



Bridging the gap between the agroecological ideal and its implementation into practice. A review

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Abstract

Despite the increasingly widespread use of the term agroecology by farmers, scientists, agrarian social movements, and lawmakers, the definition of the concept is still the object of controversies. Current interpretations range widely, from fully transdisciplinary and interdisciplinary definitions integrating ecological, socioeconomic, and political dimensions of agriculture, to more narrow definitions of agroecology as a discipline bridging ecology and agronomy. No less importantly, few actors have developed criteria and methodologies to identify and evaluate agroecological systems based on both ecological and socioeconomic dimensions. The lack of consistency in the study and application of “agroecology,” resulting from varying definitions for agroecology and the absence of standardized methodologies to identify agroecological systems, is problematic. It limits the recognition of associated benefits and disadvantages of different agroecological systems, as well as the identification of drivers that favor the implementation of agroecological practices. While lessons learned from individual case studies are valuable and showcase the potential of agroecology, results are not always relevant to other contexts. Here, we review existing theoretical and empirical agroecological literature. The major points that emerge are the following: (1) we integrate six historical ecological principles with seven socioeconomic principles to propose an overarching framework for recognizing systems oriented towards agroecology; (2) the implementation of different principles may vary greatly across spatial scales or governance contexts; (3) there are numerous barriers that farmers may face in their transition towards an agroecological “ideal”—this highlights the need for improved recognition of systems in transition, as well as the need for supportive policies to scale up agroecology. The application of two complementary methodological approaches presented in our review has the potential to help practitioners evaluate to what extent a system can be considered as agroecological based on ecological and socioeconomic principles.

Keywords Agroecology · Social justice · Food justice · Socioeconomic principles · Participative research · Pragmatic sociology · Agroecological principles · Agroecological practices · Agroecological indicators

Contents

1. Introduction
2. Methodology
3. The agroecological ideal in six ecological and seven socioeconomic principles
 - 3.1 Six ecological principles
 - 3.2 The socioeconomic dimensions in the agroecological literature
 - 3.3 Seven socioeconomic principles
 - 3.4 Principles for the design of diversified farming and food systems
4. Agroecology: between principles and practices
 - 4.1 Variation in the implementation of principles
 - 4.2 Synergies and tensions between agroecological principles
 - 4.3 The need for political support to scale up agroecology
5. Identification and evaluation of agroecological systems on the basis of the principles
 - 5.1 Towards a social justice horizon: the justification of practices model to identify orientation towards agroecology
 - 5.2 A participatory assessment to evaluate the implementation and measured benefits of agroecological principles

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5.3 Complementarities, benefits and limits of both approaches

6. Conclusion

1 Introduction

Despite limited support for agroecology at its inception in the early 1980s, the concept has gained traction in recent years. Scientific publications on agroecology have strongly increased after the 2000s (Fig. 1 in Wezel and Soldat (2009)), while at a political level, major agrarian social movements have adopted the concept—including the international movement La Via Campesina and numerous farmer organizations and unions (Declaration of the International forum for Agroecology 2015). Agroecology has further been showcased as a potential solution to current environmental and social crises faced by mainstream food systems by multi-lateral agencies like the Food and Agricultural Organization of the United Nations (HPLÉ 2019; Loconto and Fouilleux 2019), and has been included in the national political agendas of countries such as Brazil, France, and Uruguay.

While the increased use of the term agroecology appears to be unquestionable, a cohesive and widely recognized definition of the concept remains lacking, as has been pointed out by various authors (Stassart et al. 2012; Ollivier and Bellon 2013; Dumont et al. 2016; Méndez et al. 2016; Norder et al. 2016; Elzen et al. 2017; Migliorini and Wezel 2017). Proponents of a broader interpretation consider agroecology as a transdisciplinary and interdisciplinary approach which espouses the socioeconomic and political dimensions of agroecology and recognizes the importance and legitimacy of experiential and indigenous knowledge in addition to scientific knowledge (Montenegro de Wit and Iles 2016). From an academic point of view, this approach is defended by the founders of the concept, even if their first definitions focused on ecological processes at the plot and farm level (Altieri 1983, 1995; Reijntjes et al. 1992), before eventually widening from the plot scale to the global food system scale over time (Francis 2003; Rickerl and Francis 2004; Wezel et al. 2009; Gliessman 2016). Due to the evolution of this definition of agroecology, assessment of the agroecological dimension of food and agricultural systems should comprise principles acknowledging the socioeconomic dimensions of agroecology that have emerged through interactions between civil society, social movements, and scholars (Loconto and Fouilleux 2019).



Fig. 1 Illustration of a diversity of systems often presented as agroecological. Four examples are illustrated here. **a** Associated crops in vegetable cultivation in Burkina Faso. **b** Direct sales of vegetables. **c** Exchanges of knowledge in Kivu (RD Congo). **d** Mixed cropping in Belgium

In contra, authors external to the historical agroecological scientific community push forward a narrower definition of agroecology as a discipline merging ecology and agronomy. This view neglects sociopolitical aspects such as the autonomy of agroecological actors from agri-food businesses or their participation in solidarity economies (Soussana 2013; Lampkin et al. 2015; International agri-food network 2018). In this second approach, agroecology is defined as “mainly a science,” in opposition to the triple nature of agroecology as stated by Wezel et al. (2009): a science, a movement, and a set of practices. The narrower definition of agroecology as a science-based set of practices is mainly present among European and North American authors, whereas wider interpretations may be more common in Latin American literature on agroecology (Altieri and Toledo 2011; Altieri and Nicholls 2017).

Likely due to the tensions between these two interpretations, few actors have developed criteria and methodologies to identify and evaluate agroecological systems according to its founding principles (Teixeira et al. 2018). This is compounded by the inherent diversity and adaptive nature of global agroecological systems (Tittonnell 2015; Nicholls et al. 2016), which are thus difficult to measure and qualify in a consistent way (Migliorini and Wezel 2017).

This absence of a cohesive definition of agroecology and of related criteria to identify and evaluate agroecological systems is problematic for two reasons. First, it has resulted in a lack of qualification and quantification of benefits and disadvantages of agroecological systems, and of analyses of agroecological pathways. This may lead to missed opportunities in terms of understanding the potential benefits of agroecology, and may limit possibilities of scaling up the adoption of agroecological practices. In contrast, many methods are available to assess the sustainability of agricultural systems. These methods are generally based on impact- or means-indicators rather than on principles, as is the case for agroecology (López-Ridaura et al. 2002; Lebacqz et al. 2013; Schader et al. 2014; Slätmo et al. 2017; Smith et al. 2017). Second, systemic analyses of agroecological systems are lacking: most existing research reduces agroecology to few practices (D’Annolfo et al. 2017; Garibaldi et al. 2017). Such reductionist approaches may ignore innovative agroecological farms where newly developed practices do not easily fit existing assessment frameworks based on well-established practices. Moreover, focusing on single practices further limits the possibility of understanding the impacts of interactions between multiple agroecological practices (D’Annolfo et al. 2017).

In this review, we aim to better equip researchers to identify and evaluate agroecological systems. Our specific objectives are twofold: (1) to develop a comprehensive definition of agroecology as an ideal, and which integrates ecological principles of agroecology with important socioeconomic dimensions (Section 3); and (2) to propose methodologies to evaluate whether a given system can be considered as agroecological, without reducing agroecology to few practices (Fig. 1; Section 5).

To this end, we first conducted a literature review focused on the socioeconomic dimensions of agroecology (Section 2). We next develop seven socioeconomic principles that supplement already established ecological principles for the design of farming and food systems, and present these principles in a normative way, i.e., as the theoretical ideal of agroecology (Section 3). We then discuss the gap between these normative principles of agroecology and their multiple empirical applications. This will lead us to highlight barriers that the plurality of agroecological systems face on their way to the agroecological ideal, and to draw attention to the shortfalls of alternative agroecological approaches aiming to by-pass mainstream markets and institutions (Section 4). Finally, we present and discuss two complementary methodologies designed to assess whether a system is agroecological, and which also acknowledge the difficulties that actors can encounter when trying to apply agroecology in current socioeconomic and political contexts (Section 5).

Notice that the socioeconomic dimensions discussed in this article are termed *socioeconomic* and not *policy* dimensions. In our opinion, socioeconomic issues are fundamental reflections of policy decisions. Nevertheless, here, we choose to differentiate between (1) the suggested socioeconomic and ecological principles, which aim to inform the design of agroecological systems, and (2) broader policy principles, which aim to define suitable institutional frameworks to scale-up agroecology (e.g., Blesh and Wolf 2014; Kerr et al. 2019). In other words, policy principles define pathways to support food systems actors in the adoption of socioeconomic and ecological principles of agroecology. Our main objective is to develop a relevant methodology for the assessment of food and agricultural systems from an agroecological perspective. Consequently, we have favored an operational approach in our definition of the principles of agroecology, which is nevertheless complementary to an institutional approach.

2 Methodology

We first conducted a literature review of scientific publications discussing the socioeconomic dimensions of agroecology, either exclusively or jointly with ecological dimensions. Our literature review also includes publications which recognize (1) the interdisciplinary and transdisciplinary dimensions of agroecology, (2) political criticism of the “productivist” systems developed by the founders of agroecology, and (3) the legitimacy of different knowledge systems (e.g., indigenous, experiential, academic) in building agroecological systems. To identify corresponding studies, we ran a title, abstract, and keyword search using the terms ‘agroecology’ AND ‘principles’ AND (‘sociological’ OR ‘economic’ OR ‘socioeconomic’) in the Scopus database on December 20, 2018. This search yielded 76 articles. Our review further

included all publications citing two studies which have previously developed the twofold aims of our article (Dumont et al. 2016, Dumont 2017), as well as published material about the principles developed by agroecological peasant movements, particularly the Declaration of the International Forum for Agroecology (2015). As a second step, specific studies were added to delve into more specific questions. To formulate our proposed socioeconomic principles, we first surveyed this literature to identify relevant themes, then developed each theme into the principles presented here. Our review covers existing literature published in English and French. Comments and feedback received while presenting our results at conferences and seminars and discussing them with non-profit organizations were taken into account in our final text.

