Transdisciplinarity in agroecology: practices and perspectives in Europe

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ABSTRACT

Agroecology, as a science for the study, design and management of sustainable food systems, retakes epistemic, methodological and practical approaches of transdisciplinarity. However, there is not a unanimous understanding of these approaches and few studies investigate its implementation. Transdisciplinarity is defined *lato sensu* as the practices of collaboration and knowledge integration between non-academic actors and scientists. This approach is at stake in Europe, especially in the field of food systems. Our aim is to analyze the magnitude, conceptions and praxis of works from European agroecologists claiming transdisciplinarity. Based upon a content analysis of publications and interviews with some of their authors, our results show that, although there is a growing literature on transdisciplinarity in Europe, the proportion of publications is low compared to the overall publications in agroecology. Despite the global aspiration of using it as an approach to achieve cognitive justice and horizontal knowledge construction, our typology of transdisciplinarity in practice shows a diversity of patterns. Four clusters were identified, ranging from genuine co-creation of knowledge to uneven collaborations between scientists and stakeholders, thus questioning scholars' responsibility. As a nascent and promising domain, transdisciplinarity in agroecology should be encouraged in European research and experiences capitalized.

KEYWORDS

Agroecology, transdisciplinarity, Europe, research practices, content analysis

INTRODUCTION

According to the Manifesto of Transdisciplinarity (Nicolescu 2002), "transdisciplinarity concerns that which is at once between the disciplines, across the different disciplines, and beyond all disciplines". More precisely, as integration concepts are continuously debated (Mauser et al. 2003), we have chosen to use a quite consensual definition of transdisciplinarity: a practice which transgress and transcends disciplinary boundaries to co-create knowledge, relevant for concrete problem-solving, through the collaboration of researchers from different disciplines and non-academic actors (Mauser et al. 2003; Jahn et al. 2012; Popa et al. 2015). The notion is also associated with two others not implying the participation of non-academic actors in knowledge production: the multidisciplinarity – where researchers from different disciplines collaborate but maintain their disciplinary perspectives – and interdisciplinarity – where researchers collaborate with higher level of integration of goals and concepts (Mauser et al. 2013). Thus, transdisciplinarity can also be seen as an interdisciplinarity with the participation of non-academic actors.

Transdisciplinarity traverses several scientific domains, particularly those dealing with sustainability. In sustainability science, transdisciplinarity is seen as an approach that can address wicked and complex problems, entailing issue-oriented researches, that include a plurality of views, to produce socially robust and contextualized knowledge (Mauser et al. 2013; Scholz & Steiner 2015a). Agroecology has been built upon the transformation of production knowledge practices and disciplinary boundaries, whether in its strong or weak versions (Dalgaard et al. 2003), to design and manage sustainable agriculture and food systems (Altieri 1995; Francis et al. 2003; Caporali 2011). Numerous authors retake transdisciplinarity as a relevant framework in agroecology (Leff 2002; Méndez et al. 2013; Vandermeer & Perfecto 2013; Gómez et al. 2015; Meynard 2017). It provides a significant thread in agroecology, since it integrates scientific knowledge and other knowledge systems (e.g. experiential, lay, local, traditional or political), sometimes called “dialogue of knowledge” (Leff 2002; Anderson et al. 2018; Rosset et al. 2020). These authors present this epistemic practice as a way to support context-based and socially robust solutions adapted to socio-technical conditions (Caporali 2011; Francis et al. 2013; Méndez et al. 2013, 2017; Gliessman 2018); and as a response to inappropriate top-down positivist approach in agricultural knowledge production and diffusion (Altieri 1989; Chambers & Thrupp. 1989; Norgaard & Sikor 1995).

However, within the growing literature in agroecology, the theoretical and practical understanding of transdisciplinarity, does not have a straightforward and unanimous acknowledgement among its scholars, which causes tensions in the field (Méndez et al. 2013). In addition to the variety of designations (e.g. Participatory Action Research, co-design, triple helix model), transdisciplinarity may be understood as the hierarchical participation or degree of involvement of stakeholders in the research process. In this gradient,

the normative hierarchy can be ranked from information, consultation, collaboration to self-mobilization (Pretty 1995). Some authors even consider consulting as a passive participation of stakeholders and extractive approach, prone to external manipulation, which does not promote genuine interactions between stakeholders and researchers (Cuéllar-Padilla & Calle-Collado 2011).

The disparity in both conceptions and practices is not unique to agroecology. In the last 40 years, scholars have framed, defined and practiced transdisciplinarity in multiple ways (de Freitas, Morin & Nicolescu 1994; Jahn et al. 2012; Popa et al. 2015). Most of them have extensively theorized about the conception of a research agenda, the types of participation of stakeholders, the role and motivation of researchers and variations in transdisciplinarity (Mobjörk 2010; Popa et al. 2015; Scholz and Steiner 2015a,b). However, a theoretical reflection on transdisciplinarity also requires considering its practice and evaluating its development. For example, in sustainability science, few studies evaluate real transdisciplinary processes (Scholz & Steiner 2015b). In the field of agroecology, few papers discuss the practical obstacles and doings of transdisciplinary. Méndez et al. (2017) focus specifically in the difficulties and lessons learned in the context of Latin America. Can these lessons be applied to a European context, while considering that the evolution and conception of agroecology vary among countries and regions (Wezel et al. 2009; Gallardo-Lopez et al. 2018; Nicot et al. 2018; Ollivier et al. 2019)?

Therefore, the aim of this paper, far from discussing the epistemological status of agroecology as a whole, is rather to analyze the prominence, conceptions and practices of European researchers in agroecology claiming transdisciplinarity. In this scope we analyzed how these researchers understand it and how they relate with non-academic stakeholders. Since, beyond a general definition, there is not a unique way of doing transdisciplinarity.

Our research focuses in Europe, because the relationships between research and social movements are currently at stake. Both the debates inside Agroecology Europe association and within the European Innovation Partnership (EIP-AGRI 2020) show an interest to have meaningful collaborations with diverse actors to strengthen the institutionalization of agroecology in Europe. To have a broader grasp of transdisciplinarity practiced by agroecologists at the European level, we interviewed researchers and analyzed a corpus of scientific publications that involved, in the research process, non-academic actors. However, due to time limitations, non-academic actors were not interviewed; therefore, their reflections towards this scientific approach of knowledge construction goes beyond the scope of this paper. To characterize the conception and practice of transdisciplinarity in agroecology during our content analysis, we mobilized five key aspects from the literature, presented in the following section. After presenting our

methodology, the results are exposed in three sections to answer the following questions: What are the generic trends (geography and dynamics) of the European publications referring to agroecology and trandisciplinarity? What are the types of transdisciplinarity research approaches practiced in agroecology, their transdisciplinarity conception, and their stakeholder participation? And what are the drawbacks that European scholars encounter in their research work in agroecology?

1.2 State of the art of key aspects of transdisciplinary in Agroecology

In a literature review, we found the five following key aspects of the understanding of transdisciplinarity by agroecologists: i) *cross disciplinary integration,* ii*) complex system thinking,* iii) *type of stakeholders involved,* iv) *social engagement,* v) *legitimacy*. These aspects are also the theoretical basis of the categories we elaborated (Table 1) to typify the conception and practice of transdisciplinarity.

Cross disciplinary integration is characterized by the type of disciplines involved and the way concepts and methods are integrated. For some authors, agroecology is multidisciplinary whereas for others it is interdisciplinary, i.e. an integration of disciplines rather than a juxtaposition (Caporal et al. 2006; Dalgaard et al. 2003; Francis et al. 2013). Furthermore, some researchers or research units, only integrate closed disciplines, e.g. biological or agronomic sciences, meanwhile others dabbled in a matrix of disciplines that includes social sciences or even integrates ethical and political dimensions (Caporal et al. 2006; Dalgaard et al. 2003; Guzmán-Casado et al. 2000; Méndez et al. 2013).

Some considered that a *complex system* thinking is essential in a transdisciplinary perspective since it helps understand the multifunctionality, problematics, and process of the "real world", which cannot be achieved through the lenses of one specific discipline or the sum of segregated disciplines. This approach challenges the way sectorized knowledge systems create a disconnection between theories and reality (Francis et al. 2013; Gómez et al. 2015).

The t*ype of stakeholders involved* can be of three types: i) those who have local know-how (Altieri 1995; Gliessman 2018); ii) those that science has marginalized and with whom researchers should collaborate and help strengthen skills and organization capacities (Cuéllar-Padilla & Calle-Collado 2011; Guzmán-Casado et al. 2013); and iii) those that are directly or indirectly affected by a problem, which means that all types of stakeholders (policymakers, farmers, consumers, etc.) should be included (Berthet et al. 2016; Lamine 2018).

Some argue that researchers must have a political ethical and *social engagement (*Caporal et al. 2006; Guzmán-Casado et al. 2000). Therefore, the knowledge created must help create an equal debate, decrease asymmetrical power relationships by empowering and emancipating oppressed groups (Guzmán-Casado et al. 2013; Cuéllar-Padilla & Calle-Collado 2011). This means that scientists are implied actors that are not isolated from social interest (Warner 2007; Coutellec 2015).

