based on common interests from academic and non-academic actors
SC-P3: Availability of sufficient resources to sustain long-term collaborations	Institutional funding is available to allow the co-creation process to continue for an extended period of time
SC-P4: Connection between proposed activities and existing ones	Activities present a certain level of connection or continuation of existing activities farms are engaged with
SC-P5: Project is oriented towards addressing existing problems of farmers	Acknowledge farmers' concerns about issues they experience in their farms and want to tackle
SC-P6: Participatory design of goals and desire for change	Goal setting and activity design tasks are taken by both academic and non-academic actors
SC-P7: Allow flexibility to incorporate lessons learned and to make adjustments throughout the project	Presence of adjustments made throughout the process as a result from learning experiences from the process itself
SC-P8: Selection of actors based on whose behaviour or beliefs need to change, those with the know-how, and those who would be directly or indirectly affected by the issue	There is a mapping of actors in the productive sector to determine whose behaviour need to change, who would be (in)directly affected and who has the know-how
SC-P9: Establishment of communicative competence (e.g., communicating science in a relevant and accessible way to non-specialists)	Participants are able to share their knowledge and experiences
SC-P10: Effective communication	Information obtained in the co-creation process is published in different formats making it accessible to both academic and non-academic actors
SC-P11: Collaboration and interaction should be sustained in time	Projects extend for long periods of time or have different stages involving the same stakeholders
SC-P12: Construction of a common vocabulary regarding agroecology	Efforts to understand where conceptions of biodiversity differed between farmers and researchers
SC-P13: Researchers are trained in transdisciplinary research	Researchers receive training in how to interact and communicate with other non-academic actors
SC-P14: Collaborative decision of research priorities and execution of research	Are participants allowed an opinion when defining research priorities
SC-P15: Experiential learning should be core to the project	Presence of hands-on activities
SC-P16: Learning processes should be through trial and error together with other farmers	Farmers are allowed trial and error opportunities to learn with other farmers
SC-P17: Choosing methods that simultaneously further both academic and practical aims.	Research methods aim at answering research questions posed by researchers as well as achieving the development of specific skills

In the *context*	
SC-C1: Good understanding of the ecosystem	Clarity on the concepts of biodiversity and ecosystem services
SC-C2: Farmers hold a certain level of skills and knowledge about agroecological practices	farmers know different types of agricultural practices and farming styles
SC-C3: Cost-benefit ratio is acceptable for farmers	economic, social, or ecological benefits that can be translated into monetary terms, are perceived as sufficient in comparison to the costs of shifting management practices in the farm
SC-C4: Availability of subsidies to implement new practices	financial instrument can be offered by either national or regional government or private actors
SC-C5: Availability of resources to invest in new practices	Farmers are able to invest in new practices
SC-C6: Values and norms motivate farmers to shift practices	Intrinsic motivation of farmers
SC-C7: Felt responsibility to future generations	Desire to preserve the environment in optimal conditions for future generations
SC-C8: Existing community of practitioners	Other farmers are changing their agricultural practices
SC-C9: Peer pressure incentivizes a transition towards agroecological farming	The community of practitioners incentivizes a shift towards agroecological farming
SC-C10: Sufficient market demand for agroecological products	Presence of consumer demand for agroecological products/sustainably produced goods
SC-C11: Favourable political context	Governments, NGOs, or other social groups exert pressure favouring agroecological farming

4.2. Empirical case analysis

This section aims at answering sub-question 3 (*What success conditions are present in knowledge co-creation project performed by the Wine Climate Change and Biodiversity Program and Chilean wineries and what conclusions can be derived for other cases?)* by using the WCCB-JNCC project as a first test and for further refinement of the *success conditions* conceptual framework, for instance, by providing insights about relative importance of SCs or adding new ones arising from the experience with this empirical case. The section begins with additional details on the case and the co-creation processes it entailed. Then the findings are presented in the same order as previous sections, namely, analysis of the first set of success conditions or those in the knowledge co-creation process, followed by analysis of the second set of success conditions or those in farmer's context which influence their participation in co-creation processes. The tentative assessment of the SCs framework is based on the operationalization of SCs developed in the previous chapter, a summary of the conditions and their indicators is presented in Table 3.