3 The agroecological ideal in six ecological and seven socioeconomic principles

While the concept of agroecology has been around since the beginning of the twentieth century (Wezel and Soldat 2009; Wezel et al. 2009), the ecological principles designed by Altieri (1983, 1995) are generally recognized as a basis to design current agroecological farms (Stassart et al. 2012; Bellon 2016; Migliorini and Wezel 2017). In this section, we first provide a brief overview of these principles (Section 3.1). We then review the inclusion of socioeconomic aspects in existing agroecological literature (Section 3.2). In the last subsection, we present seven socioeconomic principles which we developed based on our literature review (Section 3.3). We frame our discussion of these agroecological principles on a normative basis, i.e., relating to a *theoretical* ideal. In the next section, this ideal will be discussed in relation to field *realities*.

3.1 Six ecological principles

Principles have always played a key role in agroecology, as much for scientists as for practitioners and social movements. They are used as a guide to design agroecological practices, to discuss transition pathways, and to understand the operation of agricultural systems (Stassart et al. 2012; Bellon 2016; Nicholls et al. 2016; Migliorini and Wezel 2017). While early authors acknowledged the importance of the socioeconomic and political conditions which farmers experience, the science of agroecology primarily began with the synthesis of ecology and agronomy, and with the identification of ecological principles to apply to the design of farming systems. These principles were adapted by Altieri (1995) from research on low-external input agriculture (Reijntjes et al. 1992). They were then further developed to include new knowledge on the ecology of agricultural farming systems, landscapes, and territories (Gliessman 1997, 2014; Nicholls et al. 2016;

Migliorini and Wezel 2017). More recently, they were summarized in six ecological principles (Nicholls et al. 2016; Rosset and Altieri 2017), which concern biomass recycling, strengthening of resilience through ecological pest and disease management, enhancing favorable soil conditions for plant growth, minimizing losses of resources, promoting diversification at species and genetic scales, and enhancing of synergies and biological interactions (Table 1). These ecological principles are widely recognized as the basis of agroecology nowadays (e.g., Stassart et al. 2012; Bellon 2016; Migliorini and Wezel 2017). Some scientists have adapted them more specifically (Bellon 2016), for instance, to animal production (Dumont et al. 2013) and to crop livestock farming systems (Bonaudo et al. 2013).

Ecological indicators/principles are more difficult to define at a multi-scale level than socioeconomic indicators (Dumanski et al. 1998). Still, ecological principles should not be interpreted narrowly. Even if they were originally designed at a farming system level, some principles could inspire the definition of agroecological systems' characteristics at other levels, such as the food system level. For instance, an "agroecological" food system might optimize logistics to favor recycling and might minimize the use of external inputs (e.g., petrol, plastic) (Vaarst et al. 2018).

3.2 The socioeconomic dimensions in the agroecological literature

Agroecology emerged not only out of concerns regarding the negative environmental impact of the industrial agricultural models developed after the second World War but also out of a preoccupation with the social and economic situation of small-scale farmers in the context of agricultural modernization (Altieri 1983, 2002; Conway 1987; Tripp 2008). The ecological principles of agroecology were consequently designed to protect both the environment and farmers. For instance, diversification of farming systems increases ecosystem resilience, providing a buffer against pest and disease, which in turn can help farmers to keep their independence from markets and protect them from socioeconomic shocks (Altieri 2003; Koohafkan et al. 2012; Nicholls and Altieri 2012; van der Ploeg 2012 in Dumont et al. 2016). In the 1990s, the socioeconomic dimensions of agroecology started to become more explicit in scientific publications, as the focus of research expanded beyond the concept of agroecosystems towards the broader concept of food systems. This includes aspects ranging from production to organizational and commercial dimensions (Wezel and Soldat 2009).

Yet, unlike ecologic dimensions, socioeconomic dimensions of agroecology have never been systematized into clear principles by scientists (Dumont et al. 2016), although two recent studies have started to explore this. In Stassart et al. (2012), members of the Interdisciplinary Agroecology

Table 1 Six ecological principles (Nicholls et al. 2016 as adapted from Altieri 1983, 1995; Reijntjes et al. 1992) and seven socioeconomic principles (build upon the literature mentioned in Sections 3.2 and 3.3) of agroecology

The ecological principles	The socioeconomic principles
1. Enhance the recycling of biomass , with a view to optimizing organic matter decomposition and nutrient cycling over time	7. Offer good living and working conditions for agroecological practitioners of the defined system, including through the use of the profits obtained from economic activity to remunerate workers and reach social objectives rather than to maximize the return on the capital invested
2. Provide the most favorable soil conditions for plant growth, particularly by managing the organic matter and by enhancing soil biological activity	8. Participate in the development of social embeddedness of food systems through farmer, consumer, extension, and scientific networks that support (in) organic inputs exchanges (e.g. compost, machinery, knowledge) and the exchange of output based on solidarity economy
3. Minimize losses of energy, water, nutrients and genetic resources by enhancing conservation and regeneration of soil and water resources and agrobiodiversity	9. Contribute to the development of local food systems , by promoting local employments and local technologies, by minimizing distances between production, transformation and commercialization steps, and by promoting physical, intellectual and economic access to local markets.
4. Strengthen the “immune system” of agricultural systems through enhancement of functional biodiversity – natural enemies, antagonists, etc., — by creating appropriate habitats	10. Create collective knowledge by recognizing the value of traditional, empirical, scientific knowledge and know-how, and by facilitating their exchanges between actors applying agroecology, including between peers and between generations
5. Diversify species and genetic resources in the agroecosystem over time and space at the field and landscape level	11. Take decisions based on democratic models implying balanced power relations between system actors, horizontal exchanges, transparent relationships, non-racial, sexual, gender, religious and cultural discrimination, and no decision based on members’ assets
6. Enhance beneficial biological interactions and synergies among the component of agrobiodiversity, thereby promoting key ecological processes and services	12. Ensure autonomy in terms of viability and decision making from markets, economic actors (e.g. clients, agrifood businesses), and policies (e.g. subsidies) up and downstream of the system, and more particularly from actors external to the agroecological approach
	13. Participate in political actions to promote agroecological principles and the conditions of their applications

Research Group of the FNRS in Belgium develop a first approach, suggesting three socioeconomic principles of agroecology while highlighting the need for deeper investigation. Dumont et al. (2016) go a step further, identifying 13 socioeconomic topics from popular and scientific agroecological literature, and from the literature developed by other movements oriented towards agroecology (agricultural movements promoting alternatives to conventional agriculture, as well as the fair trade, cooperative, and social and solidarity economy movements). They then suggest a broad definition for each topic concordant with the agroecological literature, and discuss their empirical implementations to clarify how to build upon socioeconomic principles. The relevance of these 13 topics has been discussed in conferences and with farmer organizations, and they have been applied in different contexts (CIDSE 2018; Heinisch 2018; Tessier et al. 2020).

While scientists have poorly tackled the socioeconomic dimensions of agroecology, social movements and associations have picked up and expressed these dimensions into charters and declarations. For instance, this is the case of the international social movement La Via Campesina (2017) and the CIDSE (2018) gathering of 18 organizations fighting for climate and food justice around the world. In 2015, a large group of organizations and social movements (Coordination nationale des organisations paysannes du Mali, La Via Campesina, Mouvement Agroécologique en Amérique latine et aux Caraïbes, Réseau des organisations paysannes et de producteurs de l’Afrique de l’Ouest., World Fisher Forum, World Forum of Fisher Peoples, World Alliance of Mobile Indigenous Peoples, and Movimento de Atingidos por Barragens) organized an International Forum on Agroecology in Nyéleni, Mali, and wrote a declaration in

which socioeconomic and political principles are central (International Forum on Agroecology's members 2015). Scientists, organizations, and social movements recognize the triple dimensions of agroecology: as a science, a movement, and a practice (Wezel et al., 2009). There is active discussion and literature exchange among these diverse actors, and thus the socioeconomic principles are built on feedback between scientific and popular literature.

3.3 Seven socioeconomic principles

Building upon the agroecological literature (mentioned in Sections 3.2 and 3.3), we define seven socioeconomic principles to complement the historical ecological principles of agroecology (Table 1). The socioeconomic principles are meant to be applied to a clearly defined system, typically a farming or a food system. Since we presented the ecological principles of agroecology in their original version, i.e., defined at the farming system level, we present our socioeconomic principles at this same level to facilitate discussion.

- *Principle 7* includes aspects of livelihood, health, and well-being that have been central to agroecology from its inception (Gliessman 2007; Pimbert 2015; Timmermann and Félix 2015; van der Ploeg 2016). Through our use of the terms “good living and working condition,” we additionally include aspects less discussed in the agroecological literature, e.g., quality of labor contracts, work-life balance (Dumont and Baret 2017), with the goal of more broadly addressing the different priorities of agroecological practitioners. We define working conditions broadly, as the framework allowing people to decently fulfill their needs through working experiences. We recognize that these experiences pertain not only to task performance but also to interpersonal relations and social expectations (de Nanteuil 2016).

- *Principle 8* highlights the importance of (formal, such as cooperatives, or informal) social networks and social movements—for instance, through promoting the exchange of organic inputs, like compost (Dumont et al. 2016), materials (Lucas et al. 2019), or knowledge (Holt-Giménez 2006)—to favor the implementation of agroecological principles. Such social networks are fundamental to sensitize consumers to the realities of agricultural production and to establish fair prices (Gliessman 2007; Passos dos Santos and Chalub-Martins 2012). They can further support solidarity economies that promote exchange of goods and knowledge based not only on market principles but also on reciprocity and redistribution (Laville 2005).

- *Principle 9* highlights the need to locally anchor food systems (Gliessman 2007), for instance by favoring physical (e.g., roads, transport means), intellectual (e.g., information, knowledge), and economic (e.g., fee) access to local markets (Arango et al. 2020), to avoid negative externalities on the environment and favor direct relationships between food system actors.

- *Principle 10* recognizes the need for knowledge creation and acquisition mechanisms that are accessible, for instance, thanks to knowledge exchange through inter-generational, peer-to-peer networks, and *campesino a campesino* movements (Méndez et al. 2013; International Forum on Agroecology's members 2015). Experiential and indigenous knowledge is considered equally important to scientific knowledge for the design agroecological systems. Furthermore, the particularly knowledge-intensive nature of agroecology compared to other farming approaches has been recognized (Altieri 2003; Koochafkan et al. 2012; Stassart et al. 2012; van den Berg et al. 2018).