The legitimacy of any scientific knowledge is first bounded by academic norms (e.g. methodology, falsifiability, reproducibility of experiences, peer reviewing) and the alliances to interested actors (i.e. research institutions, NGO's, international organizations, research agencies), that fund or facilitate the research (Warner 2007; Coutellec 2015). However, knowledge legitimacy can also be based on a bundle of policy/politic, civic, legal and practical scientific processes. Montenegro de Wit & Iles (2016) propose that agroecology must aspire to have a "thick" legitimacy of its knowledges by bounding different processes (i.e. political, scientific and civic).

1. MATERIAL AND METHODS

2.1 Search strategy of publications on transdisciplinarity in agroecology

A query search was built to identify the relevant studies in agroecology from European scholars in agroecology claiming transdisciplinarity. From the bibliographic database of Elsevier's SCOPUS, we extracted publications that contained as the main search in the title, key words and abstract the word agroecology (or agro-ecology), which was bounded by 26 European countries (see Supplement 1 for details on the query). To grasp transdisciplinarity in its diversity, we designed a lexical query supported by an analysis of core papers in the domain. The query finally contains words related to transdisciplinarity or to multi/interdisciplinarity associated to participatory methods, stakeholder involvement or system approaches (see Supplement 1 for details). From 1960 to the 2nd of July 2019, we obtained a corpus of 405 articles from European agroecologists dealing with transdisciplinarity (Figure 1). Although most articles in Elsevier's SCOPUS are in English the articles in different languages were also analyzed.

2.2 Qualitative typology of transdisciplinary research

Using a content analysis (Krippendorf 2004), defined as the systematic description of communication content, we hand-coded full-text articles to characterize transdisciplinary practices as reflected by scientists in their publications. Based on categories from literature (particularly those exposed in section 1.2) and those emerging from the content, we elaborated a coding scheme, divided into two phases.

First, we identified articles where the participation of stakeholders was essential to create agroecological knowledge, with a transdisciplinary approach. We selected 389 full-text articles for coding, using four descriptors (Figure 1 Corpus B) that enabled us to refine the final corpus:

i) *Type of research approach* (n=151)*:* Papers without explicit stakeholder participation in their empirical research processes, were excluded; e.g. meta-analysis or reviews which have a theoretical focus or confront several empirical cases

ii) T*ype of participation of stakeholders* (n=40): Stakeholders did not participate in the research process.

iii) *Agroecological conception* (n=103): Papers with the adjectivation *agroecological zoning* were excluded from the analysis, because their focus is to describe regional soil and bioclimatic conditions at a macro-scale, without interactive participation of stakeholders. In some cases, although having a participatory angle, agroecological zoning is only used to explore a variability of contexts and support a sampling of studied situations, e.g. "*these provinces were selected as they represent the broad spectrum of agroecological zones, socioeconomic circumstances and work animal usage within the region"* (Dijkman et al. 1999). It is used as a characterization rather than developing sustainable agricultural or food systems.

iv) *Centrality of agroecology* (n=24): Papers where agroecology was not the main focus or had no citations of articles related to agroecology were discarded.

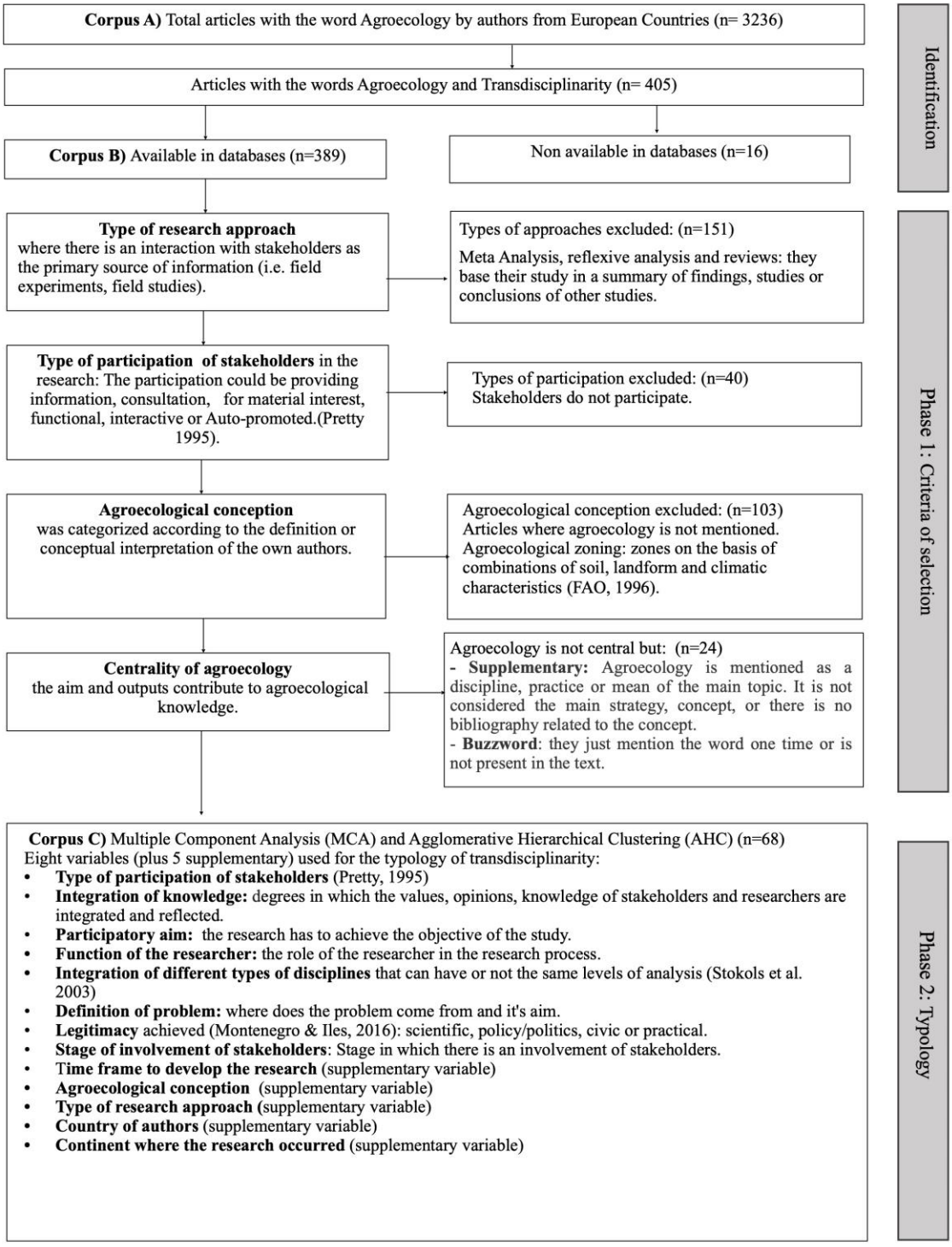

Figure 1. Flowchart and description of criteria used in the literature selection and typology

A second phase of analysis aimed to determine the diversity of transdisciplinary approaches in agroecology. This resulted in a corpus of 68 articles (Figure 1 Corpus C, see Supplement 3 for details on the references).The full texts of the articles selected in the first phase were reviewed and coded using eight qualitative variables and supplementary variables (author country, place and duration of research, plus details in Figure 1 and Table 1). These variables were created based on the five aspects of transdisciplinarity in agroecology that we identified in Section 1.2 and from sustainability sciences literature (Stokols et al. 2003; Mobjörk 2010; Popa et al. 2015; Scholz & Steiner 2015a,b).

Table 1: Coded variables and their modalities, their source and description

Categories	Modalities and their description
Type of participation (Modified from Pretty 1995)	*Direct providing/ consulting information:* People participate by answering questions or exposing their opinions. They do not influence the research since they cannot verify the accuracy of the results or define both the problems to be addressed and solutions. *Direct functional:* People participate by forming groups to meet certain pre-defined objectives of a project. Such involvement is usually not in the early stages of projects, but rather after the most important decisions have been made. These groups tend to be external initiators. *Direct interactive/Auto-promoted:* People participate in a common analysis of situations, which leads to action plans and the formation or strengthening of groups. This usually involves interdisciplinary methodologies that use structured learning processes.
Integration of knowledge Degree in which the values, opinion and knowledges of stakeholders and researchers are integrated	*Knowledge incorporated no feedback:* There is no moment of exchange between stakeholders and researchers. *Discussion among stakeholders' passive researchers*: Stakeholders interact and exchange but the researcher, remains as a facilitator and doesn't engage in the discussion as an equal. *Discussion/feedback among stakeholders and researcher:* Stakeholders and the researcher can interact and enter in a process of reflection as equals.
Participatory aim	*Assessment* *Co-innovation/ construction* *Community based development/decision making/ Adoption* *Upscaling/ transforming*
Stakeholders stage of involvement	*One stage:* Development or Design *Two stages:* Problem and or design/dissemination/development In *all stages* or a mixture of them
Function of the researcher	*Functional:* The researcher conceptualizes, systematizes, analyzes social, technological and/or biophysical process. *Collaborate:* the researcher does the functional activity but also collaborates to construct the knowledge of other stakeholders. *Transform:* the researcher is part of the transformation or changes they want to achieve; s/he is also is active in the process.
Integration of different types of disciplines Integration of concepts and methods between disciplines that can have or not the same levels of analysis (Stokols et al. 2003)	*Closely related:* e.g. disciplines such as agronomy and soil science. *Not Closely* related: e.g. anthropology, landscape ecology.

