# BRIDGING THE GAP BETWEEN THEORY AND PRACTICE IN AGRO-ECOLOGICAL FARMING

## ANALYZING KNOWLEDGE CO-CREATION AMONG FARMERS AND SCIENTIFIC RESEARCHERS IN SOUTHERN SPAIN


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| Word count: | 18020 |

*"If you have come here to help me, you are wasting your time.*
*But if you have come because your liberation is bound up with mine, then let us walk together."*
- Lilla Watson

# SUMMARY AND KEYWORDS

Conventional industrial agriculture is no longer suited to feed the world, because it has causes depletion to the ecosystems on which all life on earth depends. Agro-ecological farming is increasingly being recognized as the way forward, yet its development is highly dependent on local environmental, social, economic, cultural and political contexts. Not only is there a need for new knowledge that can be tailored to fit local circumstances, changes are also needed in the processes by which this knowledge is generated. How can these processes be organized in a way that fosters a balance between scientific rigor and robustness on the one hand, and local relevance on the other? This research aimed to answer the questions as to how knowledge co-creation process dynamics among farmers and scientific researchers are organized, to what extent the outcomes of such processes explain successful impacts in terms of positively influencing agro-ecological farming behavior and which conditions contribute to this success. A generic analytical framework on joint knowledge production dynamics was employed in conducting a systematic literature review of scientific empiric analyses of knowledge co-creation processes in the context of agro-ecology. In more than half of the sample no process impacts were mentioned, which might point towards a gap between agro-ecological theory and practice. Also, cases with successful impacts, defined as the (re)design of agro-ecosystems based on ecological principles, were limited. The findings of this research suggest that when the goal is to further develop agro-ecology, a shift is needed from focusing on agro-ecological farming practices to agro-ecological farming principles.

**Key words:** agro-ecological farming, knowledge co-creation, redesign of agro-ecosystems

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# 1. INTRODUCTION

Conventional industrial agriculture is no longer suited to feed the world because it has caused global deterioration of the ecosystems on which all life on earth depends. Conventional agriculture is characterized using synthetic chemical inputs (e.g. fertilizers, pesticides, herbicides, fungicides), genetically modified organisms, heavy irrigation, intensive tillage and/or production based on monocultures. This has led, among others, to losses of biodiversity, soil fertility and ecosystem services, which in turn all decrease the natural resilience of ecosystems. Resilience is defined as the capacity to restore after external disturbances, and it is therefore of utmost importance to foster resilience in the light of global climate change. There is thus a need for shifting away from conventional to alternative agricultural approaches that contribute to life on earth instead of further deteriorating it.

Agro-ecology is such an approach (Shiva, 2016; Bellamy & Ioris, 2017). In fact, scaling up agro-ecology was proposed as a strategic approach to fostering sustainable food system transitions during the second FAO International Symposium of Agroecology (Gliessman, 2018; FAO, 2018). Yet, the success with which agro-ecological farming can contribute to solving these challenges highly depends on local environmental, social, economic cultural and political contexts. As opposed to the input-intensive and one-size-fits-all approach of conventional agriculture, agro-ecological farming is said to be knowledge-intensive (Coolsaet, 2015; Ingram et al., 2016). The development, implementation, monitoring and evaluation of agro-ecological farming practices not only requires new knowledge that is tailored to fit a large variety of local circumstances, it even more so requires changes in the processes by which this knowledge is generated (Hainzelin, Caron & Bie, 2014; Berthet et al., 2016). This research aimed to explore (i) how changes in farming behavior towards agro-ecological farming can be explained by how such processes are organized and (ii) which factors contribute (either positively or negatively) to successful outcomes of these processes in terms of the adoption of agro-ecological farming practices.

## 1.1 AGRO-ECOLOGICAL FARMING

The concept of agro-ecology is an agglomeration of agronomy (i.e. the branch of agriculture that studies soil management, cultivation of land and crop production) and ecology (i.e. the branch of biology that studies living things, their environment and the interactions between the two). Although there might be as many definitions of agro-ecology as there are practitioners, it can broadly refer to a scientific discipline, agricultural practice and/or a socio-political movement (Wezel et al., 2009) with a focus on the application of ecological principles to agricultural production systems (Francis et al., 2003).

In practice, this means that ecosystem services are restored by rebuilding and maintaining fertile soils, recycling nutrients and making optimal use of natural resources (e.g. sun, wind, water and soil) and local genetic diversity of species. This can be done with the use of agro-ecological farming techniques, among which are crop rotation, polycultures, agro-forestry, integrated crop-livestock management, green manure and compost, cover crops and mulching. An important distinction is made between agro-ecological techniques and practices. Whereas these agro-ecological techniques together provide a universal toolkit for the redesign of agro-ecosystems, the way they are implemented by farmers is shaped by the specific characteristics of their individual context (e.g. soil and climate conditions and farmers' objectives, knowledge and resources). Agro-ecological farming practices are then defined as the adoption of agro-ecological farming techniques that are adapted by farmers to their specific local contexts (Casagrande et al., 2017).

## 1.2 OBSTACLES TO THE ADOPTION OF AGRO-ECOLOGICAL FARMING PRACTICES

The adoption of agro-ecological farming practices by farmers is hampered by obstacles that are linked to the scientific agro-ecological evidence-base. A first major issue is the performance of agro-ecological farming practices and systems. Questions remain about gaps in crop yield (i.e. harvested crops per area), crop productivity (i.e. ratio agricultural outputs to inputs, Bellamy & Ioris, 2017) and increased labor-intensity (Lampkin et al., 2015) when comparing agro-ecological farming systems with conventional ones. Not only are these apparent uncertainties frequently used as an argument against the transformation from conventional to agro-ecological farming practices and systems (Bellamy & Ioris, 2017), they may also lead to strong risk aversion among farmers (Duru et al., 2015) and thus hampers the adoption of agro-ecological farming practices (at least those with a lower risk tolerance).

For example, when monitoring and evaluation of the performance of agro-ecological farming practices and systems would be done in the limited terms of crop, land and labor productivity, this would confine their performance to the mechanisms of conventional agriculture they try to address in the first place. Instead, as several authors have argued, there is a need for more transdisciplinary agro-ecological research that facilitates the collective development of a more holistic set of evaluation measures based on criteria that are relevant for the local conditions of farmers (e.g. food security) (Altieri, 2009; Bernstein, 2014; Caron et al., 2014; Sevilla Guzmán & Woodgate, 2013; Berthet et al., 2016).

Another obstacle is the operational misfit between the demand and supply of agro-ecological knowledge. Scientific evidence of agro-ecological farming systems with comparable or even improved yields is on the rise (e.g. Horlings & Marsden, 2011; Rosset & Machín Sosa, 2011; Lampkin et al., 2015; Garbach et al., 2016). Yet, most scientific knowledge has been generated at small spatial scales and cannot necessarily be generalized to other local contexts where this knowledge might be useful due to the high variability among these contexts (Dalgaard, Hutchings & Porter, 2003; Duru et al., 2015). Currently available scientific agro-ecological knowledge may therefore not be relevant to most farmers. This is hampering the adoption of agro-ecological farming practices because, as mentioned earlier, the extent to which farmers can successfully implement agro-ecological farming practices is highly dependent on knowledge that fits with their local environmental, social, economic, cultural and political conditions (Tilman et al., 2002; Altieri, 2009; Bernstein, 2014; Caron et al., 2014; Sevilla Guzmán & Woodgate, 2013; FAO, 2018). It is thus important to make sure that this knowledge is made relevant and applicable for farmers.

## 1.3 KNOWLEDGE CO-CREATION AS THE SOLUTION

The relevance and applicability of science for society, in this case farmers, can be increased by jointly producing knowledge (Hazard et al., 2017; Djenontin & Meadow, 2018). Knowledge co-creation refers to a collaborative process in which stakeholders that differ in their epistemologies and capacities mutually exchange, create and apply knowledge (e.g. Cash et al., 2003; Jasanoff, 2004; Regeer & Bunders, 2009; Edelenbos et al., 2011). It is closely linked to participatory and transdisciplinary (or mode-2) science, as the aim is to transform practice by means of an ongoing horizontal dialogue in which researchers and stakeholders are all considered to be co-researchers (Blackstock et al., 2007). In agro-ecology, knowledge generated by farmers, researchers and social movements are integrated: “when these three forms of knowledge are linked, new knowledge is created and change occurs” (Gliessman, 2018, n.p.). As such, knowledge co-creation is an inherent feature of agro-ecology.

## 1.4 PROBLEM DEFINITION, KNOWLEDGE GAP AND SCIENTIFIC RELEVANCE

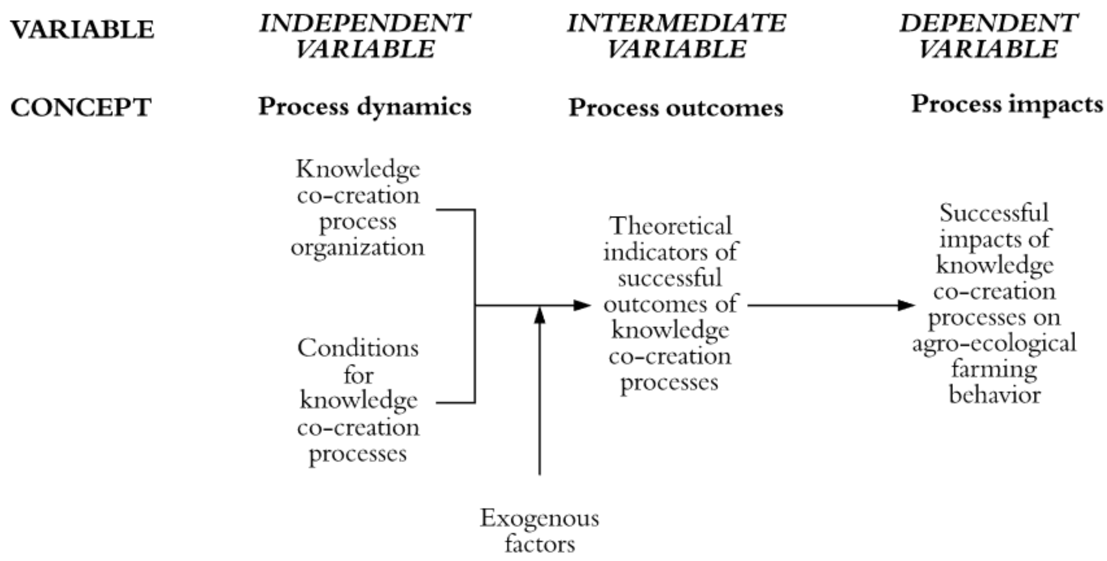
The need for knowledge co-creation is increasingly being recognized by scientific researchers by inviting farmers to participate in their research projects (Lacombe et al., 2018), but is raises an important challenge. Farmers and researchers hold different epistemologies and are likely to differ in the needs and goals that drive their participation in knowledge co-creation processes. While farmers may be looking for practical and how-to knowledge that is applicable to their individual circumstances and may consider their participation as a way of legitimizing their practices and produce, scientific researchers need to ensure methodological rigor and may be driven by the prospect of publishing their work. The confrontation between different types of knowledge that takes place during knowledge co-creation processes, in this case generic and theoretical scientific knowledge and locally specific and practice-based farmer knowledge, thus raises a tension between ensuring relevance and applicability in local conditions and robustness according to scientific rigor (Hainzelin et al., 2014; de Wit, 2016). If the goal is to enable real changes in farming behavior towards the adoption of agro-ecological farming practices, it is required to find a balance between the two.

A relevant contribution, although not specifically in the field of agro-ecology, comes from De Vente et al. (2016). They explicitly linked participatory processes on combating dryland degradation to their outcomes. They evaluated the role that process design and minor local contextual variations played in determining the outcomes of eleven different cases with varying methods of participatory decision making in Spain and Portugal. They also evaluated the role played by national contexts in determining participation outcomes of a process that was replicated in thirteen dryland areas around the world. They found that explanatory factors for the success of knowledge co-creation processes are not necessarily local context-dependent, contrary to agro-ecological knowledge itself, and concluded that three factors determine process outcomes: (i) who participates, (ii) how the process and communication among participating stakeholders are organized and (iii) how process outputs are linked to the implementation of solutions (de Vente et al., 2016).