- As highlighted by *principle 11*, scientists and social movements insist on recognition of cultural particularities, on non-discrimination, and on transparent and horizontal relationships between food system actors to build agroecological democratized food systems (International Forum on Agroecology's members 2015; Pimbert 2015; CIDSE 2018). However, the necessity of insisting on democratic governance to manage relationships between farmers and farmworkers, or between family members working in agriculture, has not yet been widely recognized in existing literature (we highlight that development agencies prioritizing agroecology, or Dumont and Baret (2017), are notable exceptions here). The democratic governance principle is often mentioned from a political perspective rather than from a socioeconomic perspective. Scientists and social movements suggesting political strategies to scale up adoption of agroecology highlight the necessity of more democratic governance to strengthen farmers' decision-making rights (Wittman, 2011; Vaarst et al., 2018).

- The five socioeconomic principles described above refer to relationships between agroecological actors *within* and *across* studied systems. In contrast, *principles 12* and *13* refer to interactions between *agroecological* actors and *non-agroecological* actors. *Principle 12* focuses on the need for autonomy (e.g., from political or market structures) (Nicholls and Altieri 2012; van der Ploeg 2012; La Via Campesina 2015) in order both to avoid depending on the mainstream food system and to avoid financing it (Migliorini and Wezel 2017). *Principle 13* links socioeconomic principles with broader political strategies, especially regarding food sovereignty which is recognized as one of the main strategies allowing farmers to put agroecology into practice (Holt-Giménez and Altieri 2013; International Forum on Agroecology's members 2015). This last principle seeks to address social movements' demands for amplification of agroecology.

3.4 Principles for the design of diversified farming (and food) systems

Rosset and Altieri (Rosset and Altieri 2017, pp. 19–21) summarize the role of the ecological principles as follows:

“Agroecologists use well-established ecological principles for the design and management of diversified agroecosystems, where external inputs are replaced by natural processes such as natural soil fertility, allelopathy and biological control. When applied in a given location, *principles take different technological forms or practices* depending on the local socioeconomic needs of farmers and their biophysical circumstances, resources on hand, etc. Once applied, the practices set in motion ecological interactions *that drive key processes for agroecosystem function* (nutrient cycling, pest regulation, productivity, etc.). Each practice is linked to one or more principles, thus contributing to their manifestation in function of the agroecosystems”.

Together, these processes improve plant health, enhance the soil fertility, increase total productivity, and enhance general agroecosystem resilience (Rosset and Altieri 2017).

Similarly, and as we will illustrate (Section 4.1), the suggested socioeconomic principles *take different forms and practices* when applied in different locations. In addition, the literature suggests that *these practices drive key processes for food systems function*: equitable distribution of resources, political power, and economic and social benefits between system’s actors and with future generations (Gliessman 2007; Koohafkan et al. 2012; Vaarst et al. 2018), recognition of actors’ diverse contributions, knowledge, and preferred practices (Altieri 2003; Gliessman 2007; Coolsaet 2016), etc.). These processes bring social equity and food security, and enhance the adaptive capacity of the farming (or food) system (Fig. 2).

4 Agroecology: between principles and practices

The present section tackles the complex relationship between principles and practices of agroecology. We first assess factors driving variation in the practical implementation of principles (Section 4.1), and further discuss the tensions and synergies that arise between diverse practices and their related principles when applied in current global contexts (Section 4.2). This will lead us to highlight barriers that the plurality of agricultural systems may face when trying to implement agroecological principles, and to draw attention to the limitations of current alternative approaches aiming to by-pass mainstream markets and institutions to design agroecological systems (Section 4.3).

4.1 Variation in the implementation of principles

Implementation of the ecological and socioeconomic principles of agroecology defined in Section 3 can vary widely according to different factors. First, it is highly dependent on the spatial scale of analysis. Across territories, observed

practices implemented in agroecological systems vary depending on geographic, socioeconomic, and cultural factors. For instance, from an ecological perspective, *principle 3* (good soil conditions) may be met through worm composting in one context, while in another it might be through planting green manure (Rosset and Altieri 2017). From a socioeconomic perspective, farmers in developing market economies often practice family-level food subsistence, which contributes to *principle 7* (good living and working conditions) (Heinisch 2018). In contrast, in more developed market economies, this practice is often absent or marginal, and the attainment of *principle 7* might be dependent on adequate market valorization of farm products.

At the territory scale, even though there may be similarities in terms of geographical, socioeconomic, and cultural features, actors’ implementation of agroecological principles can take different forms and is dependent on practitioners’ personal history, access to resources (land, labor, etc.) and markets, or personal motivations and preferences (Galt 2008; Dumont et al. 2016; Rosset and Altieri 2017). For instance, one farmer may address *principle 12* (autonomy from mainstream markets) by selling produce to a Community-Supported Agriculture (CSA) structure, while another might prefer to focus on multiple market channels to avoid dependence on a single group of consumers (Dumont et al. 2016).

In addition, farming and food system practices are susceptible to vary with time and policies as geographical, socioeconomic, and cultural contexts, and preferences, history, and access to resources (e.g., Singh et al. 2016) are affected by policies and evolve over time. A CSA developed to fulfill *principle 12*, for instance, may be no longer helpful years later as shown in a previous study in the Walloon region (Dumont and Baret 2017). The study documents some vegetable producers’ decisions to sell vegetable boxes to collective buying groups known as “GACs” in French with the goal of by-passing mainstream markets (*principle 12*), obtaining fairer prices (*principles 7 and 8*), maintaining flexibility in terms of crop choices (*principles 1, 3, 4, and 5*), generating cash flow (*principle 7*), and anchoring marketing routes locally (*principles 8 and 9*). In the 2000s, the implementation of these principles was possible as GACs gathered consumers willing to support producers and to accept some constraints (such as to commit to an annual subscription and organize the distribution of the vegetables). By about 2015, increased governmental support for shorter food chains led to an expansion in the number of actors directly selling vegetable boxes, which included not only small farmers but also retailers, internet platforms, social enterprises, etc. The resulting increase in supply generated increased competition and new conditions of sales, as providers started to offer vegetable boxes with more appealing conditions for consumers (e.g., delivery at home, possible choice of the vegetables, no subscription required). This ultimately brought the “vegetable-box market” model closer to that of already-existing classical markets. This shift

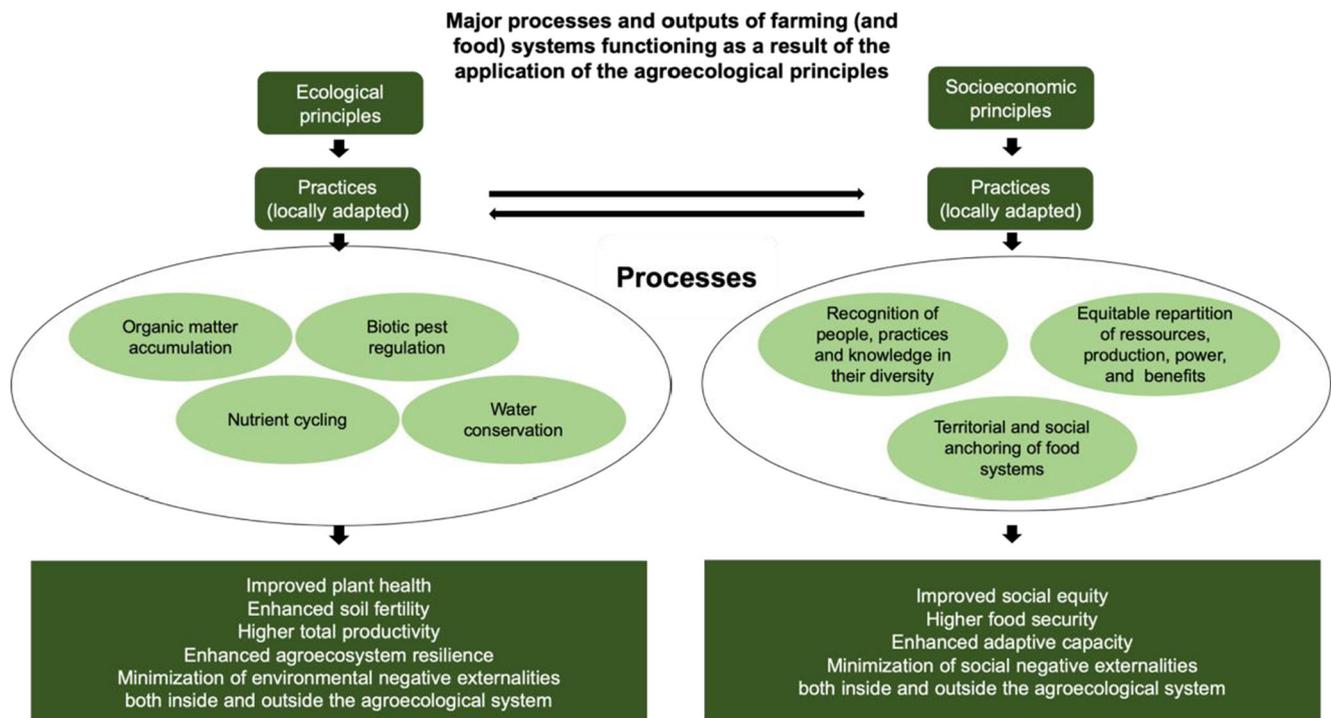


Fig. 2 The socioeconomic and ecological principles of agroecology take the form of diverse practices locally adapted. These practices drive key processes and produce final outputs. The figure is adapted from Nicholls et al. (2016)

has directly affected agroecological producers as part of their consumers became less accepting of the constraints associated with the initial GAC model. Selling vegetable boxes started out as a good strategy to implement many agroecological principles at once. Nevertheless, a decade later, some agroecological farmers have adapted to shifts in market and policy conditions and switched their distribution to farm stores. These provide more protection from competition and allow for a more efficient implementation of the agroecological principles given present conditions in Belgium. This example illustrates that agroecological actors need to continuously adapt their practices to macro and local contexts' evolution to fulfill the principles.

Ultimately, any one principle can be implemented differently at food or farming system level (Vaarst et al. 2018), and within dimensions of the same system (e.g., production, commercialization, or organization and governance). For example, at the production level, a farmer can work towards achieving *principle 12* (autonomy from markets) by processing grain into bread to lessen dependence on international fluctuations of grain prices. At the commercial level, the same principle can be addressed by selling farm products to a CSA (Dumont et al. 2016).

4.2 Synergies and tensions between principles and practices

Theoretically, the application of *all* agroecological principles defines a system as agroecological (Stassart et al. 2012).

Agroecological practices can contribute to addressing one or several of these principles and together, principles and practices form a holistic set of guidelines (principles), and flexible tools (practices) which can be used by farmers to achieve agroecological ideals.