Definition of problems How and who formulates the research problem	*Knowledge gap*: The research aims to answer a knowledge gap that has been previously recognized in the scientific arena. *Social living issue*: The research recognizes an issue that has an impact on society and which contribution could help solve or visualize the situation. *Exterior request:* Bottom up or top down
Legitimacy people accept, practice, something widely as credible and authoritative (Montenegro de Wit M. & Iles 2016)	*Scientific* *Scientific and practical* *Scientific, practical and/or Policy/politic and/or Civic*

To construct the typology of transdisciplinarity practices in agroecology, a Hierarchical Clustering on Principal Components (HCPC) was conducted using the FactoMiner R package (Husson et al. 2011). HCPC is a Multiple Correspondence Analysis (MCA) followed by an Ascending Hierarchical Clustering (AHC) on the MCA results. We used the eight active variables presented in Figure 1 and, extra supplementary variables to enrich the analysis (i.e. *time frame to develop the research, agroecological conception, type of research approach, country of authors, continent where the research occurred)*. HCPC allows to group the individuals and variables that are more alike. To have a robust MCA, the potential rare modalities (< frequency of 10%) in variables were grouped with those categories that were most similar. To denoise data, according to the visual analysis of the % of variance scree plot (Figure 4) and exploration of the many clustering options provided by FactoMineR, we chose to keep the first 4 dimensions of the MCA which retains 59.3% of the total inertia. Based upon the coordinates of individuals on these first dimensions and the recommended and most used parameters in such analysis, i.e. squared Euclidean distance associated with the Ward's agglomeration method (Husson et al. 2011), the AHC automatically generates a 4 clusters partition of our population. This method consists in iteratively grouping individuals in clusters which minimize within-cluster inertia and maximize between-cluster one (Ward 1963). To consolidate clusters, we also used the k-means consolidation process provided by FactoMiner. The final cut of the hierarchical tree is automatically detected by the algorithm using the inertia gained in each class and the comparison between the similarity and dissimilarities of each group. Table 2 presents the variable modalities that best characterized each cluster. The chosen parameters provide a clustering solution which is fine grained and produces balanced clusters, coherent with the interviews we made.

2.4 Interviews with researchers

Semi-structured interviews were used to complement the literature review and have a deeper understanding of the process, reasoning, conception, barriers and experience gained by doing transdisciplinary research in agroecology (see Supplement 2 for details). We interviewed European scholars that had more the one article published in Corpus C (Figure 1), are central and active authors in the agroecological community. While

having to address the availability for interviews, we tried to have a diversified sample of scholars in terms of their geographical location; their practice of transdisciplinarity; institutional and disciplinary backgrounds. This resulted in a set of 11 interviewees from France (n=4), Belgium (n=1), Spain (n=2), Norway (n=1), Italy (n=2), Netherlands (n=1), who were interviewed in July-October 2019. The duration of the interviews was between 30 min to 100 min. We established *ex-post* the links between interviewees and clusters of transdisciplinarity practice thanks to the authorship of clustered papers.

2. RESULTS

3.1 Dynamics and geography of publications

In SCOPUS, we found 3,235 articles dealing with agroecology and including European authors [1960-2019]. The temporal analysis (Figures 2 & 3) focused on papers published after 1996, because we observed a gap in the number of publications before this year. From the total number of publications in agroecology published by European authors there were 405 articles (see Figure 1) that use concepts linked to transdisciplinarity. In February 2020, the proportion of articles from European authors dealing with transdisciplinarity represents 13.1% of the literature on agroecology, whereas this proportion is 10.6% for the rest of world. Although, the proportion of publications with a transdisciplinary approach is not the same each year, there is a trend to slightly increase the number of publications each year (Figure 2). Between 1997 and 2010, the number of publications associated to transdisciplinarity went from 4 publications to 11 publications per year. After 2011, a steep growth is noticed: in less than a decade, the number of publications per year rise from 11 in 2011 to 55 in 2018.

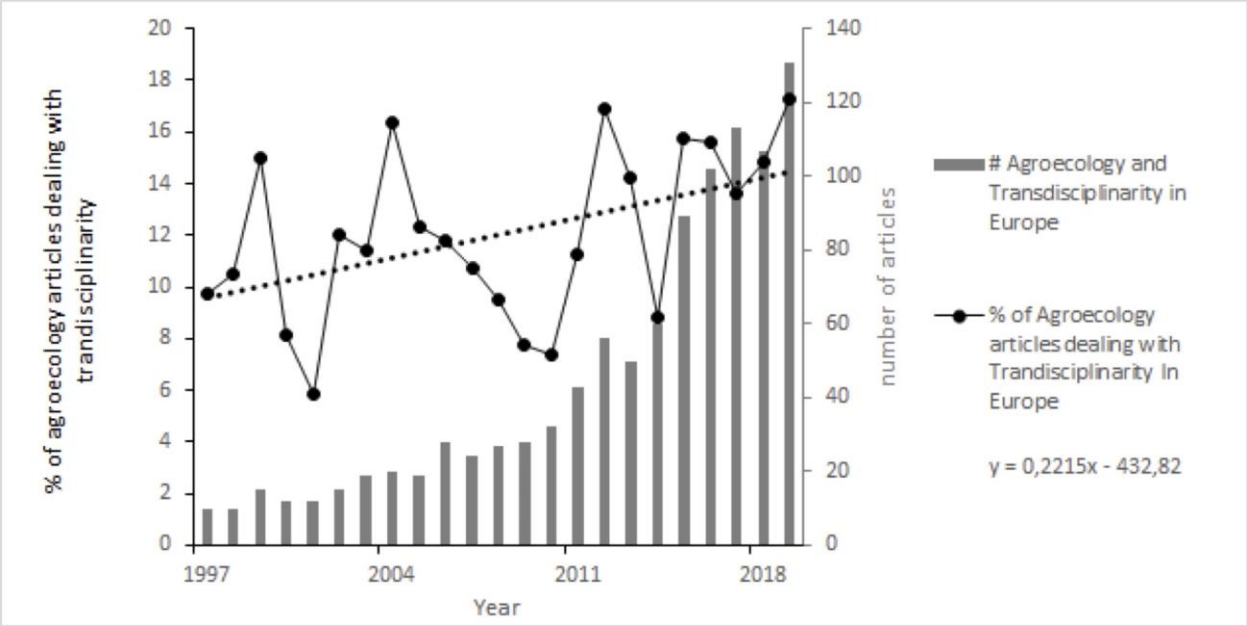

Figure 2. Evolution of the proportion of agroecology publication dealing with a transdisciplinary approach in Europe (dashed line = trend line)

From the overall content analysis (Figure 1, Corpus B), 49% of the articles use the term agroecology as a supplementary topic and 14% only use it as a buzzword (see Figure 1). As shown in Figure 3, authors approached agroecology in 13 different ways; sometimes publications included more than one conception (e.g. *agroecosystems* and *agroecological practices*) which we called a mixed conception. Over the years we observe a rising number of conceptions in agroecology. However, the number of publications per conception is not homogenous. There are conceptions that persist but do not grow (i.e. *agroecology of knowledges*) and others with a growing number of publications each year. Conceptions like *agroecological zoning* and *agroecological transitions*, have increased their number of publications, due to supportive institutional frameworks. Agroecological zoning represents 33% of the analyzed documents and the number of publications keeps growing each year (Figure 3). The use of this concept is favored and promoted by FAO in land-use planning and management methodologies (FAO, 1996). However, using a transdisciplinary framework in this conception often remains contextual and anecdotical, without contributing to the design of sustainable agriculture or food systems. The notion of agroecological transitions has boosted after 2010, especially because French researchers and various institutions (including NGO's) are developing research and creating working groups to contribute to public policies advocacy, to transition from low input or conventional systems to ecologically intensified systems (Bellon and Ollivier 2018).