This is an important contribution to the issue at hand, because it indicates that there "could be a number of generic 'good practices' in terms of design, implementation and facilitation that should be shared between local and national contexts" (de Vente et al., 2016, n.p.)". The idea that there are several process design factors that can increase the likelihood of stakeholder engagement leading to desired outcomes across a wide variety of contexts, is also supported by others (e.g. Menconi, Grohmann & Mancinelli, 2017; Reed et al., 2018). Reed et al. (2018) developed a theory that helps explain the variation in process outcomes of different types of stakeholder engagement (e.g. bottom-up, interactive and top-down), and concluded that "a theoretically informed approach to stakeholder engagement has the potential to markedly improve the outcomes of decision-making processes" (Reed et al., 2018, p.15).

The development of both agro-ecological science and practice could benefit from such a generic and theoretically informed approach, as it would allow for the creation of site-specific knowledge by means of principle-based processes that can easily be replicated to other areas. This means that the tension between ensuring local relevance and scientific robustness can potentially be relieved (de Wit, 2016). The problem is that scientific agro-ecological knowledge on how to organize knowledge co-creation processes remains fragmented, and that a systematic overview of how (or: if) such processes have led to the successful implementation of solutions is currently lacking. This research attempted to take a first step in filling this gap and thereby contributing to the strengthening of the scientific agro-ecological evidence base. The rationale behind this research is summarized in figure 1.1 below.

***Figure 1.1 Key concepts and their assumed relations***




## 1.5 RESEARCH OBJECTIVE, QUESTIONS AND FRAMEWORK

The objective of this research was to develop recommendations on how to organize co-creation processes among farmers and scientific researchers in a way that they lead to successful impacts in terms of a positive influence of agro-ecological farming behavior, and to provide insights into the conditions that contribute (either positively or negatively) to this success, by analyzing how and to what extent empirical examples of such knowledge co-creation processes have indeed resulted in successful outcomes. Outcomes were considered successful when the knowledge co-creation process has positively influenced agro-ecological farming behavior.

Given the above, the central research question that needed to be answered was:

**How are knowledge co-creation process dynamics among farmers and scientific researchers organized, to what extent do process outcomes explain the success of their impacts in terms of by positively influencing agro-ecological farming behavior and which conditions contribute to this success?**

The following sub-questions guided the process of answering the central research question:

**Sub-question 1.** When can impacts of knowledge co-creation processes be considered to have a positive influence on agro-ecological farming behavior?

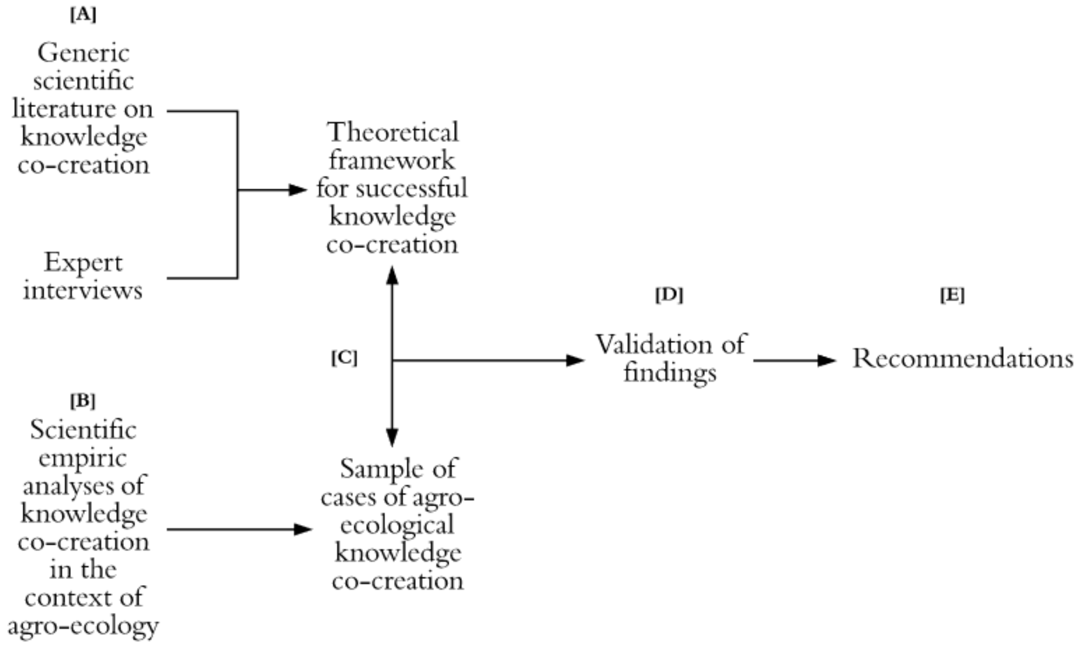
**Sub-question 2.** Which theoretical concepts explain the extent to which knowledge co-creation processes are successful in terms of their outcomes and impacts?

**Sub-question 3.** To what extent have empirical examples of knowledge co-creation process dynamics among farmers and researchers as described in the current body of scientific literature in the context of agro-ecology had successful impacts by having positively influenced agro-ecological farming behavior and which conditions contributed to their success?

**Sub-question 4.** To what extent is the theoretical image of how to successfully organize knowledge co-creation process dynamics among farmers and researchers in terms of their outcomes and impacts on agro-ecological farming behavior relevant and applicable in practice?

The research objective was met in roughly five steps. As the first step, generic scientific literature on knowledge co-creation was consulted. Interviews with experts (i.e. farmer and researchers) in the field of agro-ecology were conducted to increase understanding on how this generic theory relates to daily practices. This yielded a theoretical framework for analyzing the success of generic knowledge co-creation processes [A]. Step two was to review scientific empirical analyses of knowledge co-creation in the context of agro-ecology; this resulted in a sample of cases in which agro-ecological knowledge co-creation processes were described [B]. This sample was then analyzed based on the generic theoretical framework from step one and resulted in theory-based and generic guidelines on how to organize successful agro-ecological knowledge co-creation processes [C]. As agro-ecological farming is highly context dependent, it was needed to explore if and how these generic guidelines were relevant and applicable in a specific local context. This validation took place with farmers and scientific researchers in Southern Spain [D]. The last step was to formulate recommendations on how to organize successful agro-ecological knowledge co-creation processes among farmers and researchers [E]. These steps visually summarized in the research framework below (see figure 1.2).

***Figure 1.2 Research framework***



## 1.6 PROJECT CONTEXT AND STUDY AREA

This research was conducted in close collaboration with Regeneration Academy, which is a transdisciplinary learning environment where (student) researchers (BSc, MSc and PhD) gather insights from on-site scientific experiments and researching regenerative agricultural and land use practices together with local farmers. Regeneration Academy is situated at *La Junquera* which is, with 1100ha, the largest organic farm located in Southern Spain, on the border between Andalusia and Murcia. The farm is part of the AlVelAl-network: a regional farmer network that aims to "mobilize local communities and convey that the vision of a self-sufficient region, full of life and growth, is achievable when ecological agriculture and livestock techniques that improve the soil's fertility and retain water in the soil are applied" (AlVelAl, 2019, n.p.). This network brings together five areas that are known for their production of high-quality rain-fed almonds (i.e. Granada, Los Vélez, Alto Almanzora, Guadix and Northeast Murcia).

This research project followed from an inquiry conducted by Regeneration Academy into the research needs among farmers within the AlVelAl-network and was thus demand-driven and societally relevant. From November 2018 to March 2019 they provided the opportunity for conducting this research, as well as supervision throughout part of the process and connections with relevant stakeholders. The months spent in Spain were helpful for becoming more acquainted with daily agro-ecological farming practice and provided an opportunity to validate the relevance and applicability of the generic and theoretical research findings for an empirical local context.

Within Europe, Spain is the country with the largest area under risk of desertification (Rubio & Recatalá, 2006; Dominguez Gómez & Relinque, 2014), which is classified as semi-arid to arid and is among the warmest and driest regions in Europe. Regional climate forecasts predict less precipitation and increased heat and drought in the near future, and this may have catastrophic impacts on the livelihoods of farmers due to losses of harvests and thus income. It is therefore of utmost importance that farmers can prepare for and adapt to their changing circumstances by cultivating the resilience of their agro-ecosystems. As pointed out by Milgroom, Bruil and Leeuwis (2016), climate resilient agriculture requires the development of knowledge that relates to local adaptation strategies and farmers' knowledge of soils, seeds, land, water and the local community. Knowledge co-creation is therefore both relevant and urgent in the face of global climate change.

## 1.7 OUTLINE

The next chapter provides an overview of the theoretical foundations of this research. Chapter three provides an elaboration on the research methods employed. Research findings, an analysis thereof as well as their empirical validation are presented in chapter four. Chapter five elaborates on the conclusions drawn and provides an answer the central research question, followed by a discussion of these findings and recommendations in chapter six.

# 2. THEORETICAL FRAMEWORK

This chapter presents an answer to sub-question one (i.e. defining the success of process impacts on agro-ecological farming behavior) and to sub-question two (i.e. theoretical explanatory concepts that explain when and how knowledge co-creation processes result in successful outcomes and impacts). Generic scientific literature on science-policy-society interfaces, knowledge co-creation and environmental and agricultural decision making was consulted and provided the theoretical lens through which these sub-questions were aimed to be answered. Although this theoretical lens was by no means claimed to be exhaustive, it was intended to provide the reader with a logically structured representation of the variables, explanatory concepts and their relations that were used in this research with the aim of clearly identifying what will be explored (and what not).

This chapter was organized into five sections. Section one describes how different levels of successful outcomes were defined. Section two presents the theoretical concepts that were employed to define the extent to which knowledge co-creation processes are likely to obtain successful outcomes. Section three provides the theoretical outlines of how such processes can or should be organized. In section four, the conditions required for knowledge co-creation processes to be successful are discussed. Again, without claiming to be exhaustive, section four presents other external factors that may have an influence on the success of knowledge co-creation processes. A synthesis of this chapter is provided in section six by means of a conceptual model and a set of assumed causal relationships (hypotheses).

## 2.1 DEPENDENT VARIABLE – KNOWLEDGE CO-CREATION PROCESS IMPACTS ON AGRO-ECOLOGICAL FARMING BEHAVIOR

As briefly touched upon in the previous chapter, the ultimate objective of knowledge co-creation processes among farmers and scientific researchers was to obtain successful impacts in terms of positively influencing agro-ecological farming behavior. Yet, what is considered a positive influence may be quiet a subjective issue. Further specification was thus required. A useful specification was found in the analytical framework for identification of the agro-ecological character of food system transitions as proposed by Gliessman (2015). Food system transitions are defined as the shift away from conventional to agro-ecological food production systems as the foundation of both our local and global food systems. Farmers may vary in the pace at which they make this shift, as they face obstacles and opportunities that are highly specific to and influenced by their unique local conditions.