Empirically, various studies have underlined convergences across principles and practices, as illustrated through our example about vegetable boxes sold to GACs in which Belgian producers meet *principles 1, 3, 4, 5, 7, 8, 9, and 12* through collective buying groups. Similar examples exist in other contexts. For instance, Heinisch (2018) documents the organization of a "community basket" in Chimborazo, Ecuador, which directly links urban consumer groups with agroecological farmers with the assistance of a local non-profit organization. This community basket emerged from a sociopolitical context favoring food security and sovereignty, cultural identity, and solidarity economy in Ecuador, and contributes to implementing several theoretical agroecology principles, including the following: (i) ecosystem-based farm management (*principles 1 to 7*), especially through increased crop diversification (*principle 5*); (ii) access to local markets, fair prices, and locally anchored food systems (*principles 8 and 9*); (iii) knowledge exchange and creation of new quality standards (*principle 10*); (iv) autonomy from old municipal markets controlled by retailers and intermediaries (*principle 12*).

Empirical studies have also highlighted tensions between principles and practices. For instance, in Costa Rica, Galt (2008) highlights the complexities of synthetic and organic

pesticide use across agroecological farming landscapes. Galt found that despite high interest in organic production methods, most surveyed farmers applied synthetic fertilizers (*in opposition to principles 1, 2, and 6*) in order to maintain production levels and ensure farm income in an area characterized by high pest and disease occurrence (*principle 7*). Nevertheless, farmers had high awareness of potential negative impacts of synthetic pesticide use, and those who had access to agroecological training simultaneously adopted a range of agroecological practices such as use of organic homemade fungicides or application of worm tea (*principles 1, 2, and 6*), yet in conjunction with synthetic fertilizers (*in opposition to principles 1, 2, and 6*). A similar case study in Indonesia showed smallholder cocoa farmers' simultaneous awareness of the benefits associated with the use of organic fertilizers (*principle 2*) and of the negative impacts of chemical fertilizers on soils. Farmers received information about this through farm-extension activities as well as knowledge dissemination through local farmer networks (Wartenberg et al. 2018). Yet, even the farmers most interested in agroecological practices often applied both agroecological and non-agroecological methods considering that it is a necessity to ensure higher productivity. In Canada and Belgium, financial analyses of diversified market garden models have shown that, even in alternative food systems aiming to by-pass mainstream markets, prices often remain based on global market prices rather than on the cost of production, which is difficult to evaluate accurately for each separate vegetable crop (Mundler 2007; Dumont 2017). In this context, even in alternative markets, prices are generally too low to compensate the cost of farm-labor adequately. Partly to address this, one common strategy of market gardeners—in Ecuador, France, Canada, and Belgium—is to increase turnover by purchasing vegetables from wholesalers at lower costs and reselling them at marked-up prices to cover their own production costs (Bellec-Gauche and Chiffolleau 2015, Dumont and Baret 2017, Heinisch 2018). As studied in Wallonia, Belgium, this “purchase/resale” practice represents a real dilemma for Belgian agroecological farmers (Dumont and Baret 2017; Dumont 2017). Many farmers reject the practice to avoid dependence on organic industrial agriculture (*principle 12*), but consequently struggle to pay themselves and their farmworkers (in conflict with *principle 7*). In contrast, some farmers have decided to generate more than 50% of their turnover through “purchase-resale” practices (in conflict with *principle 12*) in order to improve their livelihoods and that of their farmworkers (*principle 7*).

4.3 The need for political support to scale up agroecology

Are these observed tensions between agroecological principles and practices due to an incomplete application of all

agroecological principles, or rather to unavoidable trade-offs between and within ecological, social, and economic dimensions that farming systems have not been able to overcome? The question is still debated (Bernstein 2014; McMichael 2014). More generally, synergies and oppositions between ecological and socioeconomic processes at different spatial—from field to farm to landscape—and temporal scales are currently poorly understood (Bretagnolle et al. 2018). Agroecologists point out the need for more empirical studies on the socioeconomic dimensions of agroecology, and for more systemic and multidisciplinary assessments (Montenegro de Wit and Iles 2016; D'Annolfo et al. 2017; Garibaldi et al. 2017; Bretagnolle et al. 2018; Vaarst et al. 2018).

Nevertheless, our literature review indicates that there is a negative circle: in current socioeconomic and political contexts, agroecological practitioners struggle to apply all agroecological principles, and this leads to lack of performance within systems. While the agroecological ideal requires the application of all principles, in reality, many farming and food systems are situated on a spectrum *towards* agroecology, covering a variety of practices and application intensities (Teixeira et al. 2018). While many systems have a high potential for socioeconomic and ecological benefits, these may not be fully expressed (and so measurable) due to limitations by external pressures driven by current socioeconomic and political contexts (Herrmann et al. 2018), which hamper the application of all principles (Dumont 2017).

The literature has indeed highlighted multiple barriers that agricultural actors may face in building farming systems that fulfill the principles of agroecology (Vanloqueren and Baret 2009; Rosset and Altieri 2017; Mier y Terán Giménez Cacho et al. 2018). While there are debates on agroecological performances within the current context, the pressures on agroecology are more commonly accepted, ranging from local barriers that farmers face to establish an “agroecological” farm—for instance, the lack of access to (good) land in many regions of the world—to macro barriers such as the lack of national and international research funding for agroecology (Pimbert and Moeller 2018). The multiplicity of barriers at different scales has led to a lock-in situation in which dominant technologies (e.g., GMO) sideline the development of agroecology, even if it might provide superior solutions (Vanloqueren and Baret 2009).

To overcome the consistent lack of institutional support for agroecology (Vanloqueren and Baret 2009; DeLonge and Basche 2017; Rosset and Altieri 2017; Pimbert and Moeller 2018), the literature insists on the creation of alternative practices that by-pass mainstream markets and institutions (e.g., alternative markets connecting producers and consumers, such as “nested markets” (Van Der Ploeg et al. 2012), or the *campesino a campesino* movement (Mier y Terán Giménez Cacho et al. 2018)). Yet, they often necessitate societal and institutional mechanisms that are still lacking in several contexts (such as

policies that support food sovereignty and solidarity economies, information campaigns regarding the importance of agroecology, or the intervention of non-profit associations, advising centers, development, state or regional agencies) (Galt 2008; Van Der Ploeg et al. 2012; Dumont et al. 2016; Rosset and Altieri 2017; Heinisch 2018; Mier y Terán Giménez Cacho et al. 2018). For example, as illustrated in Section 4.1, the multiplication of vegetable baskets created too much market competition between Belgian producers, including for agroecological farmers selling their products directly to consumers in collective buying groups. A policy promoting more reciprocity and redistribution and minimizing competition at a larger level (following the principle of solidarity economy (Laville 2005) and Polanyi's proposition (1944) of embeddedness of the economy into broader social systems (Krippner and Alvarez 2007)) appears necessary to restore the benefits of baskets sold in collective buying groups. In the same vein, trade-offs observed between producers' autonomy and their ability to offer good working conditions are partly the result of the difficulty of establishing fair prices (Section 4.2). The literature highlights the important role that non-profit organizations can play in assisting farmers in establishing fairer prices, while keeping products accessible even for low-income consumers (Dumont et al. 2016; Heinisch 2018b). Lack of support, on the other hand, can lead to tensions and to lack of implementation of all agroecological principles. This in turn may lead to self-exploitation of producers (Galt 2013), harmful labor conditions for farmworkers (Dumont and Baret 2017), or the development of niche markets accessible only to wealthy citizens (Hinrichs 2000). Furthermore, studies on the drivers scaling-up agroecology suggest that not only NGOs and development agencies ((Gonsalves 2001; Parmentier 2014) in Mier y Terán Giménez Cacho et al. 2018) but also "broad-based, inclusive social movements" (Rosset et al. 2011; Rosset 2015; McCune et al. 2017a, b; Rosset and Altieri 2017; Khadse et al. 2018) in Mier y Terán Giménez Cacho et al. 2018) are necessary to allow the implementation of all agroecological principles.

As such, it is unclear to what extent tensions can arise between agroecological principles and practices, but first and foremost these tensions exist between agroecology and the capitalist market model (Hatt et al. 2016). We conclude that a systemic understanding and accurate assessment of the functions and the performances of agroecological systems require at least an acknowledgment of the barriers these systems face.

5 Identification and evaluation of agroecological systems on the basis of the principles

The previous section showed that, on the one hand, multiple practices can allow to implement a unique agroecological principle, and, on the other hand, some agroecological

practices and related principles are hard to pursue given current socioeconomic and political contexts. Given this reality, how can we qualify a system as agroecological and how should one evaluate the performances of agroecological systems? While theoretically, it is the application of all principles as a whole that qualifies a system as *agroecological* (Stassart et al. 2012), our finding makes clear that more practical guidelines are needed to deal with reality.

Once one recognizes the gap between the normative principles of agroecology and their real-life application, the evaluation of whether a farm system can be considered agroecological has two different meanings. First, one can evaluate to what extent a system is *oriented towards* the agroecological principles as defined here. Second, one can evaluate to what extent the practices implemented in a system effectively *fulfill* these agroecological principles (Fig. 3). In the first case, this entails *identifying* agroecological systems by understanding whether the actors of a system follow an "agroecological ideal," as defined by the principles, and have developed practices in order to pursue these principles. In the second case, an assessment would entail *evaluating* the benefits and services of all practices implemented within a system.

In the following section, we describe two existing approaches to respectively address the identification and evaluation of agroecological systems within current socioeconomic and political contexts. Both consist of systemic analyses of farming systems, which (a) do not reduce agroecology to few practices, and (b) account for socioeconomic and political contexts in which agroecological actors often benefit from little to no support. Both approaches account for potential barriers inherently associated with current contexts, and consider the principles of agroecology as an ideal horizon to transition our food systems towards sustainability. The first, entitled *justification of practices*, aims to identify agroecological systems by understanding drivers and motivations of actors' implementation of farming practices (Section 5.1). The second, entitled *participatory assessment*, aims to assess the performance of applied practices and to evaluate whether they fulfill the agroecological principles (Section 5.2) (Fig. 3). We detail the first approach in greater detail here, as it has previously been published only in French. We then discuss complementarities between both approaches, as well as their benefits and limits (Section 5.3).