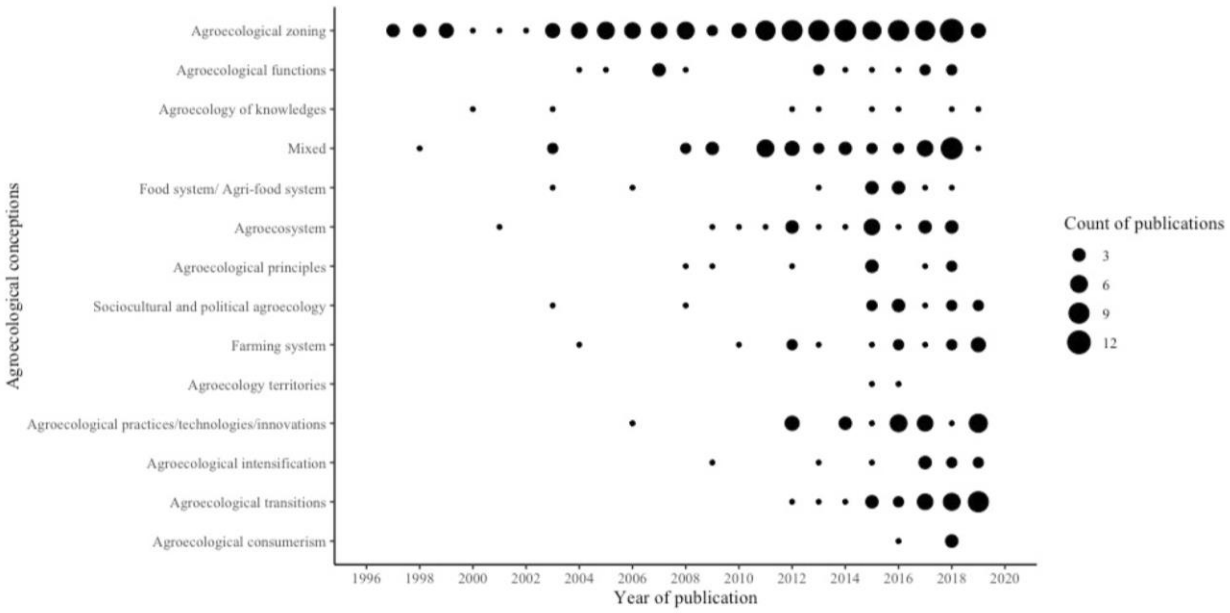

Figure 3. Dynamic of the conceptions of agroecology in Europe: Thirteen agroecological conceptions in publications related with transdisciplinarity in agroecology between 1997 & 2019. The use of multiple agroecological conceptions was named "mixed". The size of a circle represents the yearly number of articles. Articles with no explicit mention of an agroecological conception were excluded.

Most of European researchers in agroecology using a transdisciplinary framework, do their fieldwork outside of Europe (67%) (Figure 4). From 319 articles with an information on their fieldwork location, 33% were based in Europe, 29% in Africa, 13% in Latin America, 12% in Asia, 10% in more than one continent, 2% in East Asia and 1% in North America. Fourteen countries were found to publish topics related to agroecology of which most publications were from authors affiliated to France (n=100), Netherlands (n=55) and United Kingdom (n=74). There are authors from some countries that specialize in non-European countries and others that focus in their country of affiliation (Figure 4). For example, almost all publications affiliated to the Netherlands are from Wageningen University and focus on Africa or Latin America. Meanwhile most authors affiliated to France are from INRAE and do their fieldwork in France; the fieldwork done abroad, is through international institutions like CIRAD or Bioversity International.

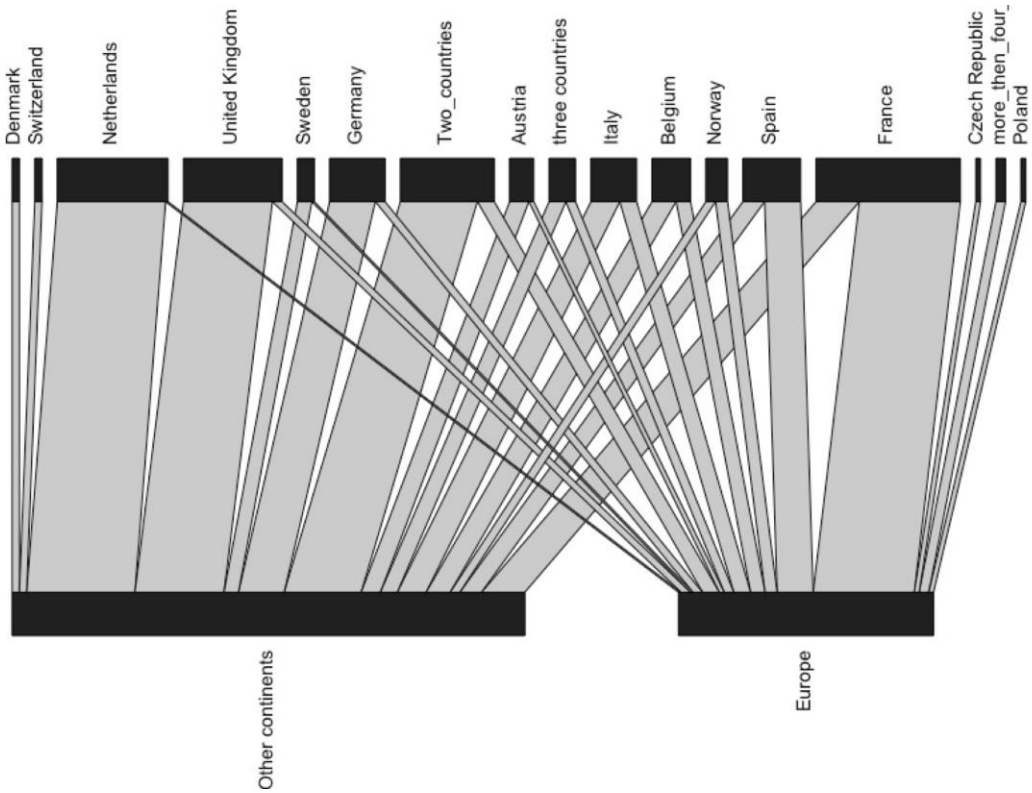

Figure 4. Relation between the countries of European authors (upper part) and the continent where they based their research (lower part). The thickness of the line represents a greater number of articles.

3.2 Type of research approach and participation of stakeholders

From the content analysis of 389 articles (Figure 1 Corpus B), we identified that authors adopted thirteen different research approaches: i) *field studies*, ii) *field experiments*, iii) *field studies and site measurements*, iv*) method proposition*, v) r*eflexive analysis*, vi) *field studies and laboratory analysis*, vii) *comparative studies*, viii) *future scenarios*, ix) *field experiments and laboratory analysis*, x) *models* xi) *meta-analysis*, xii) *review* and xiii) *theoretical*. The more theoretical studies (*Reviews*, *meta-analysis* and *theoretical*), represent 38% of the publications (n= 148). However, a citation analysis of 405 articles (see corpus A in Figure 1), using the VOSviewer software (van Eck and Waltman 2017), shows a low citation level of reflexive work on transdisciplinarity. From 25,333 citations, only 4.5% explicitly mention in their title, words related to transdisciplinarity and 1.2% in association with theory related words.

From the 241 articles that had an empirical research approach, the type of participation of stakeholders was coded using a modified classification from Pretty (1995) (Table 1 and Figure 5). The category "*minimal and passive exchange or interaction between researchers and stakeholders*" represents 62% of the articles (n=107), whereas 27% of the articles (n=63) implies stakeholders whose decision is not imperative in the

pre-established objective of the research (*functional participation*). The third category embodies 11% of the publications (n=26) in which the actors are stimulated to be the change agents of the project (*interactive or auto promoted participation*). Figure 5 shows that 55% or more of the participation of stakeholders in field studies or experiments (and their respective combination with laboratory analysis) is passive or just provides information and other resources. Therefore, the type of research approach and stakeholder's participation, claimed to use a transdisciplinary approach, does not differ from conventional agricultural settings, conducted whether in controlled experimental fields or on commercial farms.

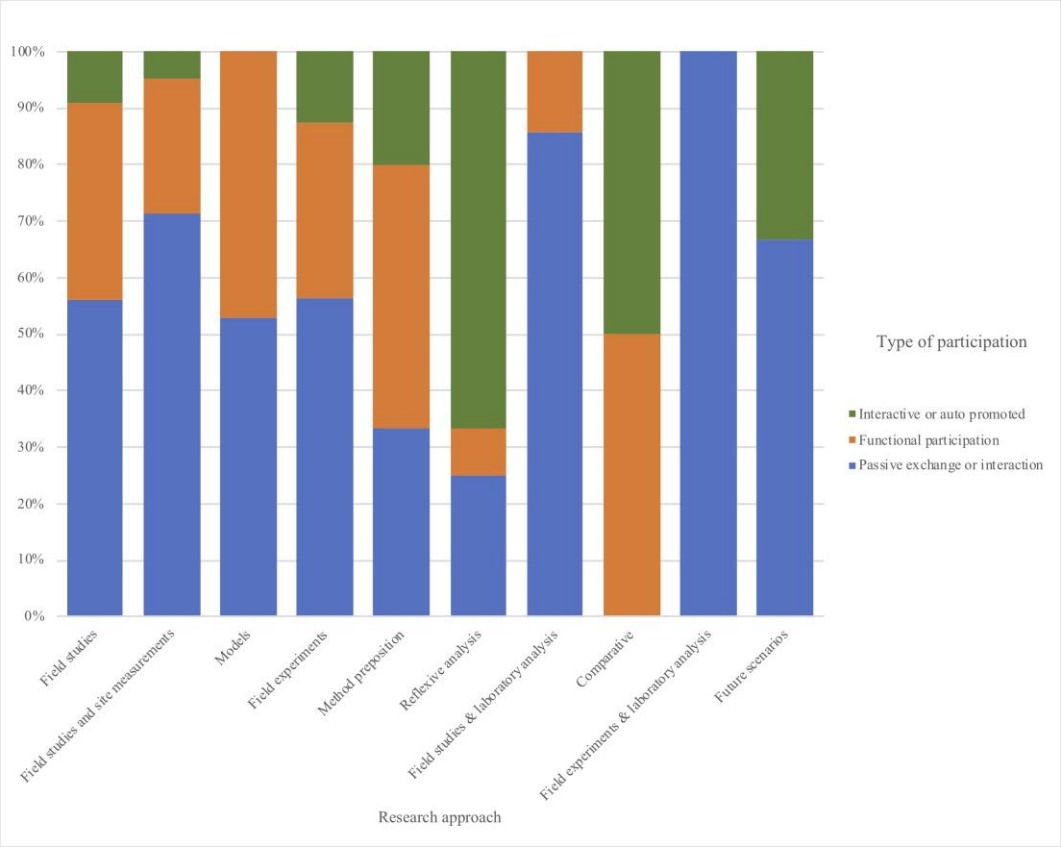

Figure 5. Percentage of the three types of participation of stakeholders according to ten research approaches. The research approaches, from left to right, are ordered according to their importance.