In this framework, five levels of agro-ecological changes are clearly distinguished (also see figure 2.1 below):

(i) *increasing* the efficiency of conventional farming practices and inputs;

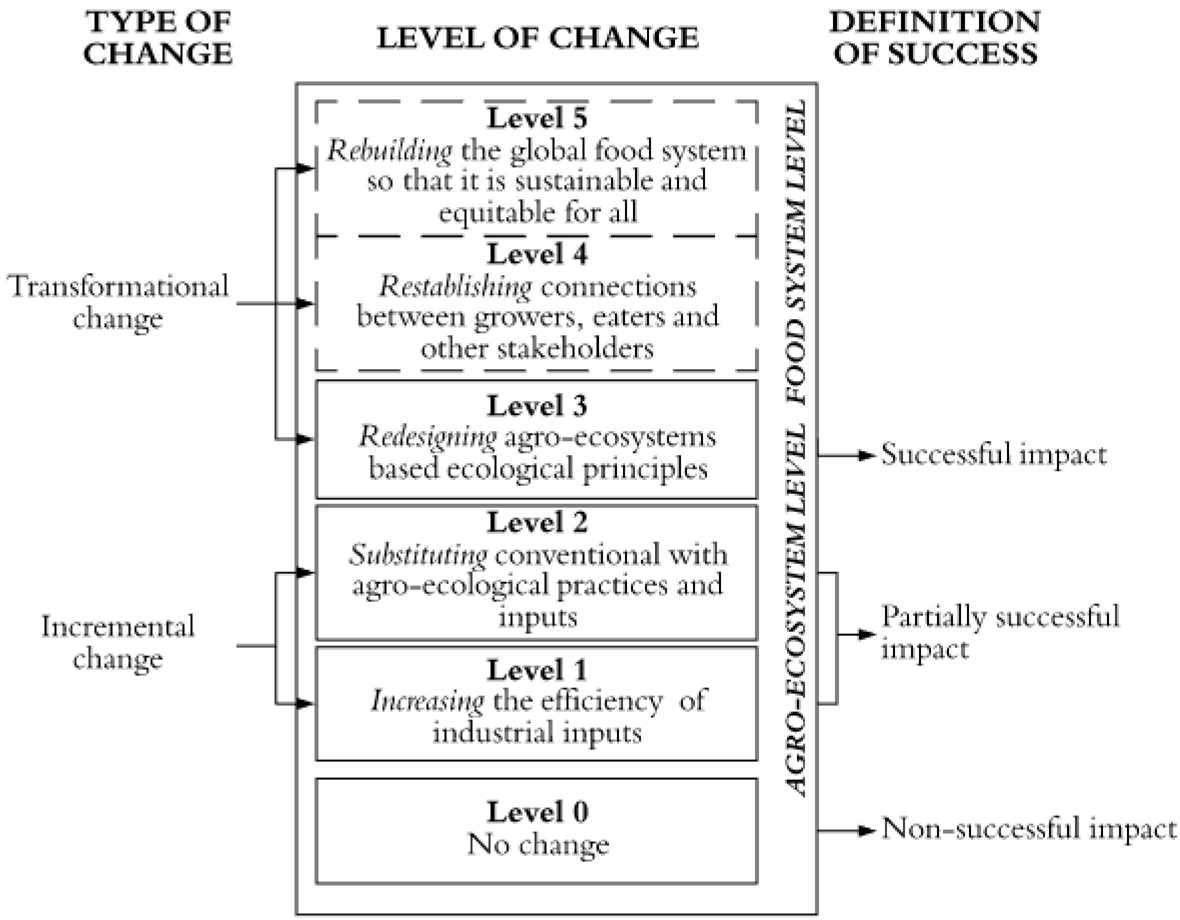
(ii) *substituting* conventional with agro-ecological farming practices;

(iii) *redesigning* whole agro-ecosystems based on ecological principles;

(iv) *reestablishing* connections and networks between growers, consumers and other stakeholders;

(v) *rebuilding* the global food system so that it is sustainable and equitable after all

***Figure 2.1 Defining successful outcomes***




Adapted from Gliessman (2015)

Levels one and two are considered incremental changes; it is only when level three is reached that a system is in line with agro-ecological principles. This is where transformative change begins. Instead of merely providing another set of farming techniques, agro-ecology provides a holistic framework or systems perspective for the conscious (re-)design of agro-ecosystems, in which the key principle is to mimic processes as they occur in our natural environment and which also includes how humans interact with agro-ecosystems through their livelihoods (Putnam et al., 2014). Central to this approach is the importance of not just the individual elements within a farming system, but even more so of the relations between these elements. Its resilience is increased when all individual elements fulfil multiple functions, and when these functions are supported by multiple elements. Therefore, agro-ecological farming is not just a matter of applying stand-alone agro-ecological farming techniques, but about redesigning entire agro-ecosystems that support ecosystem services (Gliessman, 2018).

A further distinction is made between changes on the level of agro-ecosystems (level one to three), and changes that go beyond food production and consider the whole food system (changes on level four and five). This scope of this research was demarcated by focusing on changes on the level of agro-ecosystems. Therefore, outcomes of knowledge co-creation processes among farmers and researchers are considered successful when they are transformative, i.e. the redesign of entire agro-ecosystems based on ecological principles.  Outcomes are considered partially successful when they entail incremental change, i.e. increased efficiency of conventional farming practices or their substitution with agro-ecological practices.

## 2.2 INTERMEDIATE VARIABLE – KNOWLEDGE CO-CREATION PROCESS OUTCOMES

Having specified the ultimate objective of knowledge co-creation processes, i.e. successful impact as the (re)design of agro-ecosystems based on ecological principles, the next question that needed to be answered was when co-created knowledge is indeed likely to result in the desired behavioral change. The main inspiration that was drawn from comes from Hegger et al. (2012), who developed an analytical framework for the retrospective analysis of knowledge co-creation processes. They built on an important contribution from Cash et al. (2003), who found that scientific knowledge is most likely to positively influence social responses when the co-created knowledge simultaneously meets three credibility, salience and legitimacy (i.e. process outcome). This work has been considerably influential: it has often been cited (1502 times according to Scopus and 2530 times according to Google Scholar) and it has been applied and refined by other scholars (e.g. Hegger et al., 2012).

Credibility says something about the extent to which the produced knowledge is perceived of as valid by the stakeholders involved in its co-creation process. Validity may refer to different aspects of this knowledge: to the instruments used for data collection, the type of data being collected with these instruments, the type of findings derived from the data and the kind of explanation derived from the interpretation of findings (Tengö et al., 2014). Different stakeholders have different thresholds for credibility (Cash et al., 2003; Roux et al., 2010; Hegger et al., 2012), and this also holds true in the case of farmers and scientific researchers: while knowledge is likely to be perceived of as valid by researchers when it is generated and certified through scientific conduct and rigor, whereas farmers are more likely to do so when it has been tested through everyday practice and experience (Ingram et al., 2016; de Wit, 2016). It has indeed been found that knowledge that is perceived of by farmers as valid, is more likely to be received and used by them (Ingram et al., 2016).

Salience refers to the perceived relevance of the knowledge being co-produced (Cash et al., 2003), especially so in terms of time and scale (Dunn & Laing, 2017). This criterion is important with an eye on upscaling agro-ecological farming practices for at least two reasons. First, farmers are, in the end, the ones with the power to decide whether they will implement agro-ecological farming practices. As such, how and with what success scientifically derived knowledge and measures are implemented on the ground is mostly influenced by their decisions and behavior (Feola et al., 2015). Second, and perhaps more importantly, the knowledge needed for individual farmers to implement agro-ecological farming practices is extremely dependent on their local context (e.g. soil-, water-, climate, socio-economic conditions). Thus, for farmers to perceive of the knowledge as relevant, it is important to ensuring a good fit between research questions and information needs by co-producing knowledge that is relevant and applicable to their local circumstances (Lemos et al., 2012).

While credibility and salience say something about the *content* of the knowledge being co-produced, legitimacy says something about the *process* by which this happened. It refers to the extent to which the actors involved perceive of this process as unbiased and respectful of divergent values and beliefs (Cash et al., 2003). Failing to account for these divergent values and beliefs may erode willingness to participate in the process as well as the perceived legitimacy of its outcomes (Tengö et al., 2014), thereby decreasing the likeliness that the knowledge produced will be put into action. Legitimacy is a highly relevant concept in the context of agro-ecology, as the latter is an attempt to address the epistemic superiority inherent to the industrial food system by which many voices are muted (de Wit, 2016; Shiva; 2016). Agro-ecology advocates stress the importance of recognizing the value of local knowledge, by which they shed an empowering light on the image that farmers are purely passive recipients of externally driven technology and knowledge (Thompson & Scoones, 2009).

## 2.3 INDEPENDENT VARIABLES – KNOWLEDGE CO-CREATION PROCESS DYNAMICS

The analytical framework for understanding knowledge co-creation dynamics developed by Hegger et al. (2012) explicitly links the above outcomes of knowledge co-creation processes (i.e. credibility, salience and legitimacy) to conditions that are expected to successfully influence these outcomes (see figure 2.1). As one of the objectives of this research was to explore the conditions that eventually contribute to successful outcomes and impacts on agro-ecological farming behavior, it was deemed a relevant theoretical approach. Another reason why this theory was chosen, is because the criteria credibility and salience reflect a parallel to the tension between scientific robustness and local relevance that occurs when knowledge is co-created (i.e. problem definition). It was expected that by using this framework, insights could be gained on how to alleviate this tension. It was also expected to contribute to the theory by adding a third layer: linking outcomes of knowledge co-creation processes to their impacts. It seemed, however, that the success conditions proposed by Hegger et al. (2012) relate to different aspects of a knowledge co-creation process. Their framework served as a point of departure and was slightly adapted by specifically distinguishing three elements of knowledge co-creation process dynamics that were assumed to influence the success of these processes in terms of their outcomes and thus impacts: (i) process organization, (ii) conditions and (iii) exogenous factors.

### *2.3.1 PROCESS ORGANIZATION*

**Broad actor coalition and selection of participants -** It can be expected that the success of knowledge co-creation processes is enhanced when there is a broadest possible coalition of stakeholders participating, because the inclusion of place-based knowledge in science is likely to positively influence the perception of credibility and salience (Hegger et al., 2012). In addition, departing from the assumption that every person has their own worldview it can be argued that is not only important to ensure the broadest possible stakeholder coalition, but even more so, to make sure that these stakeholders hold heterogeneous points of view as they all contribute to gaining a more holistic perspective on the issues at stake (Berthet et al., 2016). Gender (Kraaijvanger et al., 2016) and generation diversity (especially the youth) should especially be accounted for (Nyeleni Declaration, 2015). Careful selection of representative participants is therefore considered as an important indicator for the successful organization of knowledge co-creation processes, as it is key for the perception of salience and legitimacy (Gramberger, Zellmer, Kok & Metzger, 2015). Furthermore, the perception of salience is likely to be positively influenced when actors are invited to participate in knowledge co-creation processes as early as possible (Burns, Hyde, Killett, Poland & Gray, 2014).

**Inclusion of divergent perspectives –** According to the framework proposed by Hegger et al. (2012), the third expected success condition is that the effectiveness of knowledge co-creation processes is enhanced when divergent perspectives are recognized and accounted for. To account for different perspectives is crucial to make sure that the knowledge being produced is perceived as salient and legitimate (Hegger et al., 2012; Cook et al., 2013), which in turn increases the likeliness of the knowledge serving its purpose: being used. The importance of recognizing and accounting for divergent perspectives is inherent in agro-ecology. Yet, it takes it a step further: not only should these perspectives be recognized and accounted for, they should be engaged in a process of horizontal dialogue that facilitates collective sense-making (Martínez-Torres & Rosset, 2014). This is known in agro-ecology as diálogo de saberes, or: a dialogue among different knowledges and ways of knowing. This concept embodies the need for cultivating what several authors coined as epistemic humility: an attitude that embraces biases, fallibilities and strengths of different ways of knowing rather than assuming the superiority of just one of them (Shiva, 2016; de Wit, 2016). It is through such dialogues and attitudes that, when linked to collective action, participating actors gain a clear understanding of project expectations and potential barriers and benefits (Freire, 2000; Martínez-Torres & Rosset, 2014).

**Iterative and adaptive process design –** The indicators of knowledge co-creation process outcomes as proposed by Cash et al. (2003) did not remain undisputed. A relevant suggestion has been provided by Sarkki et al. (2017), who introduced iterativity as a fourth indicator to better capture the continuous multi-lateral dynamic character inherent to joint knowledge production interfaces instead of viewing such process as linear. They consider it to be an essential mechanism for fostering the sustainability and effectiveness of joint knowledge production processes on the long run, as it is conducive to the criteria of credibility, salience and legitimacy (Sarkki et al., 2017). It could be noted, however, that iterativity may say more about how the process is or should be organized than about the co-created knowledge itself. Therefore, it is considered an independent variable. Adaptivity refers to the need of adapting the process design to participants, e.g. in terms of language and location (de Vente et al., 2016).

