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The effect of collaboration on farmers' pro-environmental behaviors – A systematic review

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ABSTRACT

Given the impact of agriculture on the environment, pro-environmental farming practices are growing in importance. Collaboration has an essential role to play in addressing environmental problems and promoting pro-environmental behaviors. As ecosystems are interdependent and diverse, their management is shared among numerous groups of people who are bound to collaborate to achieve common objectives. Through their farming practices and behaviors, farmers have a key role to play in protecting the environment, and by collaborating with each other or with other experts in ecology, objectives at a larger environmental scale could be achieved. However, a systematic review of the effect of collaboration on farmers' pro-environmental behaviors has not been conducted yet. We identified and reviewed 44 articles published in peer-reviewed scientific journals. We classified the articles into 4 categories reflecting reasons for collaboration: program participation, technical training, collaboration among farmers, and peer influence. Moreover, to consider the hierarchical structure in which collaboration unfolds, we differentiated between symmetrical and asymmetrical collaboration, allowing us to estimate whether one type of collaboration is more efficient than another. Overall, collaboration has a positive effect on farmers' pro-environmental behaviors in all four categories, and both in symmetrical and asymmetrical collaborations. The review provides insights for future research directions. In particular, future collaborations with farmers may focus on groups of farmers instead of individuals, as well as on proactively involving them in the decision-making process.

1. Background

The agricultural system of present societies has an undeniable impact on the environment (Foley et al., 2005; Green et al., 2005; McLaughlin & Mineau, 1995; Norris, 2008; Sharpley et al., 2001). With human population constantly increasing, the pressure on farmers to provide more food is rising, prompting them to manage their land in a more intensive way to increase their yields (Baulcombe et al., 2009; McIntyre, 2009; Pelletier & Tyedmers, 2010). However, this has been at the expense of biodiversity, which is inextricably linked to farming as it performs a variety of ecosystem services indispensable for agricultural production (Altieri, 1999; Zhang et al., 2007). Farmers, with their unique position at the intersection of food production and environmental impact, are thereby facing a dilemma, torn between pressure to increase their production and at the same time lower their negative impact on the environment and biodiversity. They thus have a key role to play in preserving the environment on which they rely (Mendelsohn, 2009; Lehmann & Finger, 2013), by adapting their farming practices and behaviors (McLaughlin & Mineau, 1995; Šálek et al., 2018). In line with this, it is of utmost importance to understand which factors can impact their pro-environmental behaviors, defined as any behaviors benefitting the environment or the decision to stop behaviors that harm it (Lange & Dewitte, 2019).

1.1. The policy-making approach

In policy-making, an increasing focus is put on farmers' pro-environmental behaviors. For example, in Europe, the Common Agricultural Policy (CAP) was first introduced in 1962 and created the Agri-Environment Schemes in the 1980s (European Union [EU] Regulation 797/85). These schemes aim to protect and enhance landscapes, improve farmland biodiversity, and protect natural resources (Polman &

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Slangen, 2007, p. 31), by financially helping farmers committed to pro-environmental practices, such as organic farming, integrated production, or reduction of fertilizer and pesticide use (Batáry et al., 2015). In the USA, the Government already focused on soil protection in the 1930s, and in 1985 created the Conservation Research Program which aims at increasing the control of soil erosion by proposing direct payments to farmers agreeing to remove environmentally sensitive land from agricultural production and to plant species that will improve environmental health and quality for example (Hellerstein, 2017). However, the availability of such programs is not sufficient to decrease biodiversity loss (Ait Sidhoum et al., 2022; Batáry et al., 2015). There is thus a need to understand what are the factors motivating farmers to behave in a pro-environmental way.