3.3 Typology of transdisciplinary practices in agroecology

After an overview of the main characteristics on the way European agroecologists deal with transdisciplinarity, we here focus on the way researchers implemented it. Based on a restricted corpus of 68 articles (Figure 1 Corpus C), we built a typology described into two sections. The first one outlines the variables that characterize transdisciplinary in practice as they are synthetized with a MCA. The second section describes a typology of approaches based on clusters derived from the HCPC and crossed with the opinions of the interviewees.

The MCA (Figure 6a-b) allowed to determine the importance of the variables that mainly characterize transdisciplinarity in agroecology. The first plan represents 42% of the total dataset inertia, in which the first dimension (30.84% of total inertia) is characterized by the following active variables (p.values<0.001): function of the researcher (r^2=0.82), integration of the knowledge (r^2=0.82), stakeholders stage of involvement (r^2=0.77), legitimacy (r^2=0.75) and type of participation (r^2= 0.74). The time frame to develop the research is a supplementary variable that is statistically associated. The second dimension (11.35 % of inertia) is also characterized by the same variables plus the 'Participatory aim' one. Thus, the two dimensions oppose publications with in-depth transdisciplinary practice (on the right of Figure 6b) to publications with light practices in terms of social interactions, researchers and stakeholder's involvement, legitimacy process and time frame (on the left).

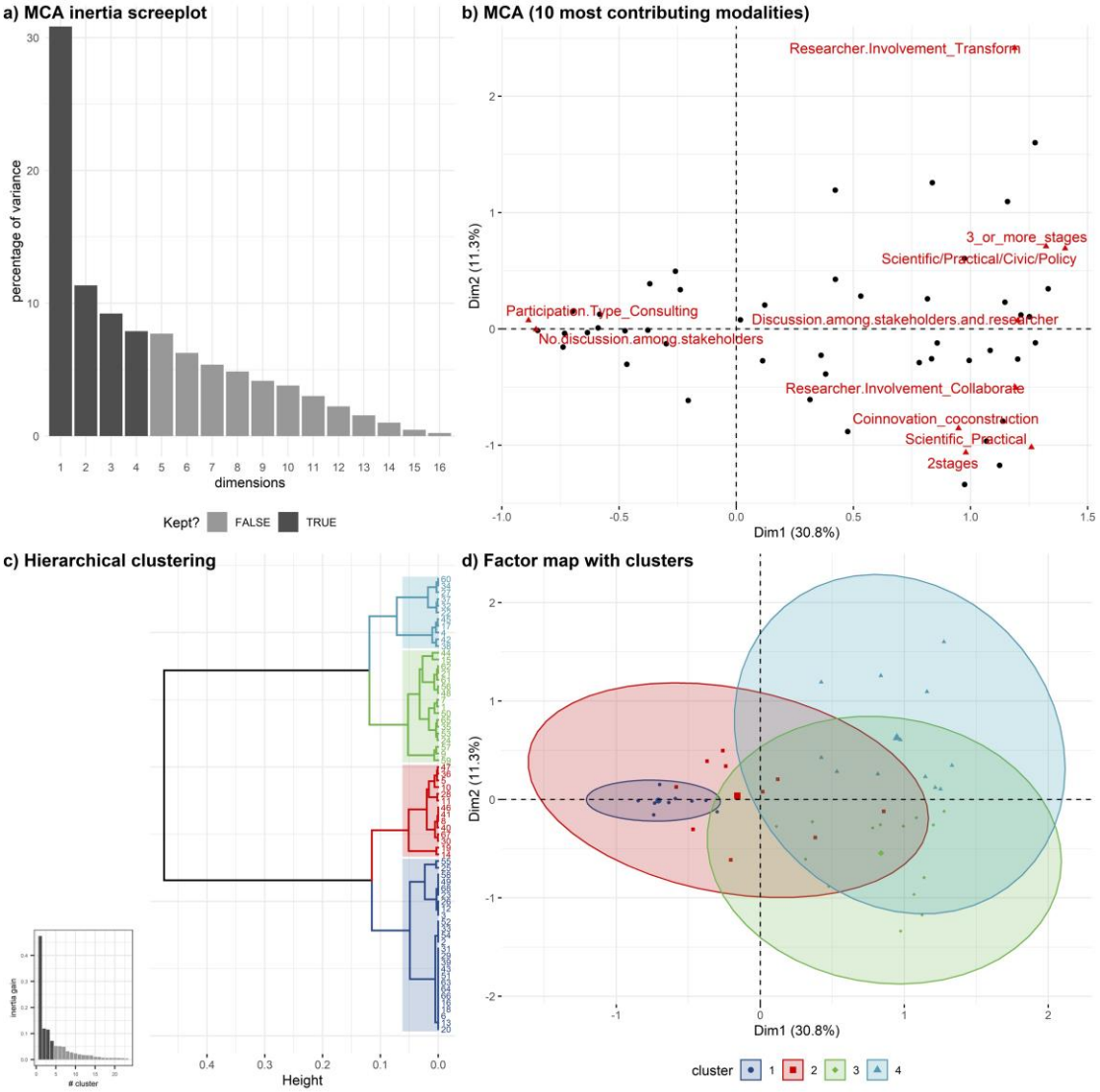

Figure 6. Transdisciplinary practices in agroecology: MCA and HCPC visualizations.

The retained HCPC – considering 4 dimensions with 59,3% of the total inertia – deepens these findings and discriminates four types of research practices claimed to be transdisciplinary (Figure 6 b-c). Table 2 describes the most structuring active variables and the modalities from active and supplementary variables significantly (p-value <0.05) associated to each cluster.

Clusters 1 and 2: classical consultative research

Based upon the HCPC, Clusters 1 and 2 reassembles 61% of the publications and share common features (Figure 6d). Stakeholders are assets to fulfill a knowledge gap and are only consulted in one of the stages of the research. This type of research is on average conducted in less than 1 year and field studies are a prevalent research approach. The researchers' position remains functional (Table 1). According to Table 2, Cluster 1 assembles 44% of the papers and it is distinct from Cluster 2 because researchers just consulted stakeholders whereas in Cluster 2 stakeholders hold internal discussions and have a more active role in the research. Also, in Cluster 1 the aim is to assess different issues (e.g. practices, food networks) and in cluster 2, the research aims to transform or develop, adopt or support decision-making issues. The most frequent research topic (>15%) in Cluster 1 was *agroecological practices*, meanwhile in Cluster 2 there is no dominant topic. Researches in Cluster 2 are associated with multi-country collaborations on non-European fields, with a tendency to integrate not close disciplines (i.e. agronomy, sociology, ecology).

Interviewees associated to both Clusters had background knowledge in natural sciences. They perceive agroecology as a science of socio-ecosystems, in which complexity cannot be reduced to one single discipline. Researchers use the framework of transdisciplinarity to produce knowledge that integrates different viewpoints. They agree that this framework goes beyond the sum of disciplines, thus disciplinary boundaries are blurred. In this vision, researchers acknowledge that stakeholders can help them connect theory and practice since they have specific knowledge of their context and a complex representation of reality. Therefore, stakeholders are chosen to participate in the research depending on what they can contribute to the research. In both Clusters researchers are willing to cross their disciplinary boundary. They consider that one of their function as a scientist is to integrate and interconnect the knowledge from different disciplines; mediate and reformulate both scientific and nonscientific language to make it more available to scientists and practitioners.

In both the HCPC and interviews, we found that scientific legitimacy is a main output for these researchers. However, our interviewees mentioned that they also delivered their results to the participants in a colloquial language. Most of the divulgation were videos, conferences or reports. They considered that most of their

information promoted a reflexive process among stakeholders about their problems, contributions, and reasonings. Some argued that they just did a dissemination because it was neither practical, nor the aim of the research.