**Organized reflection on roles and responsibilities –** The success of knowledge co-creation process is likely to enhance when there is organized reflection on participants' roles and responsibilities, because this increases the perceptions of salience and legitimacy due to autonomy and mutual understanding of individual interests and expectations (Hegger et al., 2012). Participating actors should be and feel free to decide on the identity, role(s) and responsibilities they are capable but also willing to take on throughout the process (Hegger et al., 2012; Timmerman & Félix, 2015). Such high levels of autonomous decision-making have been argued to positively contribute to the adoption of sustainable farming practices (Monzote et al., 2012; Triste et al., 2018).

#### *2.3.2 CONDITIONS*

**Shared understanding on goals and problem definition -** The success of knowledge co-creation processes is likely to be enhanced when participating actors collectively engage in a process of reflection on the nature of the problem at hand and the goals of the process as this may increase the perception of salience due to a good fit with actors' needs and interests. As farmers and researchers, and any individual human being for that matter, have unique frames of reference, their understanding of the issues at stake will be divergent. Culture and language are important vehicles through which these frames of references are expressed, so intentional effort must be made to foster inclusiveness and creating common ground by acknowledging and harmonizing these differences in cultural and linguistic traits (Akpo et al., 2015). The extent to which researchers are willing and able to cultivate an understanding of the local context in which farmers' decision-making is embedded, is a vital element to fostering salience of the knowledge being co-produced (Dilling & Lemos, 2011; Djenontin & Meadow, 2018; Lacombe, Couix & Hazard, 2018). And while reaching a shared understanding may turn out challenging, this condition is important when it comes to creating collaborative synergies across knowledge systems on the long run (Tengö et al., 2014).

**Roles of researchers and their knowledge are clear -** Clarity on the role that researchers and their knowledge play throughout the co-creation process is another condition that, when met, likely contributes to success (Hegger et al., 2014). This has to do with transparency: openness regarding intentions and expectations instead of hidden agendas is of crucial importance when it comes to fostering perceptions of credibility and legitimacy of the process as it may increase trust in researchers (Hegger et al., 2012). As the term participation "has been used both to justify extension of control of the state as well as to build social capacities" it is crucial for researchers to be transparent about the type of stakeholder engagement they envision (Pretty & Smith, 2004, p.636). For example, Rowe and Frewer (2000) distinguished three types of stakeholder engagement based on the direction of communication between stakeholders: communication, consultation and participation. Communication refers to the dissemination of information to stakeholders who are considered passive recipients, consultation happens when information is gathered from participating stakeholders while participation refers to a reciprocal process of communicating and learning between all participating stakeholders, including process organizers. It is thus not only important that the role of researchers and their knowledge is clear, but also that the envisioned role for participating stakeholders (i.e. farmers) and their knowledge is clear. By collaborating directly with farmers as co-creators, new roles emerge for scientific researchers, among which are confirming the scientific legitimacy of farmers' knowledge and experience by acknowledging them as experts in their own rights and translating these into an academic idiom for communication with other actors in the system (e.g. policymakers and civil society, de Wit, 2016).

**Resources –** In their framework, Hegger et al. (2012) specifically focus on what actors can do themselves to optimize resources for the knowledge co-creation process, and have identified three specific types of resources from the sociology of knowledge literature: (i) boundary objects, (ii) facilities and organizational forms that stimulate the interfacing and sharing different forms of knowledge and (iii) competences (e.g. negotiation, interactional expertise).

#### *2.3.3 EXOGENOUS FACTORS*

**Presence of innovative reward structures in science -** Impacts from knowledge co-creation processes differ from non-participatory and non-transdisciplinary research projects and, as such, they need to be evaluated differently than by means of the status quo measurements for science impact (e.g. number of publications and citations) (Hegger et al., 2012; Jordan et al., 2012; Podesta et al., 2013; Cvitanovic et al. 2016). Both agro-ecological science and practice are, due to their participatory and inter- and transdisciplinary character, knowledge intensive and therefore time-consuming. Fundamental changes in the organizational culture of scientific research are thus required and is expected to increase the perception of legitimacy (Hegger et al., 2014).

The importance of the possible influence of exogenous factors on knowledge co-creation process outcomes was only recognized in a late stage of the research process. Although other exogenous factors can be identified (e.g. willingness to collaborate/stakeholder participation fatigue), these have not been considered due to practical issues (i.e. time).

## 2.4 SYNTHESIS

Knowledge co-creation processes are considered to have successful impacts when agro-ecological farming behavior is positively influenced towards the (re)design of agro-ecosystems based on ecological principles. These process impacts are expected to be influenced by the outcomes of knowledge co-creation processes (i.e. the extent to which the co-created knowledge meets the criteria of credibility, salience and legitimacy). These process outcomes, in turn, are expected to be influenced by knowledge co-creation process dynamics: process organization, conditions and an exogenous factor. This rationale is visually summarized in a conceptual framework that serves as the foundation for further analysis (see figure 2.2), and based on which the following set of hypotheses was formulated:

H1 If the outcome of a knowledge co-creation process is that the co-created knowledge is perceived of as credible and salient, and the process by which it was generated was legitimate, then the success of its impact on the adoption of agro-ecological farming practices is positively influenced.

H2 If there is a broad actor coalition participating in the knowledge co-creation process, then perceptions of credibility, salience and legitimacy are positively influenced.

H3 Or: if there is a broad actor coalition participating in the knowledge co-creation process, then perceptions of salience and legitimacy are negatively influenced.

H4 If the selection of actors participating was careful and representative, then perceptions of salience and legitimacy are positively influenced.

H5 If actors participate in the knowledge co-creation process from the beginning, then perceptions of salience and legitimacy are positively influenced.

H6 If divergent perspectives are accounted for through a horizontal dialogue, then perceptions of salience and legitimacy are positively influenced.

H7 If the process design is iterative and adaptive, then perceptions of credibility, salience and legitimacy are positively influenced.

H8 If organized reflection on roles and responsibilities takes place, then perceptions of salience and legitimacy are positively influenced.

H9 If there is a shared understanding among participating actors on goals and problem definitions, then perceptions of credibility, salience and legitimacy are positively influenced.

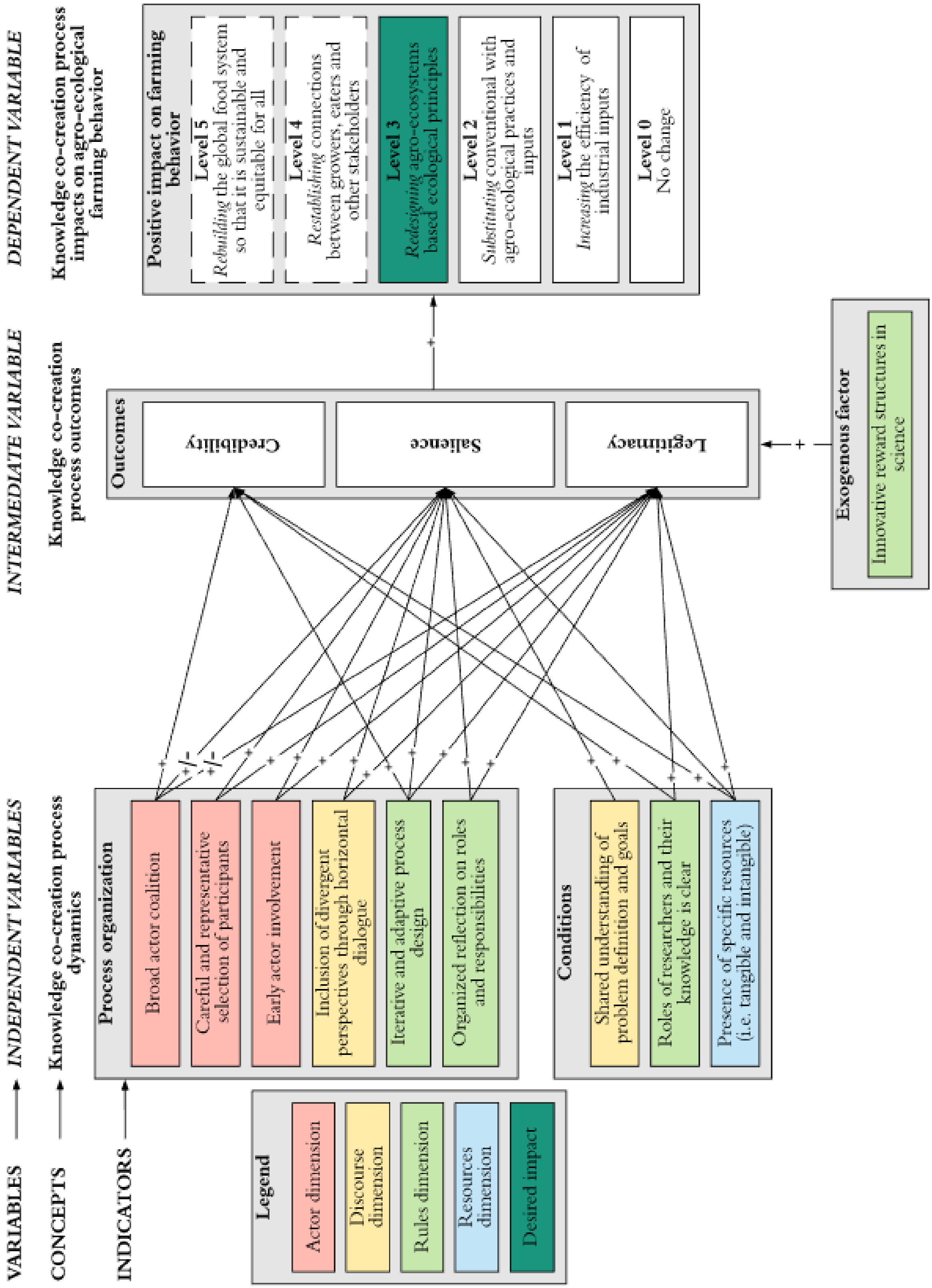
H10 If the role of researchers and their knowledge is clear, then perceptions of credibility and legitimacy are positively influenced.

H11 If specific facilitative resources are present, then perceptions of credibility, salience and legitimacy are positively influenced.

H12 If innovative reward structures in science are present, then legitimacy is positively influenced.

H13 If indicators for knowledge co-creation process dynamics (i.e. process organization, process conditions and the exogenous condition) are simultaneously met, then process impacts are positively influenced.