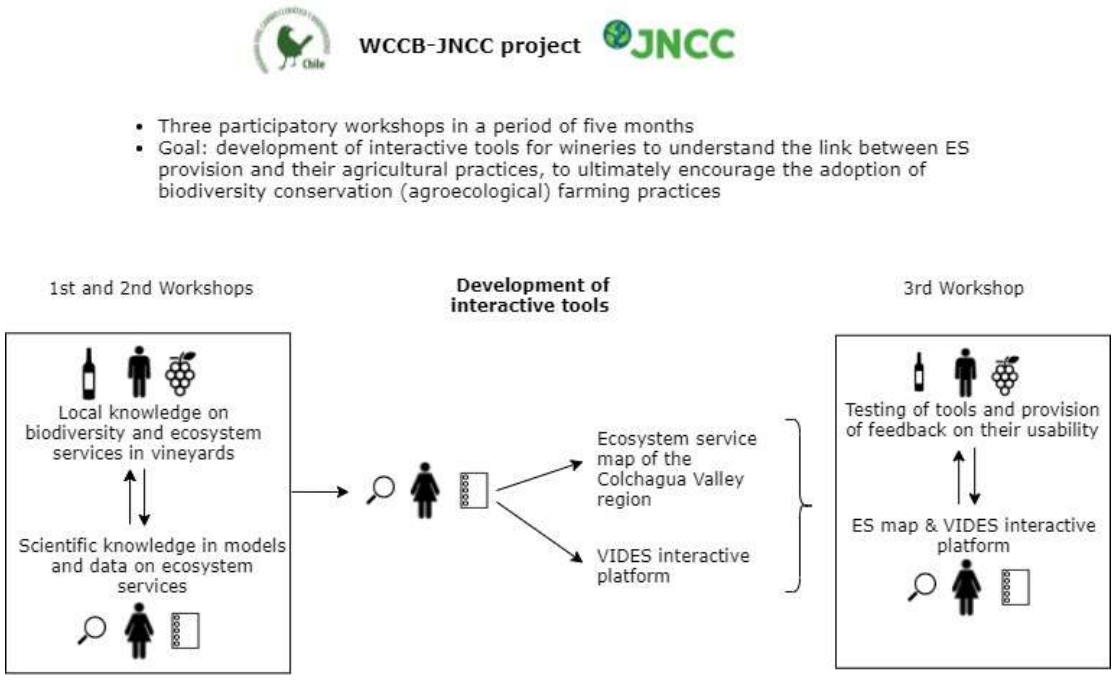

Figure 8. WCCB-JNCC project.

The WCCB-JNCC project builds upon previous participatory workshops[5] as part of an educational and research initiative in which the WCCB collaborated with wine producers to identify key ecosystem services playing a key role in wine production (Harris et al., 2019; Márquez-García et al., 2018). In these collaborations, Chilean wineries have identified 'prevention of fire', 'water supply regulation', and 'natural biocontrol of pest species' as key ecosystem services for wine production (Harrison et al., 2019). Ecosystem service (ES) knowledge provided by scientists during the WWCB-JNCC project as well as that co-created in previous WCCB workshops can inform agricultural management practices in vineyards. For example, by maintaining a balanced plant population rich in native perennial trees species (e.g., Acacia caven) which help retain humidity and contribute to a lower temperature, wildfire risk can be reduced (CONAF, 2018; Harrison et al., 2019). This practice together with reducing the amount of wildfire prone species which are mainly highly flammable non-native plants (e.g., *Pinus radiata* or *Eucalyptus* spp.) (Barbosa & Godoy, 2014), while at the same time adopting the agroecological practice of including cattle grazing in vineyards to maintain an appropriate grass length, also reduces wildfire risk.

In the case of the WCCB-JNCC project, knowledge co-creation processes prove useful for the wine productive sector by transforming ES knowledge into agricultural practices which help protect biodiversity and deliver benefits for wine producers and their business. In this way motivating the adoption of agroecological farming practices, and hereby, advancing agroecology in the Colchagua Valley region.

The three co-creation processes entailed in the WCCB-JNCC project were carried out in a period of five months in 2019 and were organized and guided by the WCCB researcher team. As mentioned before, the project yielded two different interactive tools. First an ecosystem service map of the Colchagua Valley, and second, the VIDES (Viticulture ImplemeNting Ecosystem Services) interactive platform which links effects on ecosystem service provision as a result of wineries' agricultural practices (see Figure 8) (Harrison et al., 2019). The first two co-creation processes involved the integration of producer experiential knowledge on ecosystem services in their fields (information resulting from previous work together with WCCB), which was used and combined with scientific knowledge to develop the tools. While the third one focused on using the finished tools to test their usefulness and applicability.

[5] For the purposes of this Thesis and because participatory workshops are based on interaction between knowledge systems and different sets of actors, they will be considered as knowledge co-creation processes.

As mentioned above, the WCCB-JNCC project builds upon co-created knowledge from the WCCB previous work, therefore, when deemed necessary, the analysis showed in this section will refer back to those previous collaborations.

4.2.1. Knowledge co-creation process

This sub-section presents the analysis of how the SCs in the process manifest themselves in the WCCB-JNCC project and it includes all three co-creation processes entailed by the project. The aim of this analysis was to understand how the SCs present themselves in a co-creation empirical case and thus serve as input to refine the SCs framework, rather than presenting an exhaustive analysis of the case itself. The assessment itself was based on how the participating researchers experienced the SCs as well as insights from descriptions of the co-creation processes in WCCB-JNCC project documents and minutes. These were analysed based following the indicators summarized in Table 3.

The analysis of SCs is presented following the four principles of knowledge co-creation categorization as introduced in the theory chapter of this paper (section 2.2). Each principle includes the analysis of a group of success conditions, and it ends with an overall conclusion of the conditions entailed in the principle.