Cluster 3: practical problem-solving and co-innovation

This Cluster represents 21% of the publications; researchers have a collaborative role (Table 1) and are in constant discussion with stakeholders (Table 2). The HCPC results also show that the main goal of the research is to have functional participation of people to achieve a co-innovation. Most of this research lasts between 3-5 years and stakeholders participate in at least 2 stages of the research process. The knowledge is legitimized through science and practice, and sometimes civic or policy devices (Table 2). The type of transdisciplinarity of Cluster 3 is mostly associated to French authors. They usually work in research teams covering a knowledge background issued from a diversity of disciplines from social and natural sciences. The dominant topic (>15%) is participatory methodologies to foster agroecological transitions; that often use serious games, such as "TataBox" and "Rami fourrager" (Hazard et al. 2018; Bergez et al. 2019).

The interviewees from this cluster affirmed that an agroecological transition, the most associated conception of agroecology, requires a transdisciplinary framework because any adaptation, from a practice to a food system, needs to be tailor-made by the actors of their territory. One interviewee mentioned that the main advantage is enabling an integrated representation with a non-equivalent model that provides a different viewpoint of the system, that is required to deal with different values or representation of stakeholders; which otherwise would be impossible for scientists to define from a laboratory. Furthermore, interviewees argue that agroecology deals with problems, issues or innovations that have a high degree of uncertainty, and high social stakes or impacts; therefore, it requires a transdisciplinary framework to propose alternatives for conflicting interests and territorial collective approaches. Our interviewees consider that their role as scientists is to develop and operationalize the methodology, coordinate a research program and analyze the different viewpoints; thus, they agree that the research questions need to be co-constructed.

In the interviews, researchers highlighted that when the research aims a social living issues, stakeholders are easily interested because it affects them. Regardless of the research aim, some interviewees chose actors based on theoretical stakeholder analysis of power relationships and other researchers chose individuals or actors that impact and are impacted by the issue. Some interviewees affirm that it is naïve to think that stakeholders should be involved in all stages of the research since researchers have to alternate between an analytical stance to a participatory one. Also, not all stakeholders can interact, especially if considering power relationships among them. Therefore, the research process is a back and forth process between an interdisciplinary team and stakeholders. Our interviewees affirmed that their scenarios or models had an

impact on the public services territorial projects and aimed to reinforce other research projects that had practical innovations. Moreover, intangible outputs are derived from interacting among stakeholder's, which help clarify their own positions, learning from each other and taking part in a collective process.

Cluster 4: transformative and reflexive processes in education and science

The 12 publications (18%) assembled in this Cluster are inserted in a transformative perspective. Table 2 shows that researchers are involved in a collaborative stance and stakeholders have an auto promoted participation (Table 1). It is based upon interactions among stakeholders and researchers mainly from distant disciplines. For example, the interviewees and research teams had background knowledge on a diversity of disciplines in social and natural sciences. The research process is usually long (> 5 years) with many stages of participation with stakeholders; it encompasses reflexivity and comparative approaches, with diverse conceptions of agroecology. The main topics (>15%) are education, transitions and participatory methodologies. The knowledge is legitimized through scientific and policy processes.

Our interviews revealed that we could subdivide this category in an academic and an activist transdisciplinarity. The academic transdisciplinarity is based on the experience of the educational program of Agroecology in Norway (Francis et al. 2013). In their action-learning system, transdisciplinarity is used to understand a complex issue of reality and promote an experiential learning. Their goal is that students learn by observing and experiencing a problem and deliver suggestions or identify problems with stakeholders. Contrastingly, an activist transdisciplinarity (Stassart et al. 2018; Cuéllar-Padilla & Calle-Collado 2011) is used in agroecology as an ethical and political commitment of scientist to be at the service of society and recognize that academic knowledge is not above other knowledges or ways of generating knowledges, but they are equally valid and true. Under this vision, transdisciplinarity can only be achieved through a horizontal scheme of knowledge forms, social status and shared needs and motivations. The outputs created are very context-dependent since they emerge from a situated knowledge, and non-tangible results are an important part of the research. In this case the process itself becomes a result, for example, the maturity of a group and network, the articulation and empowerment of the collective, the mutual collaboration and the development of skills and mutual learning.

Table 2: Description of variables, modalities and clusters of transdisciplinary practices
*[*Values in cells correspond to i) the proportion of publications of the Cluster having the modality, ii) the v.test, the intensity of the relation between the cluster and the modality, in red when positive and blue when negative, and iii) its significance (*** for p<0.001, ** for p<0.005, * for p<0.01, for p<0.05*). Variables are ordered by their decreasing importance in the structuration of clusters (p.value from chi² test)]*

status	variable	modalities	Cluster 1 (n=30)	Cluster 2 (n=12)	Cluster 3 (n=14)	Cluster 4 (n=12)
active	Knowledge Integration *** p value=4 4e-19	No discussion among stakeholders (n=30)	93%, 7.7***	8%, -2.8**	7%, -3.2**	0%, -3.6***
		Discussion among stakeholders and researcher (n=23)	0%, -5.6***	0%, -2.9**	86%, 4.4***	92%, 4.4***
		Discussion among stakeholders (n=15)	7%, -2.7**	92%, 5.7***	7%, -1.5	8%, -1.2
	Researcher Involvement *** p value=8 5e-14	Functional (n=43)	100%, 6***	92%, 2.3*	14%, -4.1***	0%, -5***
		Collaborate (n=20)	0%, -5.1***	8%, -1.7 .	86%, 4.9***	58%, 2.2*
		Transform (n=5)	0%, -2*	0%, -0.9	0%, -1	42%, 4***
	Participation Type *** p value=2 2e-12	Consulting (n=33)	93%, 6.8***	42%, -0.5	0%, -4.3***	0%, -3.9***
		Interactive/Autopromoted (n=21)	7%, -3.9***	25%, -0.4	36%, 0.4	92%, 4.7***
		Functional (n=14)	0%, -3.9***	33%, 1.1	64%, 4***	8%, -1.1
	Stakeholder Participation Stage *** p value=1 2e-11	1stage (n=43)	100%, 6***	75%, 0.9	7%, -4.8***	25%, -2.9**
		2stages (n=13)	0%, -3.8***	25%, 0.6	64%, 4.2***	8%, -1
		3_or_more_stages (n=12)	0%, -3.6***	0%, -1.8 .	29%, 1.1	67%, 4.2***
	Participatory aim *** p value=8 7e-10	Assesment (n=34)	87%, 5.4***	42%, -0.6	14%, -3**	8%, -3.2**
		Coinnovation_coconstruction (n=14)	7%, -2.5*	0%, -2*	71%, 4.7***	17%, -0.3
		upscaling/transforming (n=12)	0%, -3.6***	33%, 1.4	7%, -1.1	58%, 3.5***
		development/decision_making/adoption (n=8)	7%, -1.1	25%, 1.4	7%, -0.5	17%, 0.6
	Knowledge Legitimization *** p value=1 3e-07	Scientific (n=48)	100%, 5.1***	92%, 1.7 .	29%, -3.6***	25%, -3.5***
		Scientific/Practical/Civic/Policy (n=11)	0%, -3.4***	8%, -0.7	29%, 1.3	50%, 3**
		Scientific_Practical (n=9)	0%, -2.9**	0%, -1.4	43%, 3.1**	25%, 1.2
	Disciplines Integration *** p value=8 1e-04	not_closely_related (n=39)	33%, -3.5***	67%, 0.7	64%, 0.6	100%, 3.5***
		Closely_related (n=29)	67%, 3.5***	33%, -0.7	36%, -0.6	0%, -3.5***
	Problem Definition * p value=3 6e-02	knowledge_gap (n=39)	70%, 1.8 .	58%, 0.1	43%, -1.2	42%, -1.2
		Social_living_issue (n=20)	30%, 0.1	8%, -1.7 .	43%, 1.2	33%, 0.3
		exterior_request (n=9)	0%, -2.9**	33%, 1.9 .	14%, 0.2	25%, 1.2
suppl.	Time_inter *** p value=8 9e-07	3_5years (n=20)	13%, -2.6*		71%, 3.6***	
		1_2_years (n=18)			7%, -1.8 .	
		6_moreyears (n=11)	0%, -3.4***			67%, 4.4***
		less_1year (n=10)	27%, 2.4*		0%, -1.7 .	
		NA (n=9)	23%, 2.1*			
	Author_Country ** p value=2 6e-03	France (n=21)		0%, -2.7**	86%, 4.7***	
		More_then_two_countries (n=9)		42%, 2.7**		
	Article Approach * p value=1 1e-02	Field_studies (n=39)	73%, 2.3*		36%, -1.8 .	33%, -1.8 .
		Reflexive analysis/Comparative (n=11)	7%, -1.8 .	0%, -1.7 .		50%, 3**
		Models (n=5)			21%, 1.9 .	
	place * p value=1 7e-02	NA (n=37)		25%, -2.2*	79%, 2*	
		NonEU (n=31)		75%, 2.2*	21%, -2*	
	Agroecology Approach p value=1 2e-01	Agroecological transitions (n=17)	10%, -2.5*		64%, 3.5***	
		Mixed (n=9)				33%, 1.9 .
		agroecology of knowledges (n=5)	17%, 2.5*			

3. DISCUSSION

In summary, our results show that transdisciplinarity in agroecology remains under construction and that researchers have different ways of understanding and practicing it. The following discussion is divided into 3 sections to consider 1) how the disparity between the theoretical discourses and the agroecological movements expectations affects the practical frameworks; 2) three barriers researchers face when practicing transdisciplinary research, and 3) the institutionalization and future perspectives of transdisciplinarity in Europe.

4.1. Disparity in the practical and theoretical discourses

In agroecology, the theoretical and practical framework of transdisciplinarity contrasts with what its movements seek to achieve. Agroecology Europe, food sovereignty forums (e.g. Nyeleni), international expert panels (HLPE, FAO), researchers and diverse actors are calling for meaningful collaborations, in which knowledge is co-created, exchanged and social, environmental, cognitive justice is achieved (Wezel et al. 2018, Duncan et al. 2019; HLPE 2019). To achieve this goal, in theory, agroecological knowledge is based on holism, complexity, system thinking, epistemological pluralism, and contextualization as an alternative to the simplistic, positivist paradigm of classical sciences (Norgaard & Sikor 1995; Bland & Bell 2007; Gómez et al. 2015; Bell & Bellon 2018). However, some authors mention a lack of clarity within these epistemological principles, entailing uncertainty as to whether agroecology is multidisciplinary, interdisciplinary or transdisciplinary (Méndez et al. 2013; Dalgaard et al. 2003; Gómez et al. 2015). The epistemological plurality within agroecology is reflected in our results; which show that of 3,235 publications on agroecology, only 12.6% are related to transdisciplinarity forms. Previous authors have divided agroecology in *hard* and *soft* agroecology (Dalgaard et al. 2003), arguing that a *soft* system perspective includes the viewpoints of people, operating at farm to regional levels and with engaged scientists. Our results show that the majority of the 68 publications analyzed (87.4%) can be considered as close to *hard* agroecology even though they consider actors in their research process. However, they also show that not all s*oft* agroecology has the same characteristics. For example, there is a diversity of conceptions of agroecology and the subjects or levels of analysis do not delimit a transdisciplinary approach. Contrary to what was expected, topics such as system design and social movements, which are considered by Brym and Reeve (2016) as central issues in agroecology, are little addressed with transdisciplinarity, whereas participatory design approaches are increasingly advocated in specific disciplines (Meynard 2017; Berthet et al. 2018). Besides, most *soft* researchers continue to have a rather positivist paradigm, where researchers maintain a 'neutral' function seen as a source of scientific legitimacy (Montenegro de Wit & Iles 2016). As a consequence, stakeholders become passive objects of study, which can limit the researcher capacity to recognize, frame and assess problems from the perspectives of actors.

This reflects that agroecology is appropriated with a diversity of scientific paradigms and approaches (multi/inter/trans-disciplinary).

Agroecologist have criticized the top-down scheme of conventional agricultural science under which research is not contextualized according to the local conditions and necessities (Altieri 1989; Norgaard & Sikor 1995). Our results show that the use of transdisciplinarity does not necessarily differ from conventional agricultural settings, where farmers are also heard, and practical studies are conducted in controlled experimental or even farmers' fields. Likewise, a transdisciplinary framework does not necessarily lead to social empowerment and legitimacy (Brandt et al. 2013). On the one hand, this shows that the associated terms to transdisciplinarity can sometimes be reduced to a buzzword or a mere involvement of stakeholders in the research (Scholz & Steiner 2015a), either in a consulting or a participative way (Mobjörk 2010), rather than a deep integration of knowledge. On the other hand, as our results show, "researchers' function" (table 1), is the main variable that differentiates the type of transdisciplinary approach. This can be the result of scientists' epistemological premises of how to interact with other stakeholders to integrate and legitimize non-scientific knowledge (Norgaard and Sikor 1995).

However, we notice a weak epistemological theorization of transdisciplinarity in agroecology. Despite the vast literature of transdisciplinarity in sustainable sciences, only few publications (particularly Méndez et al. 2013; Francis et al. 2013; Lamine 2018; Popa et al. 2015) were used as theoretical references to transdisciplinarity; in contrast with references used from participatory research. The difficulty of only using participatory research as a theoretical basis is that it is not exclusive of transdisciplinarity; since participation in a disciplinarity approach is used as a consultative process to test, implement or create knowledge based on the real world (Mobjörk 2010; Hazard et al. 2019). Therefore, we see that transdisciplinarity in agroecology is subdivided into an *instrumental* or *epistemological* approach. In an instrumental approach, transdisciplinarity is used as a bridge of knowledge between science, movements, and practice (Caporali 2011); meanwhile, an epistemological approach represents the linkage of epistemological discourses (Gómez et al. 2015). This same subdivision can be applied to dichotomies that we found in our clusters; where 61% of our publications (Cluster 1&2) represent an instrumental approach and 39% (Cluster 3&4) include an epistemological approach.

In summary, the transdisciplinary approaches in agroecology are weak and do not necessarily achieve both the theoretical premises and social movements requests. Accordingly, to achieve these requests, should all agroecological research be transdisciplinary? Some interviewees, on the one hand, argue that producing context-dependent knowledge is essential to interact with stakeholders in order to understand from different

perspectives the complexity of the real-world problems. On the other hand, others argue that the object of study in agroecology are problems that deal with high uncertainty and high social stakes or share interests. In either perspective, agroecology needs scientific pluralism (Hazard et al. 2019), where disciplinary and interdisciplinary approaches respond to the demands that arise from a transdisciplinary process. Both disciplinary and interdisciplinary approaches can help fill knowledge gaps that do not need a permanent dialogue (e.g. biological mechanisms that require experimental or laboratory analysis) but are embedded in a transdisciplinary context or problematic that offers a common conceptual and methodological framework. Nonetheless, we invite researchers to have a reflexive process about the premises that drive their research.

4.2 Barriers for practicing transdisciplinarity

The information obtained in the already presented statistical results and complementary comments from the interviews helps us understand the motives and barriers of why other research in agroecology might or might not retake a transdisciplinary approach. The following section assembles three barriers that determine the practice of transdisciplinarity.

Matrix of disciplines- In agroecology the use of multiple disciplines is linked to the capacity to tackle complex problems (Caporal et al. 2006); however, it is not clear whether it should include disciplines with different or similar concepts and methods and levels of analysis (Stokols et al. 2003). Caporal et al. (2006) argued that it is necessary to integrate social sciences since the use of only natural sciences cannot address the complexity of a phenomenon. In our results, most of the publications include disciplines that are closely related (Cluster 1 & 2) mostly with a background in natural sciences. This can be explained by the institutionalized notion of agroecology in themes of life sciences (Nicot et al. 2018), which dismisses the contributions of social sciences (Wezel et al. 2018). More generally, historians and sociologists of science teach us that disciplines are the result of social and institutional mechanisms to maintain boundaries between different established cognitive orders which constraint individuals (Kuhn 1962; Abbott 2010). Furthermore, our interviews show that more than just including social sciences, the challenge is to operationalize a transdisciplinary framework among researchers and at the individual level. The challenge is to create a common representation system, among scientists of different disciplines; where a common theoretical, methodological, conceptual and problematic understanding emerges. This does not mean that specialized knowledge cannot be created but rather that there is a general understanding among disciplines allowing integration rather than a juxtaposition of disciplines. However, most interviewees highlight that they were not trained to do transdisciplinary research, and this requires a willingness and ability to incorporate knowledge that can be abysmally different from their disciplines. Guimarães et al. (2019) argue

that their abilities are an inherited nature of their personality and their experiences and could hardly be acquired through training. Nonetheless, opening the disciplinary matrix and having a common representation system has the potential to transition to more collaborative forms of transdisciplinarity.

Collaboration- The type of collaboration among researchers and non-academic can be differentiated on effective and symbolic participation; effective participation leads to empowerment and involves non-academics in all phases of the research (Mobjörk 2010). We identified four factors that influence the type of collaboration. First, our interviewees achieve a greater engagement and legitimacy by attending non-academic needs or directly benefiting them. Second, the power relationships between stakeholders, priorities, opportunities, interest or the age of the stakeholders can delimit the type of collaboration. Third, establishing a relationship with stakeholders is a time-consuming process whereas researchers are mostly evaluated on the number of publications (per year or over time) and engaged in 3 to 4 years projects. For example, a research can last more than 6 years (Cluster 4) in order to build trust, a strong social network and achieve a "thick" legitimacy. However, our interviewees argue that, once this relationship is established the research process can even be faster than conventional research. Fourth, researchers' function (*functional* vs. *collaborative* or *transformative*) (Table 1) can also determine the type of collaboration. Scientists with a collaborative or transformative stance are criticized for creating knowledge that lacks objectivity and rigor or the risks of being over politicized (Stassart et al. 2018). However, as our interviewees mention, their role is not only to produce knowledge, but they are also communicating, negotiating and engaging with the stakeholders, research and finance institutions; breaking barriers between disciplines, and supporting the dissemination of outcomes (Latour 1991).

Reflexivity- In general there is heterogeneity and a lack of reflexivity on researchers' theoretical and practical transdisciplinarity framework. Popa et al. (2015), state that transdisciplinarity does not aim for a common theoretical and methodological framework, but it encourages a reflexive process to reduce the risk of becoming a consulting science with no social or political legitimacy. Reflexivity is understood as a creative process to critically evaluate the values and assumptions of all participants, that help develop unique langue and methodologies (Popa et al. 2015). Our results show a lack of reflexivity between researchers and non-scientific actors. For example, when asked to our interviewees how non-scientific actors thought about what their function was or how they felt in transdisciplinary research, most interviewees did not know or assumed that people felt listened and grateful for contributing to the process. However, social movements have expressed there is no reciprocal association and researchers do not feel accountable for the impact of their outcomes (Duncan et al. 2019).

4.3 Institutionalization of transdisciplinarity in agroecology and future perspectives

The institutionalization of transdisciplinarity in agroecology has the potential to influence its conception and practice which may be contingent of local epistemic cultures and institutional framings. For example, Cluster 3 denotes how the French institutional history has been influenced by strong theorists on transdisciplinarity and systemic thinking (de Freitas, Nicolescu, Morin 1994); who contributed and inspired French researchers and institutions (Teixeira 2004; Hubert & Mathieu 2016). In 2017, INRAE conceived interdisciplinarity and transdisciplinarity as essential frameworks to pursue an agroecological transition and articulate different disciplines, to co-produce knowledge having scientific rigor (Caquet & Tixier-Boichard 2020). The institutionalization has had a positive effect in terms of funding projects and assembling projects with interdisciplinary backgrounds. However, in many other European countries funding for agroecological research is still limited or nearly absent (Pimbert & Moeller 2018; Wezel et al. 2018). In our results, we found that 37% of the publications did not mention funding sources or assured that there was no funding, and most of the interviewees had difficulties financing their research; whether because financing institutions do not consider transdisciplinarity or because it is difficult to deliver all the results of a process that can take years. However, nowadays transdisciplinarity is increasingly becoming a legitimate approach in European panels and projects that promote agroecological transitions. For example, in European programs like Horizon 2020, innovation projects foster knowledge exchange, partnerships, co-learning and a horizontal dissemination trough learning hubs or other platforms that support sustainable agroecological transitions (HLPE 2019; EIP-AGRI 2020). The institutionalization of transdisciplinarity in agroecological research can impulse a more integrative knowledge production or else risk becoming a new buzzword that does not transcend an extractive scheme of participation.

CONCLUSION

This study aimed to reflect on the transdisciplinary research that is practiced and formalized by European agroecologists. Transdisciplinarity, can be defined *lato sensu* as the practices of collaboration between non-academic actors and scientists, in knowledge production processes, which through reflective processes seek to integrate different knowledge systems. Our results show that the share of researches with a transdisciplinary approach in agroecological researches in Europe is still limited (13.1%) and under construction. There is room for enhancing transdisciplinarity in agroecology, through the confrontation of practices and experiences of researchers and involved actors. The content analysis revealed that the word agroecology is mostly used as a buzzword or is related to conception of agroecological zoning. Despite the criticisms of agroecology towards vertical and unidirectional schemes of stakeholder participation on

conventional agriculture, we found that the participation of non-scientific actors remains passive in field studies and experiments. In addition, the citation analysis revealed that practical studies lack a theoretical basis on transdisciplinarity. The combination of interviews and HCPC revealed four different ways of practicing and understanding transdisciplinarity. However, in 61% of publications (Groups 1 and 2), stakeholders and researchers establish unequal collaborations and roles. Subsequently, there is a disparity between the theoretical and practical framework of transdisciplinarity, which questions the type of contributions that agroecology makes to transition towards sustainable food systems. We conclude that although transdisciplinarity in agroecology is a quite young approach that is still under construction, this approach needs to be supported since it has the ability to address wicked problems. Likewise, agroecology needs a scientific pluralism, where, disciplinary and interdisciplinary approaches respond to the demands that arise from a transdisciplinary process. Additionally, researchers need to start a reflexivity process of their theoretical and practical frameworks, to achieve an effective collaboration with non-scientific actors that promotes social and political legitimacy. In that sense, institutional frameworks can help promote a more horizontal creation of agroecological knowledge, that could better legitimate transdisciplinarity through funding and evaluation of researchers.

ACKNOWLEDGMENTS

To the interviewees that provided their time and valuable input.

FUNDING

We thank the IDAE project (ANR-15-CE21-0006) for financial support.

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Supplementary material

Supplement 1 Scopus query search

TITLE-ABS-KEY("agroecolog*" OR "agro-ecolog*") AND TITLE-ABS-KEY("participat*" OR "transdisciplinar*" OR "multidisciplinar*" OR "interdisciplinar*" OR "system* research*" OR "system* approach*" OR "system* think*" OR "action research" OR "community-based" OR "farmer led" OR "Ethno*" OR "cross-disciplin*" OR ((stakeholder* OR farmer* OR peasant* OR communit*) PRE/2 (involvement OR engagement OR experiences)) OR ("knowledge*" PRE/ 2 (system*))) AND (LIMIT-TO (AFFILCOUNTRY,"France") OR LIMIT-TO (AFFILCOUNTRY,"United Kingdom") OR LIMIT-TO (AFFILCOUNTRY,"Netherlands") OR LIMIT-TO (AFFILCOUNTRY,"Germany") OR LIMIT-TO (AFFILCOUNTRY,"Italy") OR LIMIT-TO (AFFILCOUNTRY,"Spain") OR LIMIT-TO (AFFILCOUNTRY,"Belgium") OR LIMIT-TO (AFFILCOUNTRY,"Denmark") OR LIMIT-TO (AFFILCOUNTRY,"Sweden") OR LIMIT-TO (AFFILCOUNTRY,"Switzerland") OR LIMIT-TO (AFFILCOUNTRY,"Austria") OR LIMIT-TO (AFFILCOUNTRY,"Hungary") OR LIMIT-TO (AFFILCOUNTRY,"Norway") OR LIMIT-TO (AFFILCOUNTRY,"Croatia") OR LIMIT-TO (AFFILCOUNTRY,"Finland") OR LIMIT-TO (AFFILCOUNTRY,"Czech Republic") OR LIMIT-TO (AFFILCOUNTRY,"Poland") OR LIMIT-TO (AFFILCOUNTRY,"Portugal") OR LIMIT-TO (AFFILCOUNTRY,"Slovakia") OR LIMIT-TO (AFFILCOUNTRY,"Greece") OR LIMIT-TO (AFFILCOUNTRY,"Latvia") OR LIMIT-TO (AFFILCOUNTRY,"Lithuania") OR LIMIT-TO (AFFILCOUNTRY,"Slovenia") OR LIMIT-TO (AFFILCOUNTRY,"Estonia") OR LIMIT-TO (AFFILCOUNTRY,"Romania") OR LIMIT-TO (AFFILCOUNTRY,"Luxembourg"))

Supplement 2 Interviewees questionnaire

Questionnaire for semi-structured interviews to researchers active in agroecology and transdisciplinarity:
What is your scientific background and current area of knowledge?
Can you tell me what is your experience in doing transdisciplinary research?
Why did you decide to do transdisciplinary research? How would you define transdisciplinary research in agroecology and what are the key elements attached to this approach?
Under what conditions do you think research in agroecology should have a transdisciplinary approach? And why?
In your experience how long does transdisciplinary research takes?
Who funds this type of research (i.e. universities, farmers, NGO's, private sector)?
Of the type of research, you do find a difference or advantage of doing transdisciplinary research?
What makes stakeholders engage/commit to participate in the research and does their participation change over time? Why and what type of changes? And what makes them disengaged?
How many actors should you work with and how much time should they in the research process, so it is considered transdisciplinary research?
How were the stakeholder(s) chosen or how did they incorporate themselves?
How do you think stakeholders perceive/feel about participating in the research (i.e. do they think is their job to create, provide knowledge for science)?
Have the stakeholders used the outputs of the research? If so what type of impact did it have? Is there a dissemination process in the research?
Do you think that there is a willingness from different stakeholders to create a dialogue and learn from each other? Why?
To your knowledge have the culture (incl. religion), history, interests, etc. have become a challenge to overcome to do transdisciplinary research? If so, what approaches did you take to solve this?
During the research process (beginning formulation, as a data source and/or at the end for validation) when do you consider to be important for stakeholders to incorporate their opinions, needs, values, etc.?

In which part of a research (beginning formulation, as a data source and/or at the end for validation) do you think their opinions, needs, values, etc. are most fruitful?
How would you describe the process/methodologies/tools you use to incorporate the knowledge, opinion, needs, etc. of the stakeholders? And why is it useful to follow them?
Do you work with a team of researchers from different disciplines? If so, what disciplines?
What role do you think you play as a researcher in this type of transdisciplinary approach?

Supplement 3 References used for typology of transdisciplinary practices in agroecology

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