1.2. Predictors of farmers' pro-environmental behaviors

The scientific literature focused on farmers' willingness to take part in conservation programs, considering this willingness as a pro-environmental behavior. For instance, Burton (2014) summarized farmers' demographic characteristics and showed that younger, more experienced, more educated or female farmers engage more easily with environmental programs. Lastra-Bravo et al. (2015) analyzed the factors influencing farmers' decision to join agri-environmental schemes (AES) and disentangled the impact of economic factors and other demographic factors. They found that farmers who highly depend on farm income or involve a high proportion of family labor are less likely to join an AES, whereas larger farms, the absence of a successor on a farm, or previous experience with AES positively affect farmers' willingness to join. Knowler and Bradshaw (2007) focused on the adoption of conservation agriculture worldwide and concluded that there is a lack of universal variables explaining it, emphasizing the need to focus on local conditions to promote adoption. Bartkowski and Bartke (2018) pointed out that financial incentives and constraints have a strong impact on farmers' decision-making, but also other factors such as farmers' pro-environmental attitudes or past experience. Unlike the previous reviews that focused on farmers' participation in conservation programs, our study specifically examines their actual pro-environmental behaviors. This means that we focus on tangible actions taken by farmers to protect the environment, such as sustainable farming practices and resource conservation, rather than merely their enrollment in formal conservation initiatives. Moreover, they focused on individual characteristics, when it has long been recognized that individual conservation efforts need to be articulated with the participation of the wider community (Haenn et al., 2014). In particular, as stated by Bartkowski and Bartke (2018), there is a need to shift the focus to collective understudied factors, such as advisory services and collaborative projects, which have a high potential role in facilitating sustainable practices.

1.3. The collaboration approach

When aiming to decrease human impact on the environment, research shows that it is essential to focus on collaboration among people. Ecosystems are interdependent and various, and their management is spread among numerous people, from land managers to governments, who are bound to collaborate to achieve a common management goal (Bodin, 2017). There are already several collaborative projects especially between various scientists in ecology to find the best solutions for the environment (Cheruvelil et al., 2014). However, despite farmers being the main actors in ecosystem management, there is a clear lack of synthesis on the impact of collaboration between farmers and other people.

Collaboration, which is defined in the present article as any interaction between farmers and other people regarding sustainable farm management and practices, plays a major role in the agricultural world and is an essential tool to increase the production of new knowledge through social learning. It is also important to better connect insights from various knowledge systems, as emphasized by Bodin (2017) and Tengö et al. (2014). Indeed, collaborative projects with governmental agencies, NGOs, or research institutes positively impact farmers' engagement in nature conservation. For example, farmers participating in advisory programs, which are designed to help farmers understand why and how to implement the best ecological on-farm practices, are more confident and positive toward agri-environmental management (Lobley et al., 2013). Such programs can also increase farmers' knowledge about the environment, which has a positive impact on their pro-environmental behaviors (Frick et al., 2004; Meinhold & Malkus, 2005), or give them precise information, which increases their willingness to implement measures promoting biodiversity (Gabel et al., 2018). There is thus a need to focus on collaborative approaches, to estimate in what contexts they are most effective, as highlighted by Bodin (2017). The latter performed an interdisciplinary research on collaborative networks and highlighted the need to understand the effectiveness of collaboration in addressing environmental issues. This involves discerning the types of collaboration, identifying the key actors involved, and understanding their connections within the ecosystem's structures. Collaboration is thus essential for addressing environmental problems, but our understanding of how collaborative network structures contribute to expected outcomes is still not clear enough.

1.4. The present research

Considering the above, we conducted a systematic review of collaboration's effect on farmers' pro-environmental behaviors. The review includes articles published in peer-reviewed scientific journals and aims to answer how collaboration influences farmers' pro-environmental behaviors and whether one type of collaboration is more effective than another.