***Figure 2.2 Conceptual model***



# 3. RESEARCH METHODS

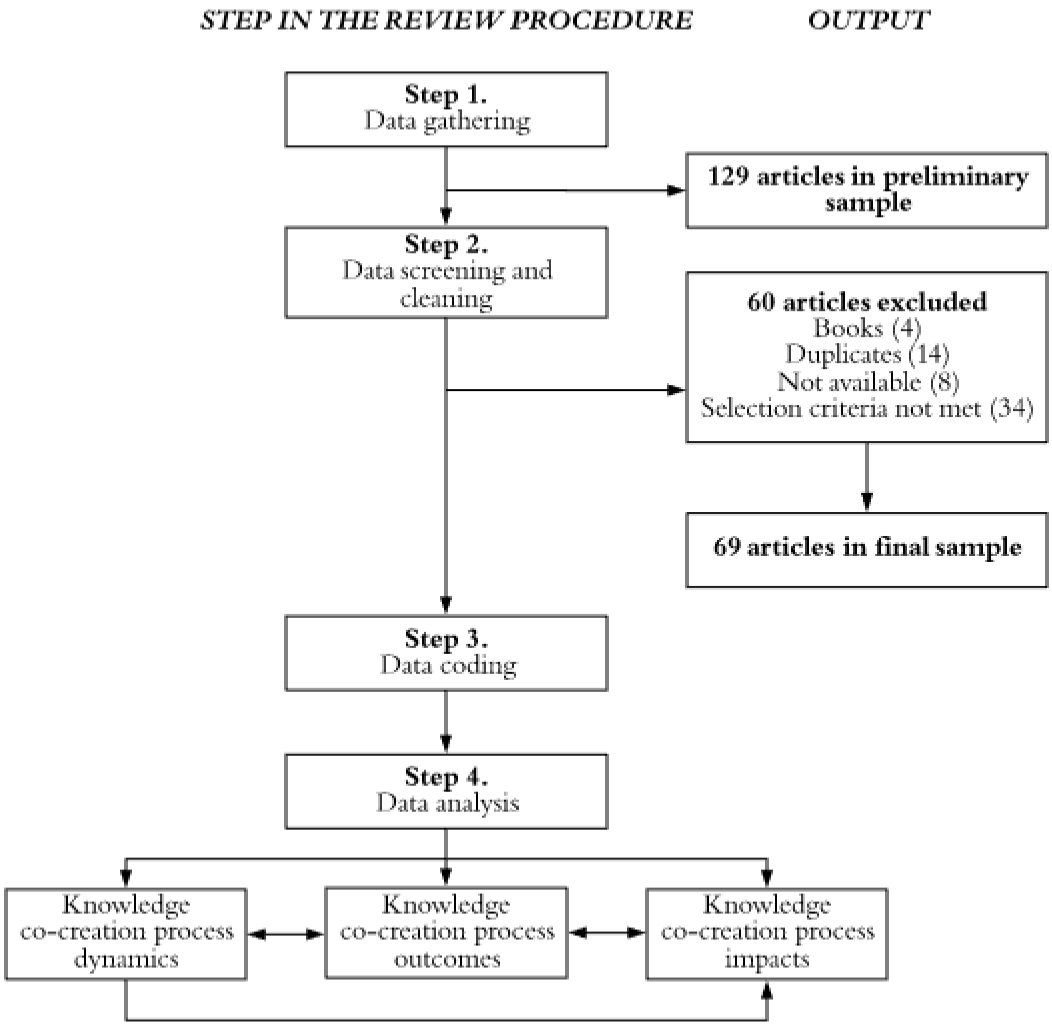
The previous chapter provided answers on sub-question one (i.e. *when can impacts of knowledge co-creation processes be considered to have a positive influence on agro-ecological farming behavior?*) and sub-question 2 (i.e. *which theoretical concepts explain the extent to which knowledge co-creation processes are successful in terms of their outcomes and impacts?*). This chapter elaborates on the research methods employed to answer sub-question three (i.e. *to what extent have empirical examples of knowledge co-creation process dynamics among farmers and researchers as described in the current body of scientific literature in the context of agro-ecology had successful impacts by having positively influenced agro-ecological farming behavior and which conditions contributed to their success*?) and sub-question four (i.e. *to what extent is the theoretical image of how to successfully organize knowledge co-creation dynamics among farmers and researchers in terms of their outcomes and impacts relevant and applicable in practice?*).

## 3.1 SYSTEMATIC LITERATURE REVIEW

A systematic literature review was conducted with the aim of answering sub-question three. This research method enables the identification and synthetization of key research findings by employing a transparent and protocol-driven approach (Fink, 2005; Higgins & Green, 2008; Okoli & Schabram, 2010), and was chosen for several reasons. Most importantly, the theoretical framework outlined in the previous chapter was developed in a rather generic (i.e. not having any particularly distinctive application) context of regional climate change adaptation projects. The systematic literature review was conducted to explore: (i) how these generic theoretical concepts could be shaped in the context of agro-ecology, (ii) the extent to which fulfillment of these generic concepts in scientific empiric analyses of knowledge co-creation processes in the context of agro-ecology contributed to successful impacts on agro-ecological farming behavior and (iii) other conditions relevant for fostering successful agro-ecological knowledge co-creation.

The process of conducting the systematic literature review roughly comprised two steps: creating a sample of empiric analyses and analyzing this sample by means of a coding framework, which in this case departed from the theoretical framework described in the previous chapter. The complete review procedure visually summarized in figure 3.1 and is followed by a more detailed description of the steps taken in the review procedure and their outputs.

**Figure 3.1 Review procedure**




#### ***3.1.1 Data gathering***

For each of the key concepts of this research (i.e process organization, knowledge co-creation and agro-ecological farming) a matrix was completed by listing relevant synonyms, antonyms and terms that more narrowly and broadly defined these concepts (see Appendix A1). One of the team members of the Regeneration Academy was invited to review the matrix and provide feedback in order to align expectations regarding to the scope of this research based on its key concepts. The matrix served as the basis for a Boolean search query (see Appendix A2) which was used in an advanced search on Scopus to arrive at a preliminary sample. While initially it was the intention to purely focus on agro-ecology, this resulted in ninety-two returns. As it was expected that not all these returns would be relevant, and exclusion of too many studies would mean a less robust sample in terms of size, the scope was broadened to other alternative agricultural approaches. This resulted in 129 returns.

The alternative agricultural practices included in the search query were: ecological-, regenerative-, sustainable-, conservation-, biodiversity- and nature inclusive farming, community supported agriculture, and sustainable- and ecological intensification. There were no returns pertaining to ecological-, regenerative-, and biodiversity agriculture, nature inclusive farming and community supported agriculture. Agro-ecology seems to show an overlap with other approaches, such as conservation agriculture and sustainable agriculture: zero tillage, crop rotation and natural pest control are among the practices they have in common (Schoonhoven & Runhaar, 2018). The concepts of ecological-, sustainable- and agro-ecological intensification also seem to bear strong resemblance as there is overlap in their definitions, principles and practices. Nevertheless, an important distinctive feature of agro-ecology is that it also considers social practices (e.g. reliance on local and cultural contexts and building on farmers knowledge) to be at the core of its rationale (Wezel et al. 2015).

#### *3.1.2 Data screening and cleaning*

All articles (n=129) in this preliminary sample were screened on criteria for inclusion based on their titles and abstracts. The following set of five inclusion criteria was arrived at after an iterative process of pre-screening:

(i) the study should describe joint knowledge production among at least scientific researchers and farmers;
(ii) the study should concern joint knowledge production in more than one research phase;
(iii) the study should concern empirically tested research (rather than normative);
(iv) the study should not be a duplication of another article;
(v) the study should be relevant for answering the research questions.

Articles were deleted from the sample in case one or more of the above criteria were not met, which resulted in a total exclusion of 60 articles. Books were unavailable and were therefore excluded.

#### *3.1.3 Data coding*

To be able to answer the research questions and meet the research objective (i.e. to develop recommendations on how to organize co-creation processes among farmers and scientific researchers in a way that they lead to successful impacts), all data was coded based on the conceptual framework presented in the previous chapter. More specifically, all data was screened on the three variables, i.e. dependent (process impacts), intermediate (process outcomes, also see appendix B) and independent (process dynamics), and each of their respective indicators were attributed a score ranging from zero to two (or a question mark, see table 3.1 below) that indicated the extent to which the indicator was met. As a matter of preparing for the next step, i.e. data analysis, the numerical data obtained were then summarized in tables and visually translated in graphs and figures.

**Table 3.1. Scores attributed per indicator**

| Variables and concepts | Indicator score | Indicator meaning |
|---|---|---|
| ***Dependent variable:*** successful knowledge co-creation process impacts on agro-ecological farming behavior | 2 | Successful knowledge co-creation process impacts: redesign of agro-ecosystems based on ecological principles |
| | 1 | Partially successful knowledge co-creation process impacts: increased efficiency of conventional farming practices or their substitution with agro-ecological farming practices |
| | 0 | Non-successful knowledge co-creation process impacts: No change in farming behavior |
| | ? | Knowledge co-creation process impacts not mentioned/unclear |
| ***Intermediate variable:*** knowledge co-creation process outcomes | 2 | Indicator (e.g. credibility, salience or legitimacy) completely met |
| | 1 | Indicator (e.g. credibility, salience or legitimacy) partially met |
| | 0 | Indicator (e.g. credibility, salience or legitimacy) not met |
| | ? | Indicator (e.g. credibility, salience or legitimacy) not mentioned/unclear |
| ***Independent variable:*** Knowledge co-creation process dynamics | 2 | Indicator (e.g. process organization, conditions or exogenous factor) completely met |
| | 1 | Indicator (e.g. process organization, conditions or exogenous factor) partially met |
| | 0 | Indicator (e.g. process organization, conditions or exogenous factor) not met |
| | ? | Indicator (e.g. process organization, conditions or exogenous factor) not mentioned/unclear |

#### *3.1.4 Data analysis*

As one of the reasons for conducting the systematic literature review was to explore the extent to which fulfilment of the generic theoretical indicators explained the success of knowledge co-creation process impacts on agro-ecological farming behavior, the data obtained from the previous step was analyzed to explore any correlations between variables. Thus, the analysis was threefold: (i) correlations between process impacts (dependent variable) and process outcomes (intermediate variable), (ii) correlations between process outcomes (intermediate variable) and process dynamics (independent variable) and (iii) correlations between process dynamics (independent variable) and process impacts (dependent variable). The set of hypotheses presented in the previous chapter served as a guide based on which these correlations were explored.

## 3.2 VALIDATION APPROACH

Following De Vente et al. (2016) and Reed et al. (2018), it was assumed that the success of knowledge co-creation processes not necessarily depends on the local contexts in which these processes are implemented, and that instead, success could be explained by a number of generic ‘good practices’ (de Vente et al., 2016). To explore the extent to which the generic theoretical framework used in this research could serve as such a set of good practices, sub-question four (i.e. *to what extent is the theoretical image of how to successfully organize knowledge co-creation process dynamics among farmers and scientific researchers in terms of their outcomes and impacts on agro-ecological farming behavior relevant and applicable in practice?*) needed to be answered.

This was done by validating the findings from the systematic literature review with farmers, researchers and agronomists in the empirical local context that was introduced in the first chapter: agro-ecological farming in Southern Spain. During the three and a half months of field work, several activities took place that were aimed at sharing and co-creating agro-ecological knowledge. Two of these were attended as a participant observer and provided good starting points for validation as both were characterized by different rationales and execution, which are elaborated upon in more detail in chapter five. The first activity was a knowledge co-creation process between AlVelAl-farmers and a local PhD researcher during one of their workshops on participatory monitoring of soil quality by means of visual assessments as part of a three-year collaborative and iterative research project. The second activity was a so-called Agro-Café hosted by AlVelAl with the aim of providing a space where farmers could share ideas and experiences. During these and other activities, personal contact with local farmers and researchers grew, were cultivated and provided informal instances during which the results from this research could be discussed as they developed. Informal semi-structured interviews were conducted based on the conceptual model outlined in the previous chapter, either in Spanish, English or Dutch, and with at least nine farmers pertaining to the AlVelAl-network of which six male and three female and four local researchers of which two male and two females.

Although biases, be it on the side of the researcher and/or respondents, cannot be out ruled completely, several other strategies have been used to at least mitigate it to the greatest extent possible. First of all, regular peer-debriefing (inviting and receiving feedback) took place with student-researchers and supervisors from Regeneration Academy during the three and a half months of field work. This was intended to mitigate researcher bias to some extent. Several activities were undertaken to get involved as a researcher in the empirical situation of the local stakeholders (summarized in table 3.2 below). This was expected to reduce the risk of respondent bias by establishing relationships of trust, although this may have increased the risk of researcher bias. Contact with some of the participating stakeholders in this research was maintained informally after the period of field work had ended.