Context-based principle

In relation to *awareness of knowledge governance* (SC-P1), project participants are aware of how knowledge and practices created during the process will be shared with them when the activities are finalized. While regarding *matching farmer and researcher needs* (SC-P2), for this project there was a scientific interest from the WCCB and JNCC group of researchers to map ecosystem services in the Chilean Mediterranean region, this was presented to producers as an interesting outcome for them as in the end they would be able to make use of the ES map and VIDES platform linking ecosystem service provision with agricultural practices. Therefore, for this particular project the need was presented to farmers instead of it arising from them. However, in most of the previous workshops both parties, academic and non-academic, usually come to an agreement as to what is needed. On the one hand, producers are interested in a certain challenge they observe in their farms such as inability to deal with a particular pest without increasing artificial pesticide use. While researchers have a scientific interest in observing native species diversity and how these interact with each other, in this way, interests from both actors are aligned and co-creation of knowledge and practices is fostered.

Continuing with the *availability of resources to sustain long term collaborations* (SC-P3), resources were available to perform the three knowledge co-creation projects which were held over a period of five months. Nevertheless, for the collaborations held between the WCCB researcher team and its partner wineries, funding is difficult to find. Interviewees reported that sometimes funding comes entirely from the public funds that WCCB is awarded as part of the Chilean Research Institute for Ecology and Biodiversity, while other times the costs are shared with partner wineries. They further expressed that such struggle in the search for longer term funding can have negative consequences for their work evidenced, for instance, by impeding further research on agroecological practices which wineries could adapt to their farm context through additional participatory processes.

Finally, there is a clear *connection between previous activities and practices* producers engaged with in the past (SC-P4), as a result of previous collaborations with WCCB such as quantification of species and ecosystem services at farm level, and the ecosystem mapping project jointly developed with JNCC (Harrison et al., 2019; VCCB & JNCC, 2019). Additionally, each of the three workshops entailed in the WCCB-JNCC project served as input for the next as they were designed to build on the results of the previous one and on the additional data analysis that took place between workshops. Therefore, connection between previous and proposed activities could also be observed in consecutive co-creation processes.

Overall, the different conditions observed within the context-based principle point out that there is a consideration on the social, economic, and ecological context from which the process emerges. Social context is evidenced, for instance, by the shared understanding on how co-created knowledge will be shared with all participants, hereby actually considering the different backgrounds and expertise of participating actors. When considering whether sufficient funding is available to carry out the co-creation project, which was the case in this analysis, then the economic context from which the project emerges is considered. Finally, there is also a clear understanding on the ecological context, given that there is an alignment of both scientific and wineries' needs concerning agricultural practices and their effects on biodiversity and ecosystem services.

Goal-oriented principle

Regarding the *consideration of existing farmer problems when designing the co-creation project* (SC-P5), wineries representatives had previously showed interest in knowing how their agricultural practices affect the local environment, more specifically the ecosystem services they had identified in previous collaborations with WCCB. They wanted to learn, for instance, how soil treatment and nutrient enrichment of soil practices affected the ecosystem services of biodiversity, water supply and quality, natural control of pest species, so that they are able to experiment with new practices that would prolong the provision of those services. Nonetheless, while the project was oriented towards farmers' existing concerns, and designed accordingly, only the WCCB and JNCC researcher team were involved in setting the goals for this project (*participatory design of goals and desire for change*, SC-P6) receiving no input from non-academic participants. Although one interviewee from WCCB emphasized that based on their decade long relationship, the WCCB researcher team holds a fair knowledge about their partner wineries' needs, concerns and preferences, and thus made efforts to include them in the goal setting process.

When assessing the *flexibility to incorporate lessons learned throughout the process* (SC-P7), WCCB asked an external company to audit the work done in the three participatory workshops and with the results of the auditing they attempt to make changes based on the lessons learned for future projects. However, no changes were incorporated while the project was on-going and since the three workshops entailed different activities and aimed at different goals, lessons learned in one could not immediately inform changes for the next one. Nevertheless, researchers mentioned that in the co-creation processes they have carried out over the years lessons learned in one workshop usually serve as input for decisions on modifications such as implementation of new strategies in future workshops.

Together the SCs analysed in this principle provide insights into how co-creation processes show they are goal-oriented, for instance, by keeping in mind existing issues wineries want to tackle, or also by including wineries representatives into process goal setting instead of it being a task taken only by academic participants. This participatory goal setting might not always be evidenced by direct collaboration, but rather is based on previous work relationships and knowledge one party has on other participants, as shown in this case. Finally, the conditions observed here highlight the importance of constant reflection and learning while carrying out

a project, and also between projects, with the latter being a more common practice as far as the empirical case is concerned.