Let us start by situating the present review in the theoretical framework that guided our analysis. Social Interdependence Theory is a conceptual framework that defines how people interact depending on the social structure in which they are embedded (Johnson & Johnson, 2005). This theory draws from the early work by Deutsch (1949), who was the first to differentiate cooperation from competition focusing on the social structure that organizes interaction between two or more actors, that is, social interdependence. Cooperation occurs when the actors' goals are positively interdependent, and the success of one party requires or implies the success of the other (like within a rowing team). This involves negotiation to achieve a common goal and alignment of different opinions and interests through compromise-making (see also Butera & Buchs, 2019). Competition occurs when the actors' goals are negatively interdependent, and the success of one party requires or implies the failure of the other (like in a swimming race). Cooperation is what interests us here, as we wish to study collaborative actions involving farmers. It should be noted that the terms cooperation and collaboration are sometimes differentiated (e.g., Davidson, 1994; Dillenbourg, 1999) and sometimes merged (e.g., Topping, 1992), but most of the time they are used interchangeably. We will use the term collaboration from now on.

Although collaboration always implies positive interdependence (common goals), the hierarchical structure within the group can be either more horizontal or more vertical, and therefore give way to either, symmetrical or asymmetrical collaborations, respectively. Symmetrical collaboration is described as an interdependent relationship without hierarchy between two or several actors (Duveen & Psaltis, 2008). Such relationships usually imply interaction between actors that hold complementary competencies, roles, or resources (Colomer et al., 2021). Asymmetrical collaboration implies a hierarchy between the different actors, in a classic teacher-learner vertical relationship (Duveen & Psaltis, 2008). Such relationships usually imply interaction between actors that hold different levels of competencies and roles, where higher competence is generally associated with superior status

(Butera & Darnon, 2017). These two types of collaboration have already been studied in other fields, such as firm management or leadership (Glasø et al., 2018; Johnsen & Ford, 2002), but there is a lack of synthesis concerning symmetrical and asymmetrical collaborations with farmers, how they can impact farmers' decision-process in their involvement for biodiversity conservation and whether one is more efficient than the other. The present study will thus focus specifically on symmetrical versus asymmetrical collaborations because these concepts allow us to take into account the hierarchical structure in which collaboration unfolds.

Our main objective is therefore to review and discuss the extent of literature on the role played by collaboration on farmers' pro-environmental behaviors in a very broad way. We wish to contribute to the literature by conducting a comprehensive review, considering all types of collaboration between farmers and other people impacting their decision-making regarding sustainable farming practices, as well as all types of on-farm pro-environmental behaviors. Such a review should result in an overview of what is currently studied in this largely neglected area and what is lacking. We hypothesize that collaboration will have a positive effect on farmers' pro-environmental behaviors, for reasons that pertain to the results obtained within the framework of Social Interdependence Theory (Johnson & Johnson, 2005). Indeed, several meta-analyses have documented the positive effects of working and studying collaboratively, in terms of quality of social relations, self-efficacy, interest in the subject, and learning (e.g., Hattie, 2008; Johnson & Johnson, 1989; Slavin, 1983). It is then possible that collaboration on sustainable farm management and practices may lead to high levels of comprehension and adoption of pro-environmental behaviors. This holds particularly true for symmetrical collaborations, which is the reason why we expect the proportion of studies reporting a positive effect to be larger in studies focusing on symmetrical collaboration compared to those centered on asymmetrical ones. In particular, as stated in the case of firm management by Johnsen and Ford (2002), asymmetrical relationships have a negative impact on the self-esteem and confidence of the parties in subordinate positions. This can then lead such parties to adopt prescribed behaviors for extrinsic reasons (Ryan & Deci, 2000), for example under the form of mere compliance, i.e. behavior change motivated by the superior status of the influence source, which is immediate or manifest, and does not translate in long-term or deep change (Pérez & Mugny, 1996). On the other hand, in symmetrical relationships, skills and knowledge will be developed proactively by all parties (Johnsen & Ford, 2002). In this case, there is a real exchange of knowledge because all actors are free to project their own ideas, analyze the opinions of others, and defend their own independent points of view (Butera et al., 2019). These increased exchanges will lead to the development of new ideas, leading to new shared knowledge (Duveen & Psaltis, 2008; Johnsen & Ford, 2002) and thus to interiorized and long-lasting behaviors.

2. Data and methods

As the general objective of this review is to get an overview of the current state of knowledge on the effect of collaboration on farmers' pro-environmental behaviors, only studies that clearly define this effect are considered.

For the purpose of this study, pro-environmental behaviors were defined following the definition proposed by Lange and Dewitte (2019) as any behaviors that benefit the environment, such as plant native species or wildflower strips, or the decision to stop behaviors that harm it, such as decrease pesticide or fertilizer use. We decided to focus only on on-farm behaviors that are consistent with the definition of "Conservation Agriculture" as described by the Food and Agriculture Organization of the United Nations, which is a farming system preventing arable land loss and regenerating degrading land, based on three interlinked principles, namely "minimum mechanical soil disturbance, permanent soil organic cover, species diversification" (FAO, 2022).

On the other hand, collaboration was defined as any interactions between a farmer and other people regarding sustainable farm management and practices, such as meetings, study groups, trainings, or workshops. To differentiate between symmetrical and asymmetrical collaboration, every article was classified according to the interactions between the different actors: (1) Symmetrical collaboration was attributed when a positively interdependent relationship without hierarchy between the farmers and the other people was described, such as farmers' actively participating in the elaboration of the management plan or discussing the best practices given their own experience. (2) Asymmetrical collaboration was attributed when a hierarchy between the other people and the farmers was described, in a classic teacher-learner vertical relationship, with farmers having the lower status position, such as with experts explaining the best practices to implement without discussing them with farmers.

2.1. Inclusion criteria

To be included in the review, the articles must follow two main criteria: (1) they estimate the effect of collaboration between farmers and any other group of people on pro-environmental behaviors; (2) they study and measure farmers' pro-environmental behaviors, either in an endogenous self-reported way or with exogenous on-farm measurements. To increase the number of studies, we decided to also consider intentions to behave in a pro-environmental way, as intentions are directly linked to behaviors according to the Theory of Planned Behaviors (Ajzen, 1991). However, while we acknowledge this link, it is imperative to bear in mind the potential intention-behavior gap when interpreting the results of studies measuring intentions instead of behaviors.

We included all kinds of collaboration, if there is a measure of its effect on the farmers' pro-environmental behaviors, and then classified them into either symmetrical or asymmetrical categories. No limit on publication date nor location has been applied, nor on study design, as long as there is a measure of the effect of collaboration. The literature search was restricted to English- and French-language peer-reviewed articles, according to the authors' language skills.

2.2. Search

A scoping search, i.e. a brief search of the existing literature on the different themes of the present review, has been performed in February 2022 to determine relevant keywords. The final research process took place in September 2023 and consisted of an extensive literature review conducted on Web of Science including all databases, using the following query:

AB = [(farmer* OR producer* OR "land manager*" OR "land owner*" OR "land employee*" OR "land tenant" OR agricultur* OR grower*) AND (behavio$r*) AND (ecolog* OR environment* OR conservation OR sustainab* OR biodiversity OR agri-environment OR eco-friendly) AND (collaboration* OR cooperat* OR coordinat* OR expert* OR specialist* OR scienti* OR partnership* OR group* OR ecologist*)]

A total of 3697 articles matching the combination search terms were identified. All screening process was performed on Rayyan, an online software for reviews (Ouzzani et al., 2016). After removing the duplicates (128) and screening for all titles and abstracts, 3481 articles were excluded, because they did not meet the inclusion criteria (3470) or because they were inaccessible, after requesting them to the authors (11). The remaining 88 articles were full-text screened: 56 articles were excluded because they did not meet the established criteria and finally, 32 articles were selected to be included in the review. As a final step, a forward search of citations as well as a backward search of references of the 32 selected papers were performed to find any other eligible papers, ending up with 12 additional research papers. In the end, 44 articles were included in the review. The flow chart summarizing the whole selection process is illustrated in Fig. 1. All exclusion reasons for the 3537 articles are available in supplementary material.

To extract information about the effect of collaboration on farmers' pro-environmental behaviors, various factors have been identified for each reviewed paper, such as collaboration type (then classified as symmetrical versus asymmetrical), pro-environmental behavior studied as described previously, and effect of the collaboration on the latter (positive, negative or null). Table 2 presents the exact breakdown of these factors as found in the current review.

3. Results

3.1. Bibliometric results

A total of 44 published studies were identified, from 35 different journals. Most of these journals are categorized into environmental sciences (18), agricultural and biological sciences (15), and social sciences (10). Most studies were published after 2008, and only 2 studies before 2000 (Fig. 2). Analysis of the location of the studies shows that 48% were conducted in developed countries (as classified according to

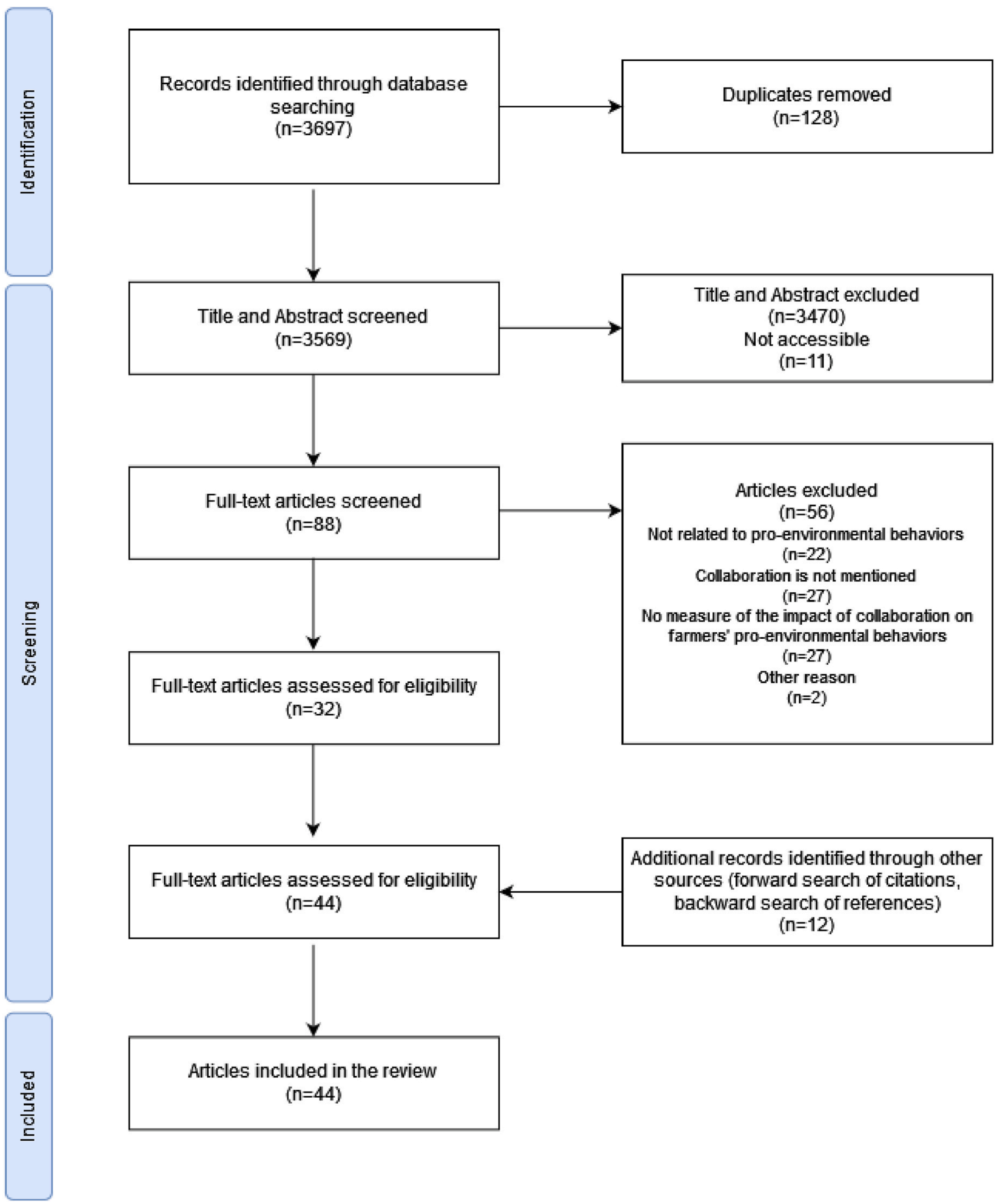

Fig. 1. PRISMA flow diagram for the review, with exclusion reasons. Some articles have several exclusion reasons, explaining why they do not sum up to 56. Adapted from: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMK 2021; 372:n71. https://doi.org/10.1136/bmj.n71.

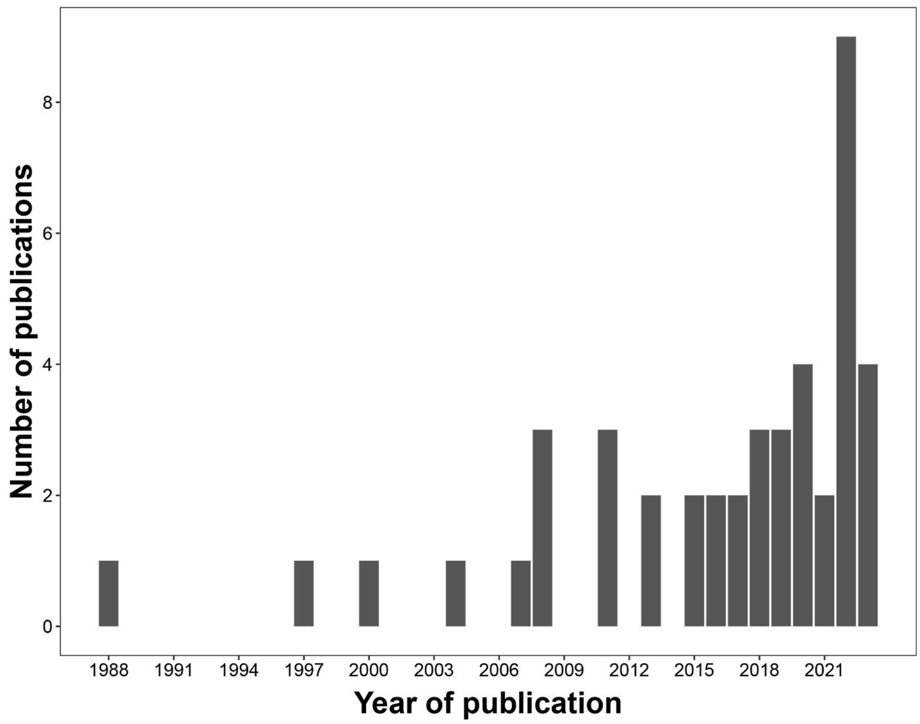

Fig. 2. Temporal distribution of the studies: Distribution of the reviewed studies according to their year of publication.

the Human Development Index (UNDP, 2019)). Differences in results between developed and developing countries are discussed in section 3.3.5 below.

3.2. Overall results

There is a very high variability among the different reviewed papers, and the various research trends, gaps, and shortcomings are summarized in Table 1. The number of participants ranges from 22 to over 4800, with a median of 355 and a mean of 674. The type of analysis conducted is also variable, some studies doing simple statistics such as percentage analysis, chi-square tests, or t-tests, and others deepening the analysis with logit regressions, generalized linear multilevel models, partial least squares modeling, or structural equation modeling.

There is also a high variability in methodologies, from experimental, to cross-sectional, longitudinal, or correlational. Not all of them allow causal claims. We thus considered a positive or negative impact when an independent variable, whatever its nature, predicted a dependent variable with clear causality drawn. Otherwise, we considered a positive or negative effect. Null effect or impact was considered when no statistical significance was reached.

Concerning pro-environmental behaviors, most studies used endogenous self-reported measurements. However, a number of different behaviors were measured, from very specific ones, such as pesticide use, organic fertilizer use, or intentions to incorporate trees in coffee plantations, to very broad measures, testing many different practices (up to 44 different sustainable practices tested in a single study, including management of disease, weed, pest, vine, water, and soil, and alternative energy use). Only two studies assessed pro-environmental behaviors with exogenous measures, one of them measuring livestock loads (number of livestock per hectare), and the other the amount of organic fertilizer used.

Concerning collaboration, it varied both in terms of duration and kind. For example, some papers focused on collaboration lasting for several years, or on collaboration for only a few meetings. Some papers studied collaboration among a large number of different people such as experts in ecology, governments or other farmers and others studied one-to-one collaborations. Moreover, only one paper among the 44 reviewed studied a field experiment involving a collaboration between farmers and scientists from a university.

The connection between collaboration and pro-environmental behaviors took two primary forms in the papers examined: direct and related (or indirect). In the first form, the collaboration directly influences a specific pro-environmental behavior, serving as an incentive for the adoption of that specific behavior. For example, a collaboration may actively promote a particular behavior (such as reducing pesticide use), which is then assessed in the study. In the second form, the link between collaboration and pro-environmental behaviors is indirect or related. Collaboration may foster a range of pro-environmental practices, or raise awareness about broader conservation issues that, while not directly tied to the specific pro-environmental behavior being assessed, contribute to an overall understanding of the importance of environmental conservation. Notably, within the scope of our review, no studies lacked any discernible connection between the collaboration type and the pro-environmental behavior studied. All connections are described in Table 2.

3.3. Results by collaboration groups

In light of the diverse reasons for collaboration found across the selected studies, we undertook a re-classification into four distinct groups to help synthesize the effects. These groups were defined inductively after reading the papers and discovering similarities between them. They correspond to (1) Program participation: when farmers are involved in a specific and well-defined program, with fixed duration; (2) Technical training: when farmers take part in specific training courses, conducted as one-time events; (3) Collaboration among farmers: when farmers work collectively, either through common management or discussions leading to decision-making about agricultural practices; and (4) Peer influence: how farmers are influenced by other farmers, without necessarily direct interaction. Moreover, each article was categorized into symmetrical versus asymmetrical collaboration to estimate whether one type influences farmers' pro-environmental behaviors more than the other. To ensure a

Table 1
Summary of Research Trends, Research Gaps, and Research Shortcomings in the 44 articles selected.

Category	Description
Research trends	Most studies primarily assessed farmers' pro-environmental behaviors as general land management and conservation practices. The second most common aspect of farmers' pro-environmental behaviors examined was pest management, followed by the use of agrochemicals. Among collaboration groups, participation in technical trainings garnered the most research attention, followed by program participation. A majority of the reviewed papers focused on a symmetrical collaboration measurement approach. In nearly all cases, collaboration was linked to pro-environmental practices promotion. In the majority of cases, collaboration was directly linked to the pro-environmental behavior measured. A well-balanced distribution of studies is evident regarding countries' development status, with research conducted in both developed and developing countries.
Research gaps	A limited number of studies focused on specific pro-environmental behaviors (e.g. invasive species management or livestock load). Little research has been conducted on measured and concrete data on actual on-farm pro-environmental behaviors. Notably, no study focused on anti-environmental collaboration, such as collaboration with pesticides or agrochemical producers.
Research shortcomings	Most studies primarily focused on self-reported measures to assess farmers' pro-environmental behaviors. Most of the studies are performing qualitative analyses. Many studies exhibited selection bias of the participants, as they compared farmers participating in a program or a training that was not randomly distributed. Demographic variables, such as age, gender, education level, and farm size, were frequently omitted from the analyses, potentially introducing bias. Some studies lacked control groups for meaningful comparisons or did not use pre-post analyses, thereby limiting the ability to draw causal conclusions. Some studies used intentions instead of actual pro-environmental behaviors.

comprehensive and unbiased classification, we proceeded to a systematic categorization with two authors and compared the independent classifications. When differences in categorization arose, only in two cases, the two authors reached a consensus through thorough discussions on the final classification for each paper.

These groups, types, their effect on farmers' pro-environmental behaviors, and the link between the behavior and the collaboration are listed in Table 2 and outlined in the following sections.

3.3.1. Program participation

Among the 44 reviewed articles, 16 studied the effect of program participation on farmers' pro-environmental behaviors. These programs are specific conservation programs proposed by NGOs (Josefsson et al., 2017; Shaw et al., 2011), governmental agencies (Boz, 2016; Byerly et al., 2021; Drescher et al., 2019; Goodale et al., 2015; Knook et al., 2020; McGinty et al., 2008; Petursdottir et al., 2017), research institutes (Adimassu et al., 2013; Buyinza et al., 2020; Forté-Gardner et al., 2004; Lentijo & Hostetler, 2013; Márquez-García et al. 2018, 2019), or groups of stakeholders (Campbell et al., 2011). Symmetrical collaborations included participatory programs, which aim at involving farmers in the decision-making, problem identification, and management process. Asymmetrical collaborations included programs giving information to farmers about conservation measures and pro-environmental practices through meetings, reports, or expert advice.

Within program participation, most of the studies focusing on *symmetrical collaboration* were found to have a positive effect on farmers' pro-environmental behaviors. Adimassu et al. (2013) and Campbell et al. (2011) both focused on watershed management and found that farmers behave more pro-environmentally when participating in collective management programs in Ethiopia and in the USA, respectively. The positive effect of participation is emphasized by Campbell et al. (2011), who compared participants in a collective management watershed with non-participants in the same watershed, and found that participating farmers adopt more best management practices, such as using cover crops, planting vegetated buffers or using reduced tillage farm practices, especially when participating to meetings. However, they also compared two different watersheds, one with collective management and one without, and did not find any difference between the two. Program participation was also found to positively influence farmers' motivation to adopt agroforestry practices in Uganda, through a project for increasing tree plantation: the T4FS project (Buyinza et al., 2020). Farmers might not be aware of programs' effect, as found by Knook et al. (2020), who focused on Participation Extension Program (PEP) in Scotland and found that PEP-participants have higher pro-environmental behavior scores than non-participants, even if they do not explicitly state that it is because of their participation. Some programs offer the opportunity for experimental projects. A notable example is the study by Forté-Gardner et al. (2004), which examined the impact of the Ralston Project in the USA, a field experiment involving both scientists and farmers and aiming at estimating the "economic, environmental and agronomic feasibility of reduced tillage and continuous spring cropping systems". They found that participation in this project positively impacts farmers' intentions to adopt new technologies, such as the use of no-till drill, crop stubble, or spring crop cycle. It is the only article focusing on a collaboration between farmers and scientists from a university. Pro-active management from farmers was found deeply important by Drescher et al. (2019), who compared two different conservation programs in Canada both providing tax relief to enrolled farmers: Conservation Lands Tax Incentive Program (CLTIP), which has no management plan and proposes only 1-year contracts to farmers, and Managed Forest Tax Incentive Program (MFTIP), which asks farmers for a clear management plan and proposes 10-years contracts. They found that MFTIP has a positive effect on farmers' invasive species management, as more MFTIP participants than expected removed invasive species and planted native ones, compared to CLTIP which has a null to negative effect on the adoption of those two practices. Some studies also found null effects of such programs. Márquez-García et al. (2018) compared two different education programs in Chile, one conventional with technical training and outdoor activities and one participatory, involving farmers in decision-making, but found no differences between the two on various pro-environmental actions. McGinty et al. (2008) found that participation in an agroforestry program did not influence farmers' intentions to