**Table 3.2. Overview of field research activities**

| Field research activities |
|---|
| □ Three transect walks with different AlVelAl-farmers (of which two male and one female). This allowed farmers to be in the position of experts of their own territory. |
| □ Co-organizing La Junquera open day. Personal role of co-facilitator of visitor groups during an interactive tour along the research projects of student researchers, effectively fostering horizontal dialogues between student researchers and visitors (farmers and non-farmers. |
| □ Weekly agro-ecosystem restoration work at several farms (e.g. planning, planting, pruning, measuring and monitoring). |
| □ Informal home visits after personal invitations from several farmers. |
| □ Regular interactions with residents (of which many conventional farmers) of the nearby rural village for three and a half months. |
| □ Living and working with an international and interdisciplinary group of student researchers for three and a half months. |
| □ Attending presentations of other local researchers. |

# 4. RESULTS AND ANALYSIS

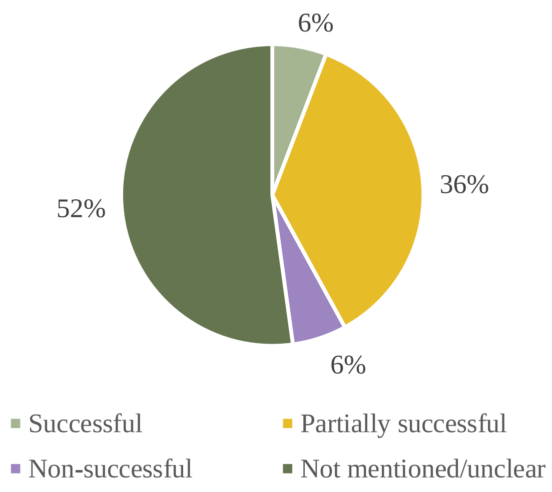
Results from the systematic literature review are presented in this chapter, together with an analysis of how the different variables (i.e. process dynamics, outcomes and impacts) were correlated throughout the sample of cases (n=69). As such, this chapter provides an answer to sub-question three: *to what extent have empirical examples of knowledge co-creation process dynamics among farmers and researchers as described in the current body of scientific literature in the context of agro-ecology been successful by having positively influenced agro-ecological farming behavior and which conditions contributed to their success?* This chapter is organized into three sections: (i) results, (ii) correlations and (iii) synthesis, and feeds into the next chapter (chapter five) that presents the findings from validating these results in the specific empirical context of agro-ecological farming in Southern Spain.

## 4.1 RESULTS

Results from the systematic literature review are presented here by zooming in on (i) the impacts of knowledge co-creation processes on agro-ecological farming behavior (i.e. dependent variable), (ii) the outcomes of knowledge co-creation processes (i.e. intermediate variable; credibility, salience and legitimacy) and (iii) knowledge co-creation process dynamics (i.e. independent variable; process organization, conditions and exogenous factor).

### *4.1.1 DEPENDENT VARIABLE – KNOWLEDGE CO-CREATION PROCESS IMPACTS ON AGRO-ECOLOGICAL FARMING BEHAVIOR*

Figure 4.1 Success of process impacts




As defined in the theoretical framework, impacts of knowledge co-creation processes on agro-ecological farming behavior (see figure 4.1) were considered successful when agro-ecosystems were (re)designed based on ecological principles. Such successful impact was obtained in 6% of the sample (n=4). A partially successful impact, defined as either an increase in the efficiency of conventional farming practices or their substitution with agro-ecological practices, was obtained in 36% of the sample (n=25). Non-successful impacts (i.e. no changes in farming behavior) were obtained in another 6% of the sample (n=4). Impacts were not mentioned or remained unclear in the remaining 52% of the sample (n=36).

The rather low number of cases with impacts that were in line with agro-ecological principles might be due to the somewhat stringent definition of success. Yet, that the outcomes in more than half of the sample were not mentioned or remained unclear, might point into the direction of another plausible explanation that seems to reinforce the need for this research: a gap between co-created knowledge and its transformation into practice. As was pointed out in one of the cases with non-successful impacts: "although collaborative approaches support the development of innovative and more sustainable livestock concepts, the research also shows that it does not guarantee successful implementation of the concepts in practice. The collaborations did not effectively support the process of implementation, especially with regard to the regulatory and financial challenges involved in the implementation. Consequently, one can question whether collaborative approaches alone can effectively facilitate a transition towards more sustainable livestock production" (Article 65, p.165).

#### *4.1.2 INTERMEDIATE VARIABLE – KNOWLEDGE CO-CREATION PROCESS OUTCOMES*

Credibility, salience and legitimacy were employed as the theoretical indicators for successful outcomes of knowledge co-creation processes. The extent to which these criteria were met was analyzed for each study in the sample, by attributing a score per individual indicator ranging from zero to two: zero indicated that the indicator was not met, one indicated that the indicator was partially met and two indicated that the indicator was completely met. A question mark was attributed when an indicator was not mentioned or if the extent to which it was met remained unclear. The process by which knowledge was co-created was completely legitimate in 77% and not legitimate in 3% of the sample. In 20% of the sample it was not mentioned or remained unclear whether the knowledge co-creation process was legitimate, i.e. respectful of divergent perspectives and unbiased in its conduct. Co-created knowledge was perceived of as salient in 61%, as partially salient in 4% and as not salient in 1% of the sample. The extent to which co-created knowledge was perceived of as salient was not mentioned or remained unclear in 33% of the sample. Co-created knowledge was perceived to be credible to a lesser extent. This indicator was completely met in 32% of the sample, followed by 3% in which the indicator was partially met and 4% in which the indicator was not met at all. In the largest part of the sample (61%) it was not mentioned to what extent the co-created knowledge was perceived of as credible by participating actors, or it remained unclear.

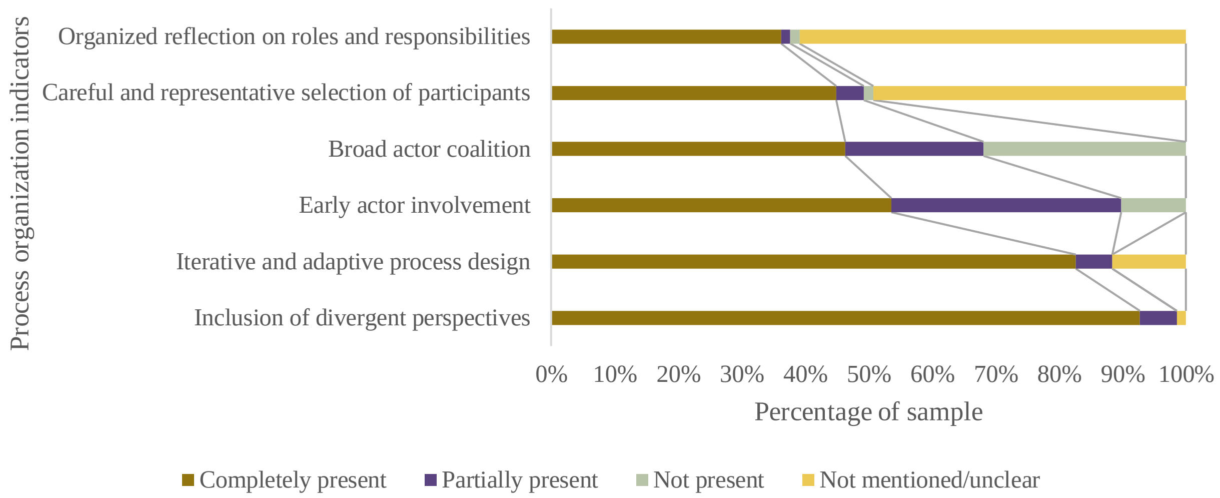
#### *4.1.3 INDEPENDENT VARIABLES – KNOWLEDGE CO-CREATION PROCESS DYNAMICS*

##### *4.1.3.1 PROCESS ORGANIZATION*

Six aspects of knowledge co-creation process organization were distinguished; these indicators were met throughout the sample to varying extents (see figure 4.2). Inclusion of divergent perspectives was completely met in almost the entire sample (93%), followed by an iterative and adaptive process design in 83%. Early actor involvement was completely met in 54%, meaning that in more than half of the sample actors were invited to participate in either an exploration of the problem history, its identification and structuring or in the construction of the research design and selection of methods.

The indicator of a broad actor coalition was completely met (i.e. more than three different parties participating) in 46% of the sample, partially met (i.e. three different parties participating) in 22% of the sample and not met (i.e. only farmers and researchers) in 32% of the sample. It was in only 45% of the sample that the selection of participating actors was careful and representative. The way in which participating actors were selected was not mentioned or remained unclear in 49%. Finally, organized reflection on roles and responsibilities was met in 36% of the sample, with 69% of the sample not mentioning such organized reflection (or it remained unclear).

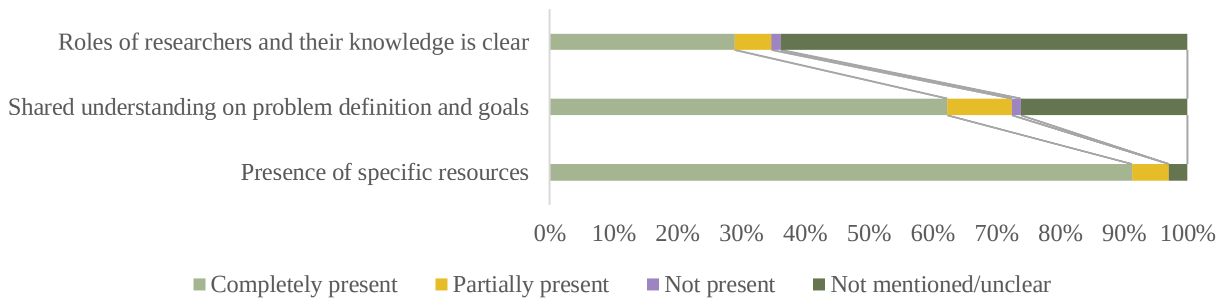
Figure 4.2 Process organization




#### 4.1.3.2 PROCESS CONDITIONS

The three indicators for process conditions, i.e. shared understanding, clear roles of researchers and their knowledge and the presence of specific resources, were also met to varying extents (see figure 4.3). Most of the cases within the sample (91%) reported presence of specific resources, both tangible and intangible. To a lesser extent (62%), there was said to be a shared understanding of problem definitions and goals. Clarity on the role of researchers and their knowledge was met to an even lesser extent: only

Figure 4.3 Process conditions



in 29% was this indicator completely met. Clarity on the role of researchers and their knowledge was not mentioned or remained unclear in 64%.

#### *4.1.3.3 EXOGENOUS FACTOR*

Presence of innovative reward structures, for both researchers and farmers, was studied as a third factor that influences the success of knowledge co-creation process outcomes. These were completely met in 20%, partially present in 12% and not present in 9% of the sample. Innovative reward structures were not mentioned or remained unclear in 59% of the sample.

## 4.2 CORRELATIONS

### *4.2.1 CORRELATIONS BETWEEN KNOWLEDGE CO-CREATION PROCESS OUTCOMES AND IMPACTS ON AGRO-ECOLOGICAL FARMING BEHAVIOR*

It was hypothesized that the success of process impacts could be explained by the extent to which the three theoretical indicators of successful knowledge co-creation outcomes (i.e. credibility, salience and legitimacy) were simultaneously met (H1). More specifically, it was expected to observe that:

(i) there would be more cases with successful impacts and high scores on outcome indicators (i.e. indicators completely met) than there would be cases with successful impacts and lower indicator scores (i.e. indicators partially met, not met or unclear);

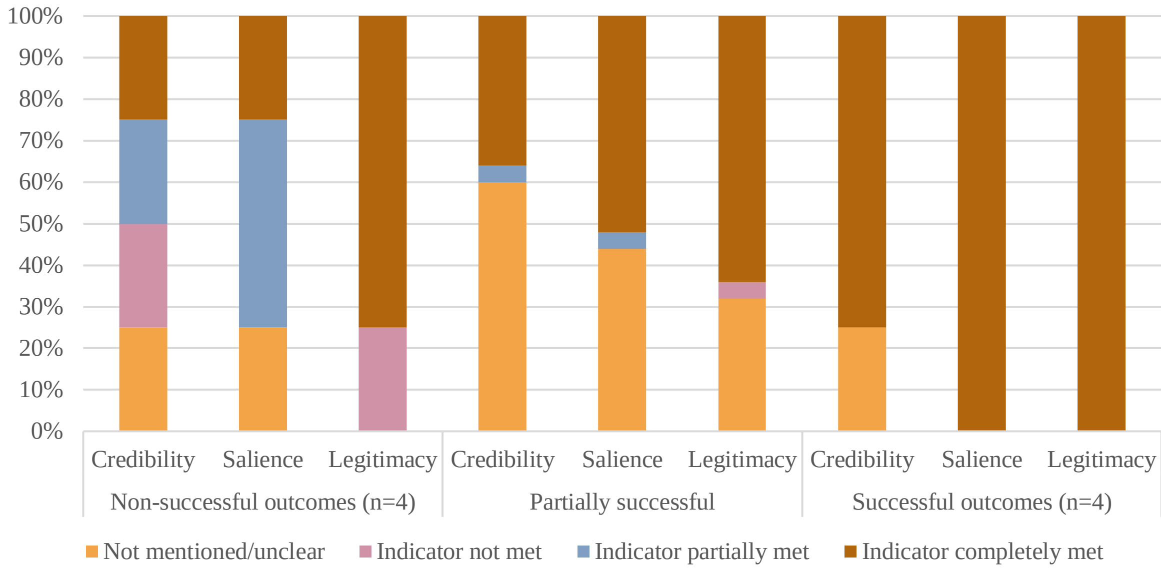
(ii) that there would be more cases with non-successful impacts and low outcomes indicator scores (i.e. indicators not met or not mentioned/unclear), than there would be cases with non-successful impacts and higher outcome indicator scores (i.e. indicators partially or completely met).