Pluralistic principle

Regarding the *three considerations for actor selection* (SC-P8), this project involved actors from wineries and ecology of ecosystems researchers, but excluded actors from the public sector, namely local government and other policy-making actors, and civil society such as local communities (Harris et al., 2019; Harrison et al., 2019; VCCB & JNCC, 2019). As reported by the interviewed researchers, this decision was based on two main reasons. First, the aim of the WCCB program is to encourage a shift in agricultural practices in the wine productive sector towards ecosystem-based practices that contribute to biodiversity conservation and protection of ecosystem service provision. Therefore, wineries, as the action taking actors, are the most important actor to be included in these co-creation processes. Second, actors from partner wineries had previously worked with WCCB to identify ecosystem services in their own fields, hence they possess the experiential knowledge which served as input to the interactive tools development (see Figure 8). Thus, as holders of the know-how, they were required to fulfil the purposes of the WCCB-JNNC project while other types of actors such as local communities and public sector actors, would not have been able to provide this input and were therefore not required to participate.

Although not all relevant actors, as suggested by SC-P8, were included in this project, there seems to be equal *communicative competence* (SC-P9) between the researcher team and their non-academic participants. Evidenced in that agricultural managers were enabled to share knowledge based on their experiences from the farm which were highly regarded and served as input for the interactive tool development. Furthermore, at a later stage, particularly in the third workshop, they were able to test the VIDES platform and provided feedback on the extent to which the platform was understandable, applicable to their needs, and useful. Proving once more that their input was considered by their academic counterparts.

The conditions in the pluralistic principle suggest that several considerations need to be made when selecting actors to take part in co-creation processes, these vary from including holders of the know-how, to those who are indirectly affected by the issue at hand. However, the experience with the case suggests that selection of relevant actors should also be shaped by the goals of the process because, for some cases, actors who would not be able to provide the necessary input to reach the goals of the process and thus should not be included in it.

Furthermore, the conditions in these principles also highlight that academic and non-academic participants should communicate in a clear and respectful manner to allow an understanding of all participants perspectives and ideas.

Interactive principle

As presented in an evaluation survey from process participants and as stated by the interviewees, researchers were transparent about what the process would entail and made an effort to make sure to explain all the steps and agree on them with their non-academic participants (VCCB & JNCC, 2019). Moreover, evidencing *effective communication* (SC-P10), how information would be shared with participants was specified at an early stage of the process. In this case, reports and the interactive platform that would result from the co-creation process were explained to agricultural managers from the beginning so they knew what would result from their joint work.

Regarding *collaboration and interaction sustained in time* (SC-P11), most participants were present for the full duration of the project, only small variations were experienced when for one workshop a different actor from the same winery would join instead of the one that joined the time before. This meant that for the most part participants were the same and they collaborated for this full period in three consecutive workshops (see Figure 8). This period of time is relatively short when compared to most co-creation projects reviewed in the literature from the previous steps of this Thesis (see e.g., Orlando et al., 2020). However, it is important to consider that collaboration between partner wineries and WCCB has been sustained for around a decade and most participants both academic and non-academic had worked together on several occasions over the years.

In relation to *training in transdisciplinary research* (SC-P13), previous to this project, the WCCB researcher team had gone through some training programs over the years, these included lessons on how to deliver a message effectively and in a clear way to different audiences. Additionally, they had also attended courses to help them facilitate discussion in group working sessions. Respondents mentioned that this training allowed them to develop skills to communicate expert scientific knowledge to their non-academic partners from wineries. This is evidenced in the fact that they have been able to *construct a common vocabulary between scientific and non-scientific actors* (SC-P12). The interviewed researchers argued that the abstract concept of ecosystem services was discussed throughout the workshops

and that they could follow producers' learning process when utilizing the concept at various points in the workshops as well as later when analysing the usability of the interactive platform.

Moving on to the *collaborative decision on research priorities and execution of the research* (SC-P14), research priorities for this project were defined by the WCCB and JNCC researcher team. However, when asked about this lack of inclusion of producers in this stage of the co-creation process, one respondent argued that in this process there was a consideration on their perception of producer needs. In her opinion, this could be done based on the level of knowledge that the WCCB team has on their partner wineries, and this practice would be accepted by producers as they have a relationship of trust and respect developed over the years.

Concerning *experiential learning* (SC-P15), the first two workshops (see Figure 8) were oriented towards mapping ecosystem services in the Colchagua Valley, for which producers provided information about their own farms obtained in previous participatory workshops with WCCB. In this case there were 'hands-on' activities such as visits to the field and active identification of animal and plant species. However, they preceded the project this Thesis is concerned with. Nevertheless, the final workshop was purely 'hands-on' and consisted in utilizing the Ecosystem services map and the VIDES platform. In this final workshop producers were divided in discussion groups in which they had to reflect on the applicability of the tools and then give an oral presentation on how the tool could be applied to inform decision making in the farm (VCCB & JNCC, 2019). Closely linked with these hands-on activities, the last workshop was characterized by *presence of trial and error activities* (SC-P16). More specifically, the ecosystem service map and VIDES platform were presented to producers for them to work together to explore the tools, understand their functioning and test their applicability.