5.1 Towards a social justice horizon: the justification of practices model to identify orientation towards agroecology

The *justification of practices* model, developed by Dumont (2017), aims to identify whether farm systems are oriented towards agroecology and to understand actors' perceptions regarding the relevance of agroecological principles. This model considers that the agroecological principles constitute

Two complementary frameworks to assess whether a system is agroecological

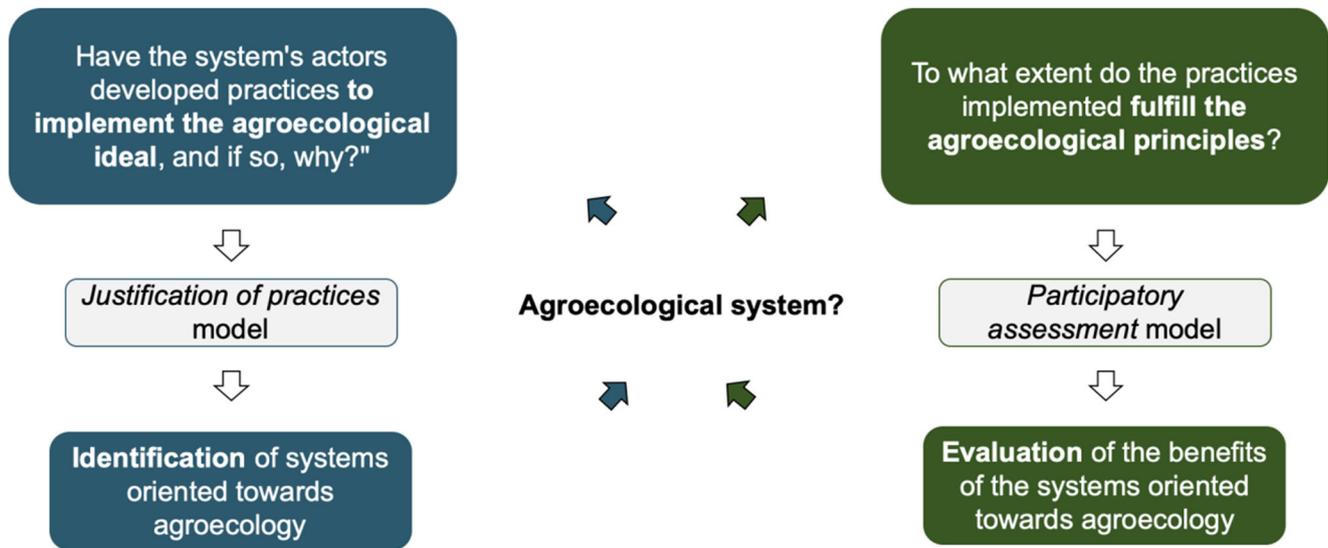


Fig. 3 There is two ways to assess whether a system is agroecological: (1) one can evaluate to what extent a system is *oriented towards* the agroecological principles as suggested by the *justification of practices*

model; (2) one can evaluate to what extent the practices implemented in a system effectively fulfill the agroecological principles, as suggested by the *participatory assessment* model. Both approaches are complementary

a social justice ideal aiming to bring justice into farming and food systems. By definition, such an ideal can never be perfectly implemented and agroecology, like any ideal, is no exception, as discussed and illustrated throughout Section 4. Every actor oriented towards agroecology can always improve her/his practices to be closer to the agroecological ideal. Based on this observation, Dumont’s approach evaluates whether actors, e.g., farmers, justify their daily practices by referring to agroecological principles when experiencing dilemma situations where they have to choose between several agroecological practices that appear incompatible in their personal context. The *justification of practices* model was built on the theories of French pragmatic sociology, especially Boltanski and Thévenot’s *polity model* (Boltanski and Thévenot 1991, 2006; Stassart et al. 2020) and Nanteuil’s model of social justice, entitled *ethics of compromise* (de Nanteuil 2016).

The model considers the two conditions presented below for a system to be oriented towards agroecology (Table 2).

Condition Actors implement a significant number of agroecological principles in a given socioeconomic and political context.

In a first step, researchers evaluate whether the motivations and perceptions driving actors’ farming or food system practices are aligned with the principles of agroecology. Use of the term “agroecology” per se is not subject to assessment; rather, the method evaluates to what extent actors may refer, with their own words, to a defined set of agroecological principles.

Concretely, this entails comprehensive interviews to assess actors’ daily practices and their motivations for implementation. Particular attention is paid to dilemma situations requiring choices between different options that are not compatible. For instance, most large-scale organic vegetable growers in

Table 2 The two conditions and the three steps of the *justification of practices* model

“Justification of practices” model		
Conditions to consider a system oriented towards agroecology	Research questions to evaluate if the conditions are fulfilled	
1. Implementation of (a significant number of)* agroecological principles in a given socio-economic and political context	1a. Qualitative step Are the agroecological principles an ideal for the actors of the system considered?	1b. Quantitative step Do the actors of the system considered implement the largest number of agroecological principles in the region?
	2a. Qualitative step For each principle that is poorly/not implemented: (1) do the actors of the system justify the situation by referring to a plurality of values? (2) do they get over the situation by taking decisions hard to reverse as there are materialized in investments, contracts or strong partnerships?	
2. In ethical dilemmas, actors take their decisions with consideration of a social justice objective		

*Counting principles is only required in a comparative context

the Wallonia, Belgium, do not prioritize crop diversification (in conflict with *principle 5*) or good farmworkers' labor conditions (in conflict with *principle 7*) (Dumont 2017). The *justification of practices* approach can provide insights into farmers' motivations for this. Those producers do not believe in agroecology as they consider that it is technically impossible to offer attractive employment conditions at large scales of operation, given the hard and repetitive nature of required work, and a view of a lack of profitability of crop diversification which requires managing smaller areas per vegetable type. Similarly, applying the *justification of practices* approach can provide information regarding drivers of some market gardeners' decisions to share production and commercialization activities within a same farm as self-employers, namely, to avoid asymmetries with farmworkers and to equitably share workload and resulting benefits (in accord with *principles 7 and 11*) (Dumont 2017).

In a second step, researchers can evaluate whether a system, e.g., a farm, implements *enough* principles to be considered agroecological. The *justification of practices* approach considers that, in a given context, the systems run by actors who apply the largest number of agroecological principles can be considered as implementing *enough* principles to be considered at least *oriented towards* agroecology. As such, this framework objectifies reality by comparing situations. It considers a system as oriented towards agroecology comparatively to the other systems and not in absolute terms. This second step is necessary only if researchers need to distinguish or compare between agroecological and non-agroecological actors and related systems. Otherwise, actors can simply analyze which principles are implemented and why, following the previous and next steps.

Condition In situations of ethical dilemma regarding the implementation of the agroecological principles (i.e., situations where a choice between different practices and related agroecological principle(s) is required), actors take their decisions with consideration of a social justice objective.

In a third step, researchers can examine whether poor implementation of a particular principle is due to a lack of personal interest in establishing an agroecological system, or to external obstacles or barriers. Concretely, due to the complex factors impacting implementation of the theoretical agroecological principles (see Section 4), the *justification of practices* approach considers actors, and their system, as agroecological based on the types of decisions taken when faced with ethical dilemmas. According to Dumont (2017)'s model, these decisions should be taken with consideration of a social justice objective. Following ethics of compromise from de Nanteuil (2016), social justice is respected when (1) actors justify their decision by referring

to a plurality of values, including the pursuit of the general interest, and (2) their decision is hard to reverse as it is materialized in investments, contracts, or strong partnerships. In the previous example of the "purchase/resale" dilemma faced by market gardeners (Section 4.2), Dumont identified two groups of agroecological farmers according to this process of analysis. The first group justifies "purchase/resale" practices as these enable them to offer good working conditions on farms and healthy food at reasonable prices to consumers (*principle 7*). The second group refuses to adopt the practices due to ethical concerns regarding support of large-scale industrial agriculture and their will to teach consumers the fair price of sustainable agriculture (*principle 12*). These differing arguments can both be linked to agroecological principles and, partly, to the general interest. In addition, for the first group of producers, their justifications are materialized in the permanent employment contracts they offer to their farmworkers. While in the second group, justifications are materialized in the conditions of sales they have settled with their consumers. As such, both groups of producers fulfill the second condition for being agroecological (or at least oriented towards agroecology), that is, they preserve the social-justice objective of agroecology when faced with ethical dilemmas.

5.2 A participatory assessment to evaluate implementation and measured benefits of agroecological principles

The evaluation of the socioeconomic dimensions of agroecology remains poorly developed, and very few models of evaluation of both socioeconomic and ecological dimensions of agroecology have been suggested so far. Recently, D'Annolfo et al. (2017, p. 638) mention that a Scopus search "on 'agroecology' AND 'labour', 'agroecology' AND 'employment', and 'agroecology' AND 'income' [between 1995 and 2015] provided only 8.2% of the overall search results for 'agroecology'". In another study, Garibaldi et al. (2017) gathered 154 comparisons between performances of conventional and alternative agriculture at the farm level (agroecology included with other movements), based on a Scopus search on human, financial, and social indicators. However, these comparative studies were very narrow in scope. Only seven comparisons referred to labor demand and labor productivity, whereas the 147 other comparisons focused on crop yield and/or farm profitability. Other selected indicators (e.g., access to the market, income stability, access of farmers to knowledge) were not addressed at all. This demonstrates a bias in existing literature "towards economic impacts rather than the broader impacts of changing agricultural systems on wellbeing" (Garibaldi et al. 2017, p. 73).

In contrast, many frameworks have been developed to assess sustainability more generally, but they do not allow to

focus on the implementation of agroecological principles. For instance, they are too rigid for being adaptable to local particularities (Schader et al. 2014). To overcome these limitations, as well as avoiding the evaluation of alternative agricultural models on the basis of few practices only, Garibaldi et al. (2017) suggest a new *participatory assessment* framework that consists of four steps (Fig. 4). They have developed their framework to assess agroecology and other alternative agriculture models. Here, the framework is adapted specifically for the evaluation of agricultural systems based on theoretical principles of agroecology.