To verify if these hypotheses were supported by the findings, all cases in the sample were grouped according to the success of their impacts (from now on referred to as sub-samples). Both sub-samples (i.e. successful and non-successful impacts) consisted of four cases. For each sub-sample, it was calculated which parts of it obtained which outcome indicator score (i.e. not mentioned/unclear, indicator not met, partially met or completely met). This was done for the three indicators individually and was expressed in percentages of the sub-sample. The findings are presented in figure 4.3 (see below).

As can be observed from figure 4.3, there were more cases in the sub-sample with successful outcomes and high indicator scores than there were cases with successful outcomes and lower indicator scores. In fact, both salience and legitimacy were completely met in all four cases within the sub-sample, which means that (i) participating stakeholders perceived the co-created knowledge as completely relevant to their needs and conditions and (ii) that the process had been fully respective of divergent values and perspectives. Credibility was completely met in three of the four cases; in one case this indicator was not mentioned or remained unclear. These findings thus matched the first expectation.

Cases in the sub-sample with non-successful outcomes reflect a different image. First, all four indicator scores were obtained once (one in each case) for credibility, and thus showed no majority of high or low outcome indicator scores. Salience was completely met in one case, partially met in two cases and not mentioned/unclear in the fourth case. There was no case with non-successful outcomes in which salience was not met. Legitimacy was not met in one, and completely met in four cases. These findings did therefore not seem to match the second expectation.

**Figure 4.4 Correlation between dependent and intermediate variables**




Of course, the size of these sub-samples was too small to draw any firm conclusions on the expected causal relationship between outcome and impact indicators. Nevertheless, these findings did seem to reflect a more nuanced perspective on what was hypothesized: knowledge co-creation processes with successful outcomes are still likely to meet the three indicators of success, yet non-successful outcomes cannot necessarily be explained by a lack of these indicators being met. The most plausible explanation was that the negative influence of certain external factors on process outcomes may outweigh the positive influence of credibility, salience and legitimacy. Indeed, each of the four cases had its own reason for not having resulted in successful outcomes: (i) a perceived lack of resources (i.e. time, money and skills) that withheld participating actors from implementing the practices that emerged from the co-creation process, (ii) successful collaboration being hampered due to power imbalances between farmers, NGOs and state agronomists, (iii) financial and regulatory obstacles that impeded the implementation of innovative concepts that emerged from the process and (iv) farmers were already implementing and evaluating the most likely alternative farming options. Zooming in on the four cases with successful process impacts revealed some shared characteristics: participatory (on-farm) action research, co-design of both content (e.g. research concepts) and process (e.g. decision-making rules), an explicit link from research to implementation and, perhaps most importantly, a sense of belonging: "A key issue regarding stakeholder involvement appears to be whether the diverse stakeholders and researchers involved share the sense of being part of a community of fate that makes them feel individually affected yet also collectively attached to a shared problem (and possibly to a shared future). This collective attachment can be reinforced through the research-action process itself" (Article 53, p.1).

#### *4.2.2 CORRELATIONS BETWEEN KNOWLEDGE CO-CREATION PROCESS DYNAMICS AND OUTCOMES*

##### *4.2.3.1 PROCESS ORGANIZATION*

**Careful and representative selection of participants**

It was expected that if the selection of participating actors was careful and representative, perceptions of salience and legitimacy would be positively influenced (H4), in other words: cases in which this was the case were expected to reflect a higher score on salience and legitimacy than cases without such careful selection. Of the cases in which this indicator was completely present (n=31), the co-created knowledge was perceived of as salient in 52% and the process itself was legitimate in 68%. There was one case in the sample in which there was no careful and representative selection of participants, yet all three indicators of successful process outcomes were completely met. In the group of cases in which participant selection was not mentioned or remained unclear (n=34), the co-created knowledge was considered salient in 74% and the process by which this was generated legitimate in 88%. Thus, the hypothesis is not supported by these findings.

**Iterative and adaptive process design**

Perceptions of credibility, salience and legitimacy were expected to be positively influenced by an iterative and adaptive process design (H7). Of the cases with an iterative and adaptive process design (n=57), the co-created knowledge was perceived of as credible in 33%, salient in 67%, and the process as legitimate in 84% of the sample. There were no cases that did not meet the indicator of an iterative and adaptive process design, but there were cases in which such characteristic was not mentioned, or the iterative character remained unclear (n=8). In this group, all three scores on process outcome indicators were lower: 13%, 38% and 63% respectively. This may support the hypothesis.

**Organized reflection on roles and responsibilities**

Perceptions of salience and process legitimacy were expected to be positively influenced when an organized reflection on roles and responsibilities was part of the process (H8). In the group of cases where this was part of the process organization (n=25), knowledge was perceived of as salient in 76%, and the process itself as legitimate in 96%. In the group of cases where such reflection was not mentioned or remained unclear (n=42), these scores were lower: 55% and 67% respectively. These findings support the hypothesis.

#### *4.2.3.2 PROCESS CONDITIONS*

Three process conditions were considered as influencing process outcomes: (i) shared understanding of goals and problem definition, (ii) clarity on the role of researchers and their knowledge and (iii) presence of specific tangible and intangible resources. The following describes to what extent these process conditions indeed influenced process outcomes as expected according to the hypotheses presented in chapter two.

**Shared understanding on goals and problem definition**

It was expected that a shared understanding among participating actors on goals and problem definitions would positively influence perceptions of credibility, salience and legitimacy are positively influenced (H9). There was such shared understanding in 43 cases, in which the co-created knowledge was perceived of as credible in 33%, salient in 74% and the process itself legitimate in 95%. There were no cases that did not meet the process dynamics indicator of shared understanding, but there were cases in which such characteristic was not mentioned or remained unclear (n=18). In this group, all three scores on process outcome indicators were lower: 28%, 28% and 44% respectively. This may support the hypothesis. Yet, one critical remark was made with regard to the measure of arriving at a shared understanding, and was worth sharing: "[…] collaborative deliberation in building a shared understanding of the problem at hand and a socially relevant framing of it has the objective to reach consensus, which can be criticized as an unwarranted attempt at reducing the irreducible pluralism o perspectives and values. Instead, taking a pragmatist approach, the goal should not be to reduce the diversity of values and visions to any form of consensus that risks silencing dissenting voices, but rather to pay attention to disagreements" (Article 53, pp.5-6).

**Role of researchers and their knowledge is clear**

It was expected that when the role of researchers and their knowledge was clear, perceptions of credibility and legitimacy would be positively influenced (H10). The role of researchers and their knowledge was explicitly clarified in twenty cases, all considered legitimate. The co-created knowledge was deemed credible in 45% and salient in 85% of these cases.

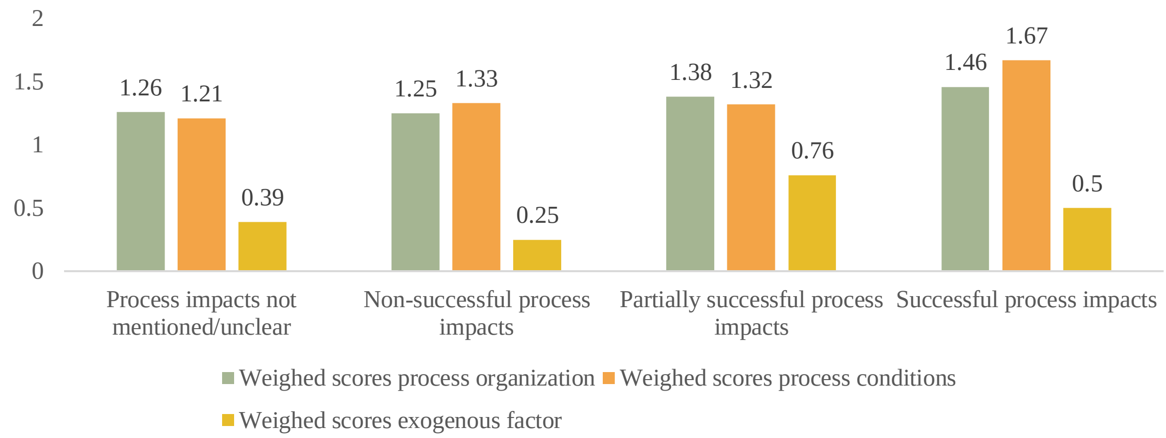
#### *4.1.3.3 EXOGENOUS FACTOR*

Regarding innovative reward structures, it was expected that its presence would positively influence legitimacy (H12). Legitimacy indeed showed the highest score in cases where such reward structures were completely present (n=14). However, cases where such reward structures were not present (n=6) had a higher score on legitimacy than cases where these reward structures were partially present (n=50). This seems to indicate that the presence of innovative reward structures does not always have a positive influence on legitimacy. The following quote from one of the cases illustrates a plausible explanation: "stakeholders were supposed to take part in both the orientation of research and the production of knowledge. However, the funding body decided not to fund this project partly because it considered the participating stakeholders to be non-representative. Although this was precisely what the research-action team aimed at - involving concerned and attached rather than (only) representative actors, this evaluation criteria reminds us that even in action-research programs, large and dominant stakeholders are considered more legitimate than small local stakeholders" (Article 53, pp.9-10).

#### *4.2.3 CORRELATIONS BETWEEN KNOWLEDGE CO-CREATION PROCESS DYNAMICS AND IMPACTS ON AGRO-ECOLOGICAL FARMING BEHAVIOR*

It was hypothesized that when the three indicators of knowledge co-creation process dynamics ((i.e. process organization, conditions and exogenous factor) were simultaneously met, process impacts would be positively influenced. More specifically, it was expected that the more these indicators were present in a knowledge co-creation process, the more successful its impacts would be (H13). With the goal of providing an overall picture of how indicators of process dynamics influenced process impact and, as such, verify if this hypothesis was supported by the data, an aggregate score was calculated for each of these three individual indicators. This was done in two steps: (i) calculating the average score per indicator for each individual case and (ii) calculating the average indicator score per type of process impact (i.e. impact not mentioned/unclear, non-successful, partially successful or successful). Note that earlier a question mark was attributed as a score in case an operationalization was not mentioned or remained unclear. These were set to zero in order to arrive at an aggregate score ranging from zero to two, where a zero indicates that a process dynamics indicator (e.g. organization, conditions or exogenous factor) was not present, and a two indicates that it was fully present. The findings are summarized in figure 4.5 below.

**Figure 4.5 Correlations between independent variable and dependent variable**



When comparing the aggregate scores from cases with non-successful process impacts with those with successful process impacts, an increase can be observed for process organization and the exogenous factors. This means that, indeed, process organization indicators were met to a larger extent in cases with successful process impacts, and that innovative reward structures were also present to a larger extent. This seems to support the hypothesis.

## 4.3 SYNTHESIS

This chapter aimed to answer the question sub-question three:

*To what extent have empirical examples of knowledge co-creation process dynamics among farmers and researchers as described in the current body of scientific literature in the context of agro-ecology been successful by having positively influenced agro-ecological farming behavior and which conditions contributed to their success?*

A sample consisting of sixty-nine scientific empiric analyses on knowledge co-creation in the context of agro-ecology was analyzed in order to explore the extent to which they had successful impacts by leading to the (re)design of agro-ecosystems based on ecological principles. These empirical examples of knowledge co-creation were successful to a very limited extent: 6% (n=4) of the cases obtained successful impacts. Participatory (on-farm) action research, the co-design of both content and process and a sense of belonging or attachment were shared features among these successful cases.