Finally, when inquiring about whether the *methods chosen further both academic and practical aims* (SC-P17), these were found to be varied, ranging from a specific modelling strategy informed by producers' experiential knowledge to participatory activities allowing participants to test the end result from the modelling stage. These methods, although applied at different stages of the project, advanced academic knowledge on evidence-based integrated management of water, land, and living resources to promote biodiversity conservation and sustainable use of resources. While at the same time, the interactive tools derived from the process have the potential to directly inform producers on what agricultural practices to apply and their

consequences. In this way facilitating decision-making that will contribute to biological diversity conservation in this productive sector, therefore also fulfilling practical aims.

Together the SCs presented here illustrate that interaction in a knowledge co-creation process is a complex quality, encompassing several aspects of communication, time during which participants interact, skills of academic actors in relation to transdisciplinary research, and the approaches and methodologies chosen for achieving process aims.

4.2.2. Context influencing farmer participation in co-creation

A total of five individuals representing wine producers in the Colchagua Valley were interviewed. They belong to four of the eleven wineries which participated in the WCCB-JNCC co-creation project. Their role within the winery is that of 'agricultural manager', which means that they are responsible for all decisions concerning farming practices in the field while at the same time they are relatively close to higher decision-making actors in the company and can therefore raise concerns and propose changes in agricultural practices the vineyard will engage with.

The section aims at describing how the success conditions in the *context* manifest themselves in the empirical case. For this purpose, agricultural managers will take on the role of farmers when assessing the conditions. The intention is far from saying that they are the same, but just for practicality purposes because, in the case of wineries, agricultural managers take an active role in encouraging and deciding to shift agricultural practices, and therefore, resemble the role of farmers in relation to agroecological farming. To present the analysis in a structured manner, the SCs are displayed following the categorization from section 4.1.2., namely 'knowledge of the agroecosystem', 'financial aspects', 'intrinsic motivation', and 'external pressures'.

Knowledge of the agroecosystem

To explore the *good understanding of the ecosystem* (SC-C1), agricultural managers were consulted about their knowledge on the concepts of biodiversity and ecosystem services as presented in Table 2. For this condition, interviewees described their knowledge to be rather high. More specifically, for biodiversity they stated that they understand what biodiversity means, that they possess knowledge on a variety of species and the interactions responsible for the provision of ecosystem services. While for ecosystem services, respondents considered their knowledge to be close to the following statement: "I understand what ecosystem services are and I can name a few present in my agroecosystem that are useful for wine production". Nevertheless, interviewees reported that this thorough knowledge was a result of their

participation in various knowledge co-creation processes with WCCB. This suggests that perhaps the lack of understanding of the ecosystem might actually be the SC instead of having a good understanding of the ecosystem. Since as observed in the case, agricultural managers did not hold this knowledge, or it was very limited, previous to their participation in the co-creation project. While when inquiring about whether farmers *hold a certain level of skills and knowledge about agroecological practices* (SC-C2), agricultural managers reported that they had some knowledge on organic farming techniques but that it was very limited.

Figure 9. Agroecological farming practices adopted by Cono Sur vineyards and winery. A; Geese walking through a biological corridor; B: Native species nursery; C: Biological pest control by including native species between vines. Sources: Arnaldo Rodriguez, Cono Sur; Cono Sur (Cono Sur, 2019).

Financial aspects

Some agroecological farming practices implemented by this group of wine producers are biological corridors and biological pest management (see Figure 9 for pictures). The former are native species-rich areas placed between rows of grapevines which contribute to connecting isolated vegetation patches, in this way allowing a flux of plant and animal species in a habitat that has been altered by human activity. While the latter focuses on maintaining a stable population of pest natural enemies this way providing a pesticide-free management of unwanted species which can damage crops (Barbosa & Godoy, 2014). Respondents seem to be divided when it comes to the *cost-benefit ratio* (SC-C3) of these agroecological farming practices, namely, some describe the investments to be so low that they can just implement these practices and will almost immediately see positive effects in the fields and therefore high benefits. While others argue that the cost-benefit is not so favourable for them because

investments, and the potential losses if the practice does not manage to regulate pests, are not well compensated by the benefits as their costumers might not be willing to pay a 'high enough' price for a product that was made through agroecological practices. The second aspect in this category is the *availability of subsidies for producers to implement new farming practices* (SC-C4) different from conventional agriculture. In this regard, all interviewees reported that funding has always come exclusively from the winery, as there are no public funds specifically for implementation of farming practices different than conventional. Public funding aiming at sustainability in the agricultural sector is rather focused on energy efficiency (Biggs et al., 2017). Continuing with the third aspect, *availability of resources to invest in new practices* (SC-C5), most respondents agreed on that their companies are aware that investments and innovations in farming practices they have engaged with thus far, are just the beginning of a transformation process. Agricultural managers believe that biological corridors will be expanded by including additional species, and that several changes need to be made to continue to improve and shift towards the 'better way of doing things', as they call it, to protect the environment in the region. They further expressed that their companies are willing to continue investing to gradually improve the practices already in place, and to include new ones. Although this was the case for most respondents, one argued that investments will only continue as far as to comply with sustainably produced wine certifications, as he considers the winery's main interest to change practices to be the sustainability certifications they seek to comply with.