In a first step, the principles of agroecology are expressed through a participatory approach involving all affected stakeholders, in order to link their priorities to the principles. In a second step, participants list all indicators that make sense for them, for instance, regarding their knowledge or the principles as they expressed them. Through focus groups, workshops, or questionnaires, a list of natural, social, human, financial, economic, and cultural measures is then established. These measures must include both qualitative and quantitative data, and primary (e.g., crop management, social science survey) and secondary data (e.g., market price, local income). The data must then be collected for a spectrum of farms potentially situated differently on the agroecological spectrum, and covering the diversity of situations that can be encountered in the defined area. The third step consists in comparing

collected data for selected farms through multivariate statistics or a multicriteria analysis framework. Spiderweb plots can be used for communicating and discussing the diverse performances of the multiple variables studied. Garibaldi et al. (2017) then propose a fourth step, which *stricto sensu* goes out of our scope of agroecological evaluation. It asks for taking actions to strengthen the selected farming systems according to the evaluation and the demand of the diverse stakeholders. Afterward, the four steps can be repeated to compare farms where actions were taken following the initial assessment with other “control” farms.

5.3 Complementarities, benefits, and limits of both approaches

The *justification of practices* model and the *participatory assessment* framework open new avenues for agroecological research and for the potential qualification of agroecological systems in a certification context. They can be used in a complementary way: the *justification of practices* to identify agroecological farms, the *participatory assessment* to evaluate their performances. They can also be used before additional research steps, especially to analyze and strengthen transition towards agroecology. Indeed, the *justification of practices* can be a first step to categorize the variety of farming systems that exist along the spectrum from non-agroecological to

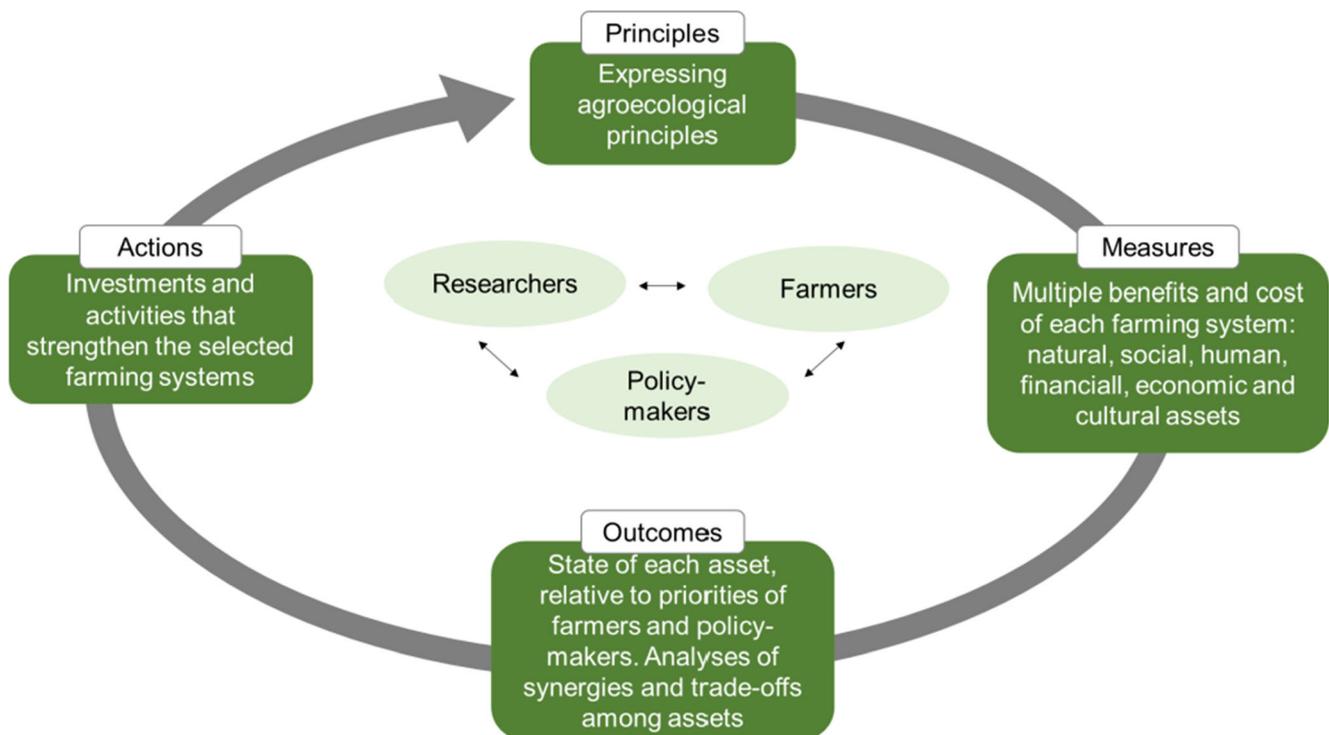


Fig. 4 The participatory assessment framework suggests four steps to evaluate to what extent a system fulfills the agroecological principles: (1) appropriation of the *principles* by field actors, (2) choice of indicators to *measure* the principles, (3) evaluation and discussion of

the *outcomes*, and optionally (4) some actions that can be taken to improve the practices. Each step should be realized through a participatory approach involving at least researchers, farmers, and policymakers. The figure is adapted from Garibaldi et al. 2017, p. 77

agroecological in the ideal sense. This represents a challenge in empirical studies on agroecological transitions (Gliessman 2016; Teixeira et al. 2018). The *participatory assessment* framework indicates a pathway to assess and strengthen performances of farms already applying agroecological principles and to support those that are transitioning towards agroecology. In addition, both approaches allow understanding to what extent agroecology makes sense for field actors, which is necessary to design policies that support agroecological transitions while responding effectively to farmers' needs (Dupré et al. 2017). Both help to recognize barriers to the implementation of agroecological principles and potential trade-off between and within ecological, social, and economic performances. The *participatory assessment* enables as well to democratically discuss these trade-offs, a necessity to respect agroecological and sustainability principles (Struik and Kuyper 2017; Bretagnolle et al. 2018).

Nevertheless, both approaches present some limits that could be addressed in the future. First, both approaches have been mainly designed to discuss agroecology at a farming system level. Their relevance at a food system level should be more strenuously evaluated. Second, the *justification of practices* has been used to identify the pursuit of the socio-economic dimensions of agroecology only. Its relevance for the ecological principles must be confirmed. As for the *participatory assessment*, it still needs to be empirically evaluated. Third, to date, the *justification of practices* has only been empirically tested in a Western context in which the absolute benefits and disadvantages of many agroecological practices remain subject to debate. Food security controls, labor inspections, high productivity demand, increasing demand for organic produce, public debates on the use of chemical inputs, or local and small-scale agriculture are all recent evolutions which have created debate and controversies in this context (Lémery 2003; Hervieu et al. 2010; Dumont 2017), making the study of *justification of practices* in dilemma situations possible. The relevance of the *justification of practices* in other contexts must be confirmed. Testing other models of justice, for instance, based on Jürgen Habermas, Amartya Sen, or Axel Honneth' theories (de Nanteuil, 2016), to evaluate the pursuit of the agroecological ideal across contexts, could provide interesting insights as shown in Stassart et al. (2020).

We further note that the two methodologies we present here may lead to divergent results. It may be possible that agroecological systems identified on the basis of their orientation towards the agroecological principles are poorly evaluated when the performance of the practices is assessed. Conversely, systems with high performance in terms of applied practices may not be oriented towards agroecological principles. Scholars with a narrow definition of agroecology (see Introduction) are increasingly placing emphasis on the use of locally adapted practices, where agroecological practices are used as proxies for agroecology, without assessment of a farmer's

drivers or motivations. Such an emphasis on practices can be beneficial for evaluating each practice's efficacy in terms of supporting positive outcomes/processes across cases, but can also reinforce a reductionist interpretation of agroecology, where the application of practices is abstracted from the socioeconomic context and from a social justice objective.

6 Conclusion

The principal objective of this review is to improve our understanding and our capacity to identify and evaluate to what extent agricultural production systems might be considered "agroecological." We put forward an overarching definition of agroecology based on six ecological and seven socioeconomic principles derived from existing literature, and we propose to consider a system oriented towards agroecology only if it addresses both types of principles. These principles are meant to be used as a guide to design sustainable practices while allowing for variation depending on contexts, individual histories, etc. To build bridges between these normative principles and empirical research involves an interpretation of agroecology as an ideal horizon guiding real-world transitions towards sustainability. From this perspective, assessing where systems are situated on an "agroecological" spectrum can be done in two ways: (i) evaluating whether the ideal driving actors' practices are aligned with the principles of agroecology and (ii) evaluating to what extent the practices implemented by the defined system fulfill these agroecological principles and perform well. Both approaches are complementary and involve an interdisciplinary assessment.

Our literature review shows that it is possible to evaluate agroecological systems without reducing agroecology to few practices, nor to conclude too quickly that no farm is agroecological except for a few successful case studies protected from capitalist markets. This opens up a new narrative on agroecology that reconciles the social justice goal of agroecology with the recognition that actors who try to implement this ideal may face strong barriers. Just transitions towards agroecology will require bridging gaps between normative agroecological principles and real-world practices through (1) understanding to what extent agroecology makes sense for field actors, (2) identifying and evaluating the socioeconomic and ecological principles of agroecology within agricultural systems embedded in a capitalist market contexts, and (3) developing technical, market- and policy-based solutions in-line with the principles.