Partially successful impacts, i.e. increasing the efficiency of conventional farming practices or substituting them with agro-ecological practices, were obtained to a larger extent (36%, n=25). Another 6% of the sample obtained non-successful impacts, and in more than half of the sample the impacts were not mentioned or unclear. This seems to reflect an actual gap between co-created knowledge and its transformation into practice.

Analysis of the correlation between process impacts and outcomes revealed that in cases with successful impacts, process outcomes (i.e. credibility, salience and legitimacy) were met to the largest extent. The opposite was not true, as cases with non-successful impacts did not necessarily reflect the lowest scores on process outcomes. This finding did not support the initial expectation that the extent to which process outcomes were successful would explain the success of process impacts.

In more than half of the sample (61%) there was no mentioning of the extent to which the co-created knowledge was perceived of as credible, or it remained unclear. This suggests that, if the goal is to manifest changes in agro-ecological farming behavior while direct implementation following from knowledge co-creation is not feasible due to whatever reason, at least attention should be paid to validation with participating stakeholders.

# 5. VALIDATION OF FINDINGS

The fourth and last sub-question that needed to be answered was:

*To what extent is the theoretical image of how to successfully organize knowledge co-creation dynamics among farmers and researchers in terms of their outcomes and impacts relevant and applicable in practice?*

This question was answered by validating the research findings with farmers, researchers and agronomists in the empirical context of agro-ecological farming in Southern Spain.

As became clear from the previous chapter, shared features of cases with successful impacts were participatory and on-farm action research, co-design of both content (e.g. research concepts) and process (e.g. decision-making rules), and a sense of belonging. The question was thus if these factors would also be relevant and applicable in Southern Spain.

Two different activities aimed at the exchange and co-creation of agro-ecological knowledge served as the starting point for this validation process: a workshop on participatory monitoring of soil quality by means of visual soil assessment, and an Agro-Café where farmers could share their motivations, difficulties and expectations about the implementation of agro-ecological farming practices. Reason why these activities provided a good starting point, was that they differed considerably in their rationale and execution.

The first activity (i.e. participatory workshop), was part of a three-year PhD research project in which farmers were involved as co-designers of the content from an early stage. Its goal was to monitor regenerative (and thus agro-ecological) farming practices on plots owned by AlVelAl-farmers in a participatory fashion. This activity showed characteristics similar to the factors positively influencing successful impacts from knowledge co-creation processes and indeed explained why these workshops were very well attended by farmers as opposed to the Agro-Café.

# 6. CONCLUSIONS

The central research question that this research aimed to answer was:

**How are knowledge co-creation process dynamics among farmers and scientific researchers organized, to what extent do process outcomes explain the success of their impacts in terms of by positively influencing agro-ecological farming behavior and which conditions contribute to this success?**

This question was attempted to be answered by means of a systematic literature review, in which a sample of scientific empirical analysis on knowledge co-creation in the context of agro-ecology was analyzed based on a generic theoretical framework that described how knowledge co-creation processes are linked to their outcomes. This research added another layer by making the explicit link between process outcomes and impacts on agro-ecological farming behavior. Knowledge co-creation processes impacts were considered to be successful when they resulted in the (re)design of ago-ecosystems based on ecological principles. Cases were considered to have partially successful impacts when they had resulted in increased efficiency of conventional practices or their substitution with agro-ecological ones. There turned out to be more cases with partially successful impacts than successful impacts.

There was a link between successful impacts and high scores on process outcomes (i.e. credibility, salience and legitimacy), although the opposite link was not found for cases with non-successful outcomes (where a lower score on process outcomes was expected).

# 7. DISCUSSION AND RECOMMENDATIONS

This research has various limitations, of which some of them will be discussed here. First, the systematic literature review only consisted of scientific empirical analyses. Relevant work published on the topic by other stakeholders, e.g. resulting from farmer-led projects, were not included and may therefore provide a skewed image of the situation. Another major limitation is the fact that, although the attempt was made to conduct the systematic literature review as structured and transparent as possible, subjectivity could not be avoided entirely.

However, despite of these limitations, this research does seem to have contributed to theory in several ways. Knowledge gaps existed with regard to a synthesis of the link between agro-ecological farming practices and their results, and on a synthesis of how knowledge co-creation processes in the context of agro-ecology were linked to outcomes and impacts. This research aimed to contribute to filling this gap. It also contributed to the theory on joint knowledge production dynamics. Where the theory as formulated by Hegger et al. (2012) focused on the link between process conditions and outcomes, this research explicitly added a third relevant layer: process impacts.

The research findings also have implications for practice. One of them is based on the finding that more than half of the sample did not report any process impacts, or they remained unclear. This points towards a gap between the co-creation of knowledge and its transformation into practice, which was why this research was conducted in the first place. This implies the importance of making implementation an integral part of scientific processes. Also, there were more cases of knowledge co-creation with partially successful impacts (i.e. increased efficiency of conventional agricultural practices or their substitution with agro-ecological ones) than there were cases with successful impacts that were in line with agro-ecological principles (i.e. the redesign of agro-ecosystems based on agro-ecological principles). This suggest that the main focus still lies on implementation of agro-ecological techniques or practices, whereas this does not necessarily result in the support of ecosystem services. Therefore, this research is a call for a shift in focus from agro-ecological farming practices to agro-ecological principles, even more because it has the potential to alleviate the tension between ensuring robustness of scientific findings and local relevance that may arise from knowledge co-creation processes.

Permaculture seems a promising pathway for future research for at least two reasons. First, permaculture provides a set of principles and ethics to guide the design, implementation and maintenance of resilient agro-ecosystems (Krebs & Bach, 2018). These ethics and principles have been developed over decades, and are characterized by their universal character, meaning that they facilitate the upscaling of what works while ensuring that solutions are tailored to the local contexts in which they are implemented. Second, it remains a largely uncovered topic within the scientific realm.

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# 10. APPENDICES

## APPENDIX A. Search query

### A1. Search query matrix

| | Key concepts | | |
|---|---|---|---|
| **Concept alternatives** | *Process* | *Joint knowledge production* | *Agro-ecological farming practices* |
| *Synonyms* | Approach<br>Arrangement<br>Mechanism<br>Method | Knowledge co-production<br>Knowledge co-creation<br>Participatory knowledge production<br>Transdisciplinary knowledge co-production | Ecological agricultural practices<br>Regenerative agricultural practices |
| *Antonyms* | Content | Knowledge transfer<br>Linear model of expertise<br>Mode-1 knowledge production | Industrial agricultural practices<br>Intensive agricultural practices<br>Conventional agricultural practices |
| *Narrower terms* | Tool | Boundary organization<br>Boundary work<br>Knowledge exchange<br>Knowledge integration<br>Participatory research<br>Post normal science | Organic agricultural practices<br>Sustainable agricultural practices |
| *Broader terms* | Design | Mode-2 knowledge production<br>Participatory action research<br>Science-society interaction<br>Science-society interface<br>Social learning | Ecological intensification |

### A2. Boolean search string

( TITLE-ABS-KEY ( ( agroecol* OR "agroecological farming" OR "ecological farming" OR "regenerative farming" OR "sustainable farming" OR "conservation farming" OR "biodiversity farming" OR "nature inclusive farming" OR "permaculture" OR "community supported agriculture" OR "ecological intensification" OR "sustainable intensification" ) AND ( "joint knowledge production" OR "knowledge co-production" OR "knowledge co-creation" OR "knowledge exchange" OR "participatory action research" OR "participatory science" OR "participatory research" OR "action research" OR "mode-2" OR "social learning" ) ) ) AND ( farmer OR peasant OR smallholder )

# APPENDIX B. Database

### B1. Final database (sorted on highest to lowest citation rate)

| Article | Reference | Cited by |
|---|---|---|
| 1 | Rockström, J., Kaumbutho, P., Mwalley, J., Nzabi, A. W., Temesgen, M., Mawenya, L., . . . Damgaard-Larsen, S. (2009). Conservation farming strategies in east and southern africa: Yields and rain water productivity from on-farm action research. Soil and Tillage Research, 103(1), 23-32. doi:10.1016/j.still.2008.09.013 | 139 |
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**Appendix B. Operationalization of indicators for success**

CREDIBILITY

| CODE | MEANING | OPERATIONALIZATION | EXAMPLE |
|---|---|---|---|
| 2 | Criterion completely met | Participating actors perceived of the co-created knowledge as valid (either expliticly or implicitly) | "The methodological challenge was to train a large number of research teams sufficiently well to take consistent, unbiased measurements in highly variable ecological conditions […] As a field-check-farmer-owners accompanied the research team during the data collection on both sustainable and conventional farms, signing off on the field sheet to indicate that in their view, observations and measurements were unbiased." (Article 2, p.91) |
| 1 | Criterion partially met | Participating actors perceived of the co-created knowledge as partially valid | "Farmers largely agreed with the suitability classes but still came up with some striking differences of which two examples are given […] This important detail on site-specific effects could never be captured in the expert land evaluation." (Article 16, p.338)<br><br>"All of the actors who had attended the workshops seemed to share a common vision of the IP as a space for coming together and exchanging information and experiences about CA […] The IP workshops also provided an occasion for some stakeholders to express their doubts, particularly in relation to the CA technical model, regarding the feasibility of obtaining permanent soil cover and of consequently modifying rules on access and management of crop residues." (Article 66, pp.467-468) |
| 0 | Criterion not met | Participating actors did not perceive of the co-created knowledge as valid | "In addition, the evidence presented suggests that the external validity of the program's approach could be limited. Biases in the targeting of beneficiaries are clearly evidenced where technologies are being tested with a limited subpopulation. This could be the implicit intention of the program in light of operational realities on the ground. However, given the rhetoric of scaling up technologies based, in this case, on trials involving selected smallholders, adoption rates and subsequent effects may fall short of expectations when "successful" technologies are scaled up. This is a common problem in many agricultural technology programs that is still not fully recognized: while the objective of promoting large-scale technology solutions is often praised, it is probably rare that partners testing those solutions actually have the capacity to target large populations and tailor them to their specific needs." (Article 48, p.324) |

**SALIENCE**

| CODE | MEANING | OPERATIONALIZATION | EXAMPLE |
|---|---|---|---|
| 2 | Criterion completely met | Participating actors perceived of the co-created knowledge as relevant (either expliticly or implicitly) | "[…] These meeting points facilitated mutual recognition, and enhanced the feeling that they were not as alone as they had thought. Problems, causes and threats identification, as well as possible solutions were shared. This mutual recognition was useful not only for the process itself and for the solution of the preliminary problems identified; it also generated a network of trust and mutual support relationships between local and external actors." (Article 12, p.381) |
| 1 | Criterion partially met | Participating actors perceived of the co-created knowledge as partially relevant | "The benefits to the farmer lie in the introduction of new land use alternatives through the conventional land evaluation approach. However, few alternatives could be defined in this specific environment because farmers were already trying out and evaluating most likely options." (Article 16, p.341) |
| 0 | Criterion not met | Participating actors did not perceive of the co-created knowledge as relevant | |

**LEGITIMACY**

| CODE | MEANING | OPERATIONALIZATION | EXAMPLE |
|---|---|---|---|
| 2 | Criterion completely met | The process of knowledge co-creation has been fully respectful of divergent values and beliefs of participating stakeholders, unbiased in its conduct and fair in its treatment of opposing views and interests | |
| 1 | Criterion partially met | The process of knowledge co-creation has been partially respectful of divergent values and beliefs of participating stakeholders, unbiased in its conduct and fair in its treatment of opposing views and interests | |
| 0 | Criterion not met | The process of knowledge co-creation has not been respectful of divergent values and beliefs of participating stakeholders, unbiased in its conduct and fair in its treatment of opposing views and interests | "Interviews with agricultural extension workers in Omusati and other Northern regions tended to confirm a lack of engagement with the land unit system. For instance, one extension worker conceded, "we go in with our own knowledge, we do not use the indigenous knowledge in our work"." (Article 7, p.766) |