Intrinsic motivation

As far as the *values and norms motivate farmers to shift practices* (SC-C6) is concerned, agricultural managers agreed in that they want to 'do things right', for them this means to produce wine in the least harmful way possible and if they can protect the environment while doing it then it is even better. They referred to the need to protect the landscape, trees, birds, and water supply. However, no particular mention was made towards protecting these assets as part of a *feeling of responsibility to future generations* (SC-C7). Some showed strong convictions towards taking action in terms of adopting agroecological farming. They mentioned that they can see how crops damage the landscape and that this motivates them to take an active role in protecting species in the field and its surroundings. These enthusiastic agricultural managers argued that they try to share these views with their colleagues to motivate them to do their jobs in an environment-conscious manner.

External pressures

Regarding an *existing community of practitioners* (SC-C8), respondents mentioned that several other wineries in the Colchagua Valley were implementing agroecological farming practices at least to some extent, the most frequently mentioned ones were natural pest control and the implementation of biological corridors. Interviewees referred to this peer behaviour as a motivation to try new things and for smaller companies to explore new market niches. Particularly, following the logic of 'it worked for them, it could work for us', and it will allow us an opportunity to enter the organic wine or sustainably producer wine market which could potentially increase profits for the company. In this way, highlighting the role of *peer pressure incentivizing a transition towards agroecological farming* (SC-C9). Regarding a *sufficient market demand for agroecological products* (SC-C10), or in this case organic or sustainably produced wine, has been increasing according to interviewees. On the other hand, national demand for organic wine is not so prominent and according to these wineries, Chilean consumers are not willing to pay a higher price for a bottle of organic wine. Although they expect this trend to shift in the next few years as younger consumers have a different mentality as they put it when it comes to choosing the products they buy and their impact on the environment. Finally, when exploring whether there is a *favourable political context* (SC-C-11), respondents reported that there is virtually no interest from the national or local government in changing agricultural practices, as they have not been approached by any of these public bodies to discuss practices nor have, they received any directives to change their farming practices. This was also confirmed through document analysis on Chilean policies in the context of sustainability, which demonstrate that the focus is mainly on energy efficiency and in preserving genetic diversity of crops (Biggs et al., 2017; ODEPA, n.d.). Furthermore, they have not been contacted by NGOs, social movements, or local communities wanting to share concern about the impacts of their farming practices on biodiversity and local ecosystems. Interestingly, they report that the only actors that have approached them to discuss these concerns and to find potential solutions together is the Wine, Climate Change and Biodiversity program from the Chilean Institute of Ecology and Biodiversity.

5. Conclusion and discussion

This study aimed at answering the following research question: *What are the success conditions in knowledge co-creation processes that facilitate the adoption of agroecological farming, and how can these be assessed in practice?* To answer this question several steps were carried out.

Firstly, a conceptualization of successful co-creation in agroecology was defined based on what kind of outputs the process should yield to facilitate the adoption of agroecological farming practices. Secondly, by means of a review of the literature on knowledge co-creation in the context of agroecology, and on agroecology, two sets of success conditions were selected, and operationalized. The first one concerns conditions in the co-creation process itself, which are theoretically expected to lead to the achievement of the three agroecology-relevant outputs, namely, co-created knowledge and practices meets *credibility*, *salience* and *legitimacy* criteria, development of *social networks*, and *capacity building*. These outputs will in turn facilitate the adoption of agroecological farming practices. The second set of conditions focuses on the context motivating farmer participation in co-creation processes. This with the purpose of ensuring engagement in co-creation processes of those actors who are the action takers in terms of adoption of agroecological practices. These two sets constituted the SCs conceptual framework proposed by this Thesis. Thirdly, an empirical case of co-creation between researchers and agricultural managers from Chilean wineries was used to tentatively assess the conditions and conclusions were derived to refine the framework.

The development of this framework and the approximation for assessing the conditions in practice (operationalization) offer an answer to the research question, by providing a set of SCs for co-creation processes which, in theory, facilitate the adoption of agroecological farming practices and therefore contribute to the study of co-creation as a means to advance agroecology. As mentioned before, the idea was not to empirically test the link between SCs and process outputs leading to adoption of agroecological farming, but rather to use this theoretical link to find conditions which so far have not been brought together in a framework like the one presented here. Although a refined framework is provided, further refinement and even tailoring to other co-creation contexts is desirable. Nevertheless, having a first SCs framework for co-creation processes in the context of agroecology proved helpful to raise awareness to practitioners on considerations which will potentially make their future co-creation projects successful.

This chapter will continue by elaborating on insights derived from the development of the SCs framework, the empirical case analysis and proposes a refinement of the framework. Additionally, this section includes reflections on the limitations of the research and recommendations for practitioners and further research.