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References

- Altieri MA (1983) Agroecology: the scientific basis of alternative agriculture. Division of biological control, University of California, Berkeley
- Altieri MA (1995) Agroecology: the science of sustainable agriculture, 2nd edn. Westview press, Boulder
- Altieri MA (2002) Agroecology: the science of natural resource management for poor farmers in marginal environments. *Agric Ecosyst Environ* 93:1–24. [https://doi.org/10.1016/S0167-8809\(02\)00085-3](https://doi.org/10.1016/S0167-8809(02)00085-3)
- Altieri MA (2003) Dimensiones éticas de la crítica agroecológica a la biotecnología agrícola. *Acta Bioethica* 9:47–61. <https://doi.org/10.4067/S1726-569X2003000100005>
- Altieri MA, Nicholls CI (2017) Agroecology: a brief account of its origins and currents of thought in Latin America. *Agroecol Sustain Food Syst* 41:231–237
- Altieri MA, Toledo VM (2011) The agroecological revolution in Latin America: rescuing nature, ensuring food sovereignty and empowering peasants. *J Peasant Stud* 38:587–612
- Arango D, Morel D, Mees M (2020) Autodiagnostic des pratiques agroécologiques en milieu paysan - Guide méthodologique. SOS Faim, Bruxelles
- Bellec-Gauche A, Chiffolleau Y (2015) Construction des stratégies et des performances dans les circuits courts alimentaires: entre encastrement relationnel et gestionnaire. *Rev d'Etud Agricult Environ* 96:653–676
- Bellon S (2016) Contributions croisées de l'agriculture biologique à la transition agroécologique. *Innov Agron INRA* 51:121–138. <https://doi.org/10.15454/1.4721192167463855E12>
- Bernstein H (2014) Food sovereignty via the “peasant way”: a sceptical view. *J Peasant Stud* 41:1031–1063. <https://doi.org/10.1080/03066150.2013.852082>
- Blesh J, Wolf SA (2014) Transitions to agroecological farming systems in the Mississippi River basin: toward an integrated socioecological analysis. *Agric Hum Values* 31:621–635
- Boltanski L, Thévenot L (1991) De la justification: les économies de la grandeur. Gallimard, Paris
- Boltanski L, Thévenot L (2006) On justification - economies of worth. Princeton University Press, Princeton
- Bonauo T, Burlamaqui Bendahan A, Sabatier R et al (2013) Agroecological principles for the redesign of integrated crop-livestock systems. *Eur J Agron* 57:43–51. <https://doi.org/10.1016/j.eja.2013.09.010>
- Bretagnolle V, Berthet E, Gross N, Gauffre B, Plumejeaud C, Houte S, Badenhauer I, Monceau K, Allier F, Monestiez P, Gaba S (2018) Towards sustainable and multifunctional agriculture in farmland landscapes: lessons from the integrative approach of a French LTSER platform. *Sci Total Environ* 627:822–834. <https://doi.org/10.1016/j.scitotenv.2018.01.142>
- CIDSE (2018) The principles of agroecology towards just, resilient and sustainable food systems. <https://www.cidse.org/publications/just-food/food-and-climate/the-principles-of-agroecology.html>
- Conway GR (1987) The properties of agroecosystems. *Agric Syst* 24:95–117. [https://doi.org/10.1016/0308-521X\(87\)90056-4](https://doi.org/10.1016/0308-521X(87)90056-4)
- Coolsaet B (2016) Towards an agroecology of knowledges: recognition, cognitive justice and farmers' autonomy in France. *J Rural Stud* 47:165–171. <https://doi.org/10.1016/j.jrurstud.2016.07.012>
- D'Annolfo R, Gemmill-Herren B, Graeub B, Garibaldi LA (2017) A review of social and economic performance of agroecology. *Int J Agric Sustain* 15:632–644. <https://doi.org/10.1080/14735903.2017.1398123>
- DeLonge M, Basche A (2017) Leveraging agroecology for solutions in food, energy, and water. *Elem Sci Anthr* 5:1–8. <https://doi.org/10.1525/elementa.211>
- Dumanski J, Pettapiece WW, McGregor RJ (1998) Relevance of scale dependent approaches for integrating biophysical and socioeconomic information and development of agroecological indicators. *Nutr Cycl Agroecosyst* 50:13–22
- Dumont AM (2017) Analyse systémique des conditions de travail et d'emploi dans la production de légumes pour le marché du frais en Région wallonne (Belgique), dans une perspective de transition agroécologique. PhD Dissertation. UCLouvain, Ottignies-Louvain-la-Neuve
- Dumont AM (2013) Contribution à la réflexion sur l'étude des principes socio-économiques de l'agroécologie par une étude de trois initiatives de systèmes alimentaires. Master thesis. UCLouvain, Ottignies-Louvain-la-Neuve
- Dumont AM, Baret PV (2017) Why working conditions are a key issue of sustainability in agriculture? A comparison between agroecological, organic and conventional vegetable systems. *J Rural Stud* 56:53–64. <https://doi.org/10.1016/j.jrurstud.2017.07.007>
- Dumont AM, Vanloqueren G, Stassart PM, Baret PV (2016) Clarifying the socioeconomic dimensions of agroecology: between principles and practices. *Agroecol Sustain Food Syst* 40:24–47
- Dumont B, Fortun-Lamothe L, Jouven M, Thomas M, Tichit M (2013) Prospects from agroecology and industrial ecology for animal production in the 21st century. *Animal* 7:1028–1043. <https://doi.org/10.1017/S1751731112002418>
- Dupré M, Michels T, Le Gal P-Y (2017) Diverse dynamics in agroecological transitions on fruit tree farms. *Eur J Agron* 90:23–33. <https://doi.org/10.1016/j.eja.2017.07.002>
- Elzen B, Augustyn AM, Barbier M, van Mierlo B (2017) AgroEcological transitions. Changes and breakthroughs in the making. Wageningen University & Research, Wageningen
- Francis C, Lieblein G, Gliessman S, et al (2003) Agroecology: The ecology of food systems. *J Sustain Agric* 22:99–118
- Galt RE (2008) Toward an integrated understanding of pesticide use intensity in Costa Rican vegetable farming. *Hum Ecol* 36:655–677. <https://doi.org/10.1007/s10745-008-9190-5>
- Galt RE (2013) The moral economy is a double-edged sword: explaining farmers' earnings and self-exploitation in community-supported agriculture. *Econ Geogr* 89:341–365
- Garibaldi LA, Gemmill-Herren B, D'Annolfo R, Graeub BE, Cunningham SA, Breeze TD (2017) Farming approaches for greater biodiversity, livelihoods, and food security. *Trends Ecol Evol* 32:68–80. <https://doi.org/10.1016/j.tree.2016.10.001>
- Gliessman SR (1997) Agroecology: ecological processes in sustainable agriculture. CRC Press Taylor & Francis Group, Boca Raton
- Gliessman SR (2016) Transforming food systems with agroecology. *Agroecol Sustain Food Syst* 40:187–189. <https://doi.org/10.1080/21683565.2015.1130765>

- Gliessman SR (2014) Agroecology: the ecology of sustainable food systems, 3rd edn. CRC Press Taylor & Francis Group, Boca Raton
- Gliessman SR (2007) Agroecology: the ecology of sustainable food systems, 2nd edn. CRC Press Taylor & Francis Group, Boca Raton
- Gonsalves JF (2001) Going to scale: what we have garnered from recent workshops. In: LEISA Mag <http://www.agriculturesnetwork.org/library/63894>
- Hatt S, Artu S, Brédart D et al (2016) Towards sustainable food systems: the concept of agroecology and how it questions current research practices. A review. *Biotechnol Agron Soc Environ* 20:215–224
- Heinisch C (2018) New local food systems in the Andes and their contribution to recognition of peasantries: the case of community baskets and citizen markets in the province of Chimborazo, Ecuador. In: 13th European International Farming Systems Association (IFSA) Symposium, Farming systems: facing uncertainties and enhancing opportunities, 1–5 July 2018, Chania, Crete, Greece. International Farming Systems Association (IFSA) Europe, Freiburg im Brisgau, pp 1–19
- Herrmann DL, Chuang W-C, Schwarz K, Bowles T, Garmestani A, Shuster W, Eason T, Hopton M, Allen C (2018) Agroecology for the shrinking city. *Sustainability* 10:1–14. <https://doi.org/10.3390/su10030675>
- Hervieu B, Mayer N, Muller P et al (2010) Les mondes agricoles en politique: de la fin des paysans au retour de la question agricole. Sciences Po, Paris
- Hinrichs CC (2000) Embedduntiness and local food systems: notes on two types of direct agricultural market. *J Rural Stud* 16:295–303. [https://doi.org/10.1016/S0743-0167\(99\)00063-7](https://doi.org/10.1016/S0743-0167(99)00063-7)
- Holt-Giménez E (2006) *Campesino a campesino*. Voices from Latin America's farmer to farmer movement for sustainable agriculture. Food First Books, Oakland
- Holt-Giménez E, Altieri MA (2013) Agroecology, food sovereignty, and the new green revolution. *Agroecol Sustain Food Syst* 37:90–102. <https://doi.org/10.1080/10440046.2012.716388>
- HPLÉ (2019) Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition. FAO, Rome
- International agri-food network (2018) Agroecology: a scientific discipline to support food security and sustainable agriculture. In: Int. Agri-Food Netw. Position Pap <https://agrifood.net/position-papers/281-agroecology-iafn-position-paper/file>.
- International Forum on Agroecology's members (2015) Declaration of the International Forum for Agroecology. *Development* 58:163–168. <https://doi.org/10.1057/s41301-016-0014-4>
- Kerr RB, Kangmennaang J, Dakishoni L et al (2019) Participatory agroecological research on climate change adaptation improves smallholder farmer household food security and dietary diversity in Malawi. *Agric Ecosyst Environ* 279:109–121
- Khadse A, Rosset PM, Morales H, Ferguson BG (2018) Taking agroecology to scale: the zero budget natural farming peasant movement in Karnataka, India. *J Peasant Stud* 45:192–219. <https://doi.org/10.1080/03066150.2016.1276450>
- Koohafkan P, Altieri MA, Holt Giménez E (2012) Green agriculture: foundations for biodiverse, resilient and productive agricultural systems. *Int J Agric Sustain* 10:61–75. <https://doi.org/10.1080/14735903.2011.610206>
- Krippner GR, Alvarez AS (2007) Embeddedness and the intellectual projects of economic sociology. *Annu Rev Sociol* 33:219–240. <https://doi.org/10.1146/annurev.soc.33.040406.131647>
- Lampkin NH, Pearce BD, Leake AR et al (2015) The role of agroecology in sustainable intensification. Land Use Policy Group, Organic Research Centre, Elm Farm, Game & Wildlife conservation trust
- La Via Campesina (2017) Mali: manifeste de l'agroécologie paysanne. In: Campesina <https://viacampesina.org/fr/mali-manifeste-de-l-agroecologie-paysanne/>.
- La Via Campesina (2015) Declaration of the international forum for agroecology. <http://viacampesina.org/en/index.php/main-issues-mainmenu-27/sustainable-peasants-agriculture-mainmenu-42/1749-declaration-of-the-international-forum-for-agroecology>.
- Laville J-L (2005) Economie solidaire. In: Dictionnaire de l'autre économie. Desclée de Brouwze, Paris, pp 303–312
- Lebacqz T, Baret PV, Stilmant D (2013) Sustainability indicators for livestock farming. A review. *Agron Sustain Dev* 33:311–327
- Lémery B (2003) Les agriculteurs dans la fabrique d'une nouvelle agriculture. *Sociol Trav* 45:9–25
- Loconto AM, Fouilleux E (2019) Defining agroecology. *Int J Sociol Agric Food* 25:116–137
- López-Ridaura S, Masera O, Astier M (2002) Evaluating the sustainability of complex socio-environmental systems. The MESMIS framework. *Ecol Indic* 2:135–148
- Lucas V, Gasselin P, van der Ploeg JD (2019) Local inter-farm cooperation: a hidden potential for the agroecological transition in northern agricultures. *Agroecol Sustain Food Syst* 43:145–179. <https://doi.org/10.1080/21683565.2018.1509168>
- McCune N, Rosset PM, Salazar TC, Saldívar Moreno A, Morales H (2017a) Mediated territoriality: rural workers and the efforts to scale out agroecology in Nicaragua. *J Peasant Stud* 44:354–376. <https://doi.org/10.1080/03066150.2016.1233868>
- McCune N, Rosset PM, Salazar TC et al (2017b) The long road: rural youth, farming and agroecological formación in Central America. *Mind Cult Act* 24:183–198. <https://doi.org/10.1080/10749039.2017.1293690>
- McMichael P (2014) A comment on Henry Bernstein's way with peasants, and food sovereignty. *J Peasant Stud* 42:193–204. <https://doi.org/10.1080/03066150.2014.936853>
- Méndez EV, Bacon CM, Cohen R (2013) Agroecology as a transdisciplinary, participatory, and action-oriented approach. *Agroecol Sustain Food Syst* 37:3–18. <https://doi.org/10.1080/10440046.2012.736926>
- Méndez VE, Bacon CM, Cohen R (2016) Introduction: Agroecology as a transdisciplinary, participatory, and action-oriented approach. In: Méndez VE, Bacon CM, Cohen R, Gliessman SR (eds) *Agroecology. A transdisciplinary, participatory and action-oriented approach*. CRC Press, Boca Raton, pp 1–22
- Mier y Terán Giménez Cacho M, Giraldo OF, Aldasoro M et al (2018) Bringing agroecology to scale: key drivers and emblematic cases. *Agroecol Sustain Food Syst* 42:637–665. <https://doi.org/10.1080/21683565.2018.1443313>
- Migliorini P, Wezel A (2017) Converging and diverging principles and practices of organic regulations and agroecology. A review. *Agron Sustain Dev* 37:1–18. <https://doi.org/10.1007/s13593-017-0472-4>
- Montenegro de Wit M, Iles A (2016) Toward thick legitimacy: creating a web of legitimacy for agroecology. *Elem Sci Anthr* 4:000115. <https://doi.org/10.12952/journal.elementa.000115>
- Mundler P (2007) Les associations pour le maintien à l'agriculture paysanne (AMAP) en Rhône-Alpes, entre marché et solidarité. *Ruralia* 20:185–215
- de Nanteuil M (2016) *Rendre justice au travail*. Presses Universitaires de France, Paris
- Nicholls CI, Altieri MA (2012) Modelos ecológicos y resilientes de producción agrícola para el siglo XXI. *Agroecología* 6:28–37
- Nicholls CI, Altieri MA, Vazquez L (2016) Agroecology: principles for the conversion and redesign of farming systems. *J Ecosyst Ecography* S5:1–8. <https://doi.org/10.4172/2157-7625.S5-010>
- Norder LA, Lamine C, Bellon S, Brandenburg A (2016) Agroecology: polysemy, pluralism and controversies. *Ambiente Soc* XIX:1–20. <https://doi.org/10.1590/1809-4422ASOC129711V1932016>
- Ollivier G, Bellon S (2013) Dynamiques paradigmatiques des agricultures écologisées dans les communautés scientifiques internationales. *Nat Sci Soc* 21:166–181. <https://doi.org/10.1051/nss/2013093>