Usefulness of the framework and contributions to the literature

The analysis shown in the previous section aimed at testing the SCs framework. Overall, the usability of the framework was proven in that it allowed a preliminary assessment of the conditions by illustrating how they manifest themselves in an empirical case of knowledge co-creation. While the empirical case proved useful to provide feedback and input for a refinement of the framework, for instance, it yielded considerations for SC assessment in practice and added new ones which will at least be useful for the WCCB program and the co-creation projects they engage with in the future. Details on the refinement of the framework will follow in the next sub-section.

Along with the practical usefulness of the framework, interesting contributions are made to the literature on co-creation processes for agroecology. Firstly, some success conditions found here are not entirely new to the knowledge co-creation literature, such as a *wide coalition of actors* and *availability of resources* (Hegger et al., 2012). However, the ones presented here are tailored for co-creation in the context of agroecology in that they aim at achieving the three agroecology-relevant process outputs which will then lead to the adoption of agroecological farming practices, or outcome (see section 2.1). While the previously described ones only focus on achieving the first output. By finding SCs which lead to these outputs, this Thesis then provided a logical and theoretically based sequence of events linking SCs to adoption of agroecological farming.

Previous research observed empirical cases of co-creation and assessed the first output and its causal relationship to the outcome in terms of adoption of agroecological farming (Bello Cartagena, 2019). Although assessing outputs in the empirical case was out of the scope of this Thesis, insights from interviewees suggest that the three agroecology-relevant outputs were present when expanding the scope to previous collaborations between wineries and the WCCB team. Additionally, wineries have adopted agroecological farming practices such as those mentioned in section 4.2.2, as a result of their collaborations with WCCB (Márquez-García et al., 2019). These insights suggest that when expanding the unit of analysis to including previous work of WCCB and its partner wineries, the argument of this Thesis is supported in that

achieving the three agroecology-relevant outputs leads to the adoption of agroecological farming practices.

Refinement of *success conditions* framework

Interesting contributions to the literature on participatory processes for agroecology arise from the development of the SCs framework and its refinement. Regarding *success conditions in the knowledge co-creation process*, two success conditions could be added to deal with barriers faced by the WCCB researcher team. Firstly, as some of the interviewees highlighted there is a need to include a higher variety of expertise within the organizing team as they have faced challenges related to a lack of expertise in certain fields such as modelling, and communication to non-academic audiences. In this sense, as well as selecting a variety of relevant actors, as proposed by SC-P8, considerations should be made in selecting and including the appropriate variety of expertise from the academic-actors side. Hereby ensuring that all the required skills to carry out the co-creation project smoothly, are covered. Secondly, researchers reported that communication and coordination among team members was not optimal which caused delay in several co-creation projects. To address this struggle, the research program could develop structured communication channels and protocols as to optimize communication among their team members. Although this aspect was not touched upon in the reviewed literature, it can nevertheless constitute a success condition for knowledge co-creation processes in agroecology as it was derived from this empirical case analysis.

Moving on now to consider *success conditions in the context*, the proposed success conditions were mainly supported by the empirical case analysis, except for a few conditions which suggest an opposite effect, namely, the absence of the SC motivated agricultural managers' participation in co-creation. The first exception relates to having a *good understanding of the ecosystem* (SC-C1) and *holding a certain level of skills and knowledge about agroecological farming* (SC-C2). These conditions were expected to encourage agroecological behaviour and to motivate farmer participation in co-creation projects. However, interviews showed the need to gain knowledge in this topic was what encouraged agricultural managers to engage in co-creation projects as evidenced by their lack of knowledge previous to working with WCCB. Thus, when an understanding of the ecosystem as well as skills and knowledge about agroecological farming are absent, it is more likely that farmers will be motivated to participate in knowledge co-creation processes. A similar pattern was observed in SC-C4, *availability of subsidies for implementing agroecological farming practices*. This was evident because

Chilean wineries are exempt of subsidies to improve agricultural practices and shift to agroecological farming. Therefore, in this case the lack of public funding encouraged producers to seek support from scientists to explore solutions that would help them tackle issues they face on their farms. Hence, absence of subsidies for farmers to shift their practices can be considered as a condition to motivate farmer participation in co-creation projects. These reflections suggest that conditions mediating farmer behaviour towards adoption of agroecological farming, might differ slightly from those motivating farmer participation in co-creation, and not be the same as was assumed earlier (section 4.2). Or may also suggest that some conditions have a more prominent effect in motivating farmer participation, for instance, absence of *skills and knowledge about agroecological farming* is more relevant than the *availability of subsidies to implement agroecological practices.* Finally, one additional factor which was highlighted by a few interviewees is the presence of highly motivated individuals within the winery. Respondents mentioned that a couple of people in their companies were the ones pushing for change, communicating with external agents such as the WCCB researcher team and decision-making roles in the company to mobilize resources and invest in agroecological farming practices. In this sense, 'environmental leaders' or highly motivated individuals (Márquez-García et al., 2019) can be key to drive change within wineries, for instance, by motivating wine producers' participation in co-creation processes to enhance the adoption of agroecological farming practices. Thus, this could also be considered as a success condition which would incentivize participation in co-creation from actors in productive sectors.

Limitations of the research

This sub-section reflects on limitations of the research methods. Firstly, it was impossible to avoid researcher bias in the literature review on participatory processes in agroecology and the selection of success conditions. However, a set of specific combination of search terms as well as inclusion and exclusion criteria (see section 3.2.) were thought of to reduce this bias as much as possible.

Secondly, the empirical case of co-creation between the WCCB research program in collaboration with JNCC and Chilean wineries is not intended as a representative case of co-creation projects in the context of agroecology. Rather it aimed at illustrating how a set of SCs found in the literature manifest themselves in practice, and at providing feedback to help refine the SCs framework for retrospective evaluation of projects or design of future projects. Additionally, it provided interesting insights about how different productive sectors face the adoption of agroecological farming practices. More specifically, in the Chilean wine productive

sector several hierarchical levels are observed within one winery, which for this case tended to limit action regarding adoption of agroecological farming as those participating in co-creation project were not the ultimate decision-makers and reaching the latter was rather difficult for them. These hierarchies might also be present in other productive sectors and in large agrobusinesses therefore they might share some of the limitations faced by Chilean wineries. Whereas this might not be the case for smaller producers as the decision of shifting practices might rely directly on farmers and therefore is not limited by higher decision-making levels.

Recommendations for practitioners and further research

The main recommendation for practitioners is related to analyses of their own co-creation projects for future improvements. The SCs framework can be particularly useful for practitioners engaging in farmer-researcher co-creation processes aiming at enhancing the adoption of agroecological farming. More specifically, when assessing the presence of the conditions in their previous projects, practitioners should consider developing a detailed operationalization of the conditions. One that is tailored to their contexts and productive sector because the one presented here is a first approximation to assessment and may therefore be considered as general. Furthermore, the SCs framework can also be used by practitioners as guidelines of good practices to design their co-creation projects in a way that will meet the SCs and will thus have higher chances to be successful in terms of adoption of agroecological farming practices.

Finally, three directions are proposed for further research. First, focus on tailoring the framework and its operationalization to cases pertaining other productive sectors. This could contribute to further refinement of the framework, by incorporating new SCs emerging from observations on barriers faced by farmers or scientists in other contexts. Second, development of detailed operationalization of SCs would allow a thorough assessment of the conditions and therefore add to the evaluation of co-creation projects, enhancing its usefulness for practitioners. Finally, the agroecology-relevant outputs and actual adoption of practices could be empirically tested to support the theoretical assumption central to this study.

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7. Annex

Annex 1. Questionnaire representatives from Chilean wineries

Knowledge of the agroecosystem

1. How would you describe your knowledge on biodiversity?

1 ----------5

(I do not know the meaning of this word) (I understand the meaning of this word and I consider I possess a fair knowledge on the variety of species and interactions among them that allow provision of ecosystem services)

2. How familiar are you with the concept of ecosystem services?

1 ----------5

(I do not know the meaning of the word) (I understand what ecosystem services are and I can list some ecosystem services in my agroecosystem that are useful for grape and wine production)

3. before the VCCB project, did you hold any knowledge on ecologically based farming practices/ management practices? – different styles and systems.

yes---------- no

Demand for agroecologically produced goods

1. do you perceive that there is a consumer demand for sustainably/ ecologically produced wine?
2. Would you say this was an important factor to consider ecologically based management practices?

Community of practitioners, peer pressure

3. Do you consider that the neighbouring community/ other network of local producers show support for agroecological farming?
4. To your knowledge, are there other farmers/ producers in the region engaged with changing their conventional farming practices?
5. Does the fact that other producers in the wine industry (competitors) are changing their practices encourage you to change your own?
   (For example, because you do not want to allow them a competitive advantage in terms of sustainability, or do you think this has a facilitating effect in terms of bureaucracy or acceptance of this transition by the community or other producers in your network?)
6. Do you feel a sense of responsibility to future generations when you make decisions regarding effects that your management practices can have on the environment of the region?

7. have you, as an individual, incentivized a shift in the company's management practices based on your own conviction towards biodiversity conservation, ecosystem preservation?
8. Are you concerned about preserving the landscape in your field and surroundings?

If yes, is this concern related to an economic interest from your company, for instance, related to tourism activities (e.g., tours through the vineyards)?

Finance, investment opportunities, subsidies

9. To what extent is your company interested in financing innovative farming practices based on ecological principles aimed at preserving the environment?

1---------- 5

(investments are a one-time thing) (they expect investments to increase in time until phasing out conventional practices)

10. Have you had access to any kind of **financial help** from the government (national or regional) to support shift in practices towards biodiversity conservation ones?
11. Is there any other type of financial help that you as the private sector have access to?
12. would you say that changes in management strategies towards biodiversity conservation ones are **cost effective**?

Yes, no, please elaborate.

Political context

13. Have you experienced that national or regional government bodies are encouraging/incentivizing a shift towards biodiversity conservation practices in the wine sector?
14. Have any NGOs or social movements approached your company and requested more action towards the protection of biodiversity in the area?

Do you perceive that the national political context (new constitution and so on) is favouring biodiversity conservation farming practices?