- Parmentier S (2014) Scaling-up agroecological approaches: what, why and how? In: Oxfam-Solidar. Belg <https://www.oxfam.org/oxfam-sol/be/fr/scaling-agroecological-approaches-what-why-and-how>.
- Passos dos Santos F, Chalub-Martins L (2012) Agroecology, sustainable consumption and collective learning in Brazil. *Educ E Pesqui* 38: 469–483. <https://doi.org/10.1590/S1517-97022011005000008>
- Pimbert M (2015) Agroecology as an alternative vision to conventional development and climate-smart agriculture. *Development* 58:286–298. <https://doi.org/10.1057/s41301-016-0013-5>
- Pimbert MP, Moeller NI (2018) Absent agroecology aid: on UK agricultural development assistance since 2010. *Sustainability* 10:1–10. <https://doi.org/10.3390/su10020505>
- Polanyi K (1944) *The great transformation: the political and economic origins of our time*. Beacon Press, Boston
- Reijntjes C, Haverkort B, Waters-Bayer A (1992) *Farming for the future: an introduction to low-external-input and sustainable agriculture*. McMillan Education Ltd, London and Oxford
- Rickerl D, Francis CA (2004) *Agroecosystems analysis*. American Society of Agronomy, Madison, WI
- Rosset PM (2015) Social organization and process in bringing agroecology to scale. In: *Proceedings of the FAO International symposium. Biodiversity & ecosystem services in agricultural production systems, Italy*
- Rosset PM, Altieri MA (2017) *Agroecology: science and politics*. Practical Action Publishing, Rugby
- Rosset PM, Machín Sosa B, Roque Jaime AM, Ávila Lozano DR (2011) The campesino-to-campesino agroecology movement of ANAP in Cuba: social process methodology in the construction of sustainable peasant agriculture and food sovereignty. *J Peasant Stud* 38:161–191. <https://doi.org/10.1080/03066150.2010.538584>
- Schader C, Grenz J, Meier MS, Stolze M (2014) Scope and precision of sustainability assessment approaches to food systems. *Ecol Soc* 19
- Singh C, Dorward P, Osbahr H (2016) Developing a holistic approach to the analysis of farmer decision-making: implications for adaptation policy and practice in developing countries. *Land Use Policy* 59: 329–343. <https://doi.org/10.1016/j.landusepol.2016.06.041>
- Slätmo E, Fischer K, Rööös E (2017) The framing of sustainability in sustainability assessment frameworks for agriculture. *Sociol Rural* 57:378–395
- Smith A, Snapp S, Chikowo R, Thorne P, Bekunda M, Glover J (2017) Measuring sustainable intensification in smallholder agroecosystems: a review. *Glob Food Secur* 12:127–138
- Soussana J-F (2013) “L’agroécologie” est d’abord une science. *Rev Proj* 1:58–62. <https://doi.org/10.3917/pro.332.0058>
- Stassart PM, Baret PV, Grégoire J-C et al (2012) L’agroécologie: trajectoire et potentiel. Pour une transition vers des systèmes alimentaires durables. In: *Agroécologie, entre pratiques et sciences sociales*. Educagri, Dijon, pp 27–51
- Stassart PM, Dumont A, Hecquet C, Klaedtke S, Lacombe C, de Nanteuil M (2020) What Models of Justice for the Agroecological Transition? The Normative Backdrops of the Transition In: Lamine C, Magda D, Marsden T & Riverra Ferre M *Agroecological Transition, between Determinist and Open-ended Visions*, Peter Lang, Brussels
- Struik PC, Kuyper TW (2017) Sustainable intensification in agriculture: the richer shade of green. A review. *Agron Sustain Dev* 37:1–15. <https://doi.org/10.1007/s13593-017-0445-7>
- Teixeira HM, van den Berg L, Cardoso IM, Vermue A, Bianchi F, Peña-Claros M, Tittonell P (2018) Understanding farm diversity to promote agroecological transitions. *Sustainability* 10:1–20. <https://doi.org/10.3390/su10124337>
- Tessier L, Bijttebier J, Marchand F, Baret PV (2020) Pathways of action followed by Flemish beef farmers—an integrative view on agroecology as a practice. *Agroecol Sustain Food Syst* 45:1–23. <https://doi.org/10.1080/21683565.2020.1755764>
- Timmermann C, Félix GF (2015) Agroecology as a vehicle for contributive justice. *Agric Hum Values* 32:523–538. <https://doi.org/10.1007/s10460-014-9581-8>
- Tittonell P (2015) Food security and ecosystem services in a changing world: it is time for agroecology. In: *Agroecology for food security and nutrition: proceedings of the FAO international symposium*. FAO, Rome, pp 16–31
- Tripp R (2008) *Agriculture change and low-input technology*. In: *Agricultural systems, agroecology and rural innovation for development*, Sieglinde Snapp Barry Pound. Academic Press, Cambridge, pp 129–160
- Vaarst M, Getz Escudero A, Chappell MJ et al (2018) Exploring the concept of agroecological food systems in a city-region context. *Agroecol Sustain Food Syst* 42:687–711. <https://doi.org/10.1080/21683565.2017.1365321>
- van den Berg L, Roep D, Hebinck P, Teixeira HM (2018) Reassembling nature and culture: resourceful farming in Araponga, Brazil. *J Rural Stud* 61:314–322. <https://doi.org/10.1016/j.jrurstud.2018.01.008>
- van der Ploeg JD (2012) The drivers of change: the role of peasants in the creation of an agro-ecological agriculture. *Agroecologia* 6:47–54
- van der Ploeg JD (2016) The importance of peasant agriculture: a neglected truth. *Wagening Univ Res, Wageningen*. <https://doi.org/10.18174/403213>
- van Der Ploeg JD, Jingzhong Y, Schneider S (2012) Rural development through the construction of new, nested, markets: comparative perspectives from China, Brazil and the European Union. *J Peasant Stud* 39:133–173. <https://doi.org/10.1080/03066150.2011.652619>
- Vanloqueren G, Baret PV (2009) How agricultural research systems shape a technological regime that develops genetic engineering but locks out agroecological innovations. *Res Policy* 38:971–983. <https://doi.org/10.1016/j.respol.2009.02.008>
- Wartenberg A, Blaser WJ, Janudianto KN et al (2018) Farmer perceptions of plant–soil interactions can affect adoption of sustainable management practices in cocoa agroforests: a case study from Southeast Sulawesi. *Ecol Soc* 23:18. <https://doi.org/10.5751/ES-09921-230118>
- Wezel A, Bellon S, Doré T, Francis C, Vallod D, David C (2009) Agroecology as a science, a movement and a practice. A review. *Agron Sustain Dev* 29:503–515. <https://doi.org/10.1051/agro/2009004>
- Wezel A, Soldat V (2009) A quantitative and qualitative historical analysis of the scientific discipline of agroecology. *Int J Agric Sustain* 7: 3–18
- Wittman H (2011) Food sovereignty: a new rights framework for food and nature? *Environ Soc* 2:87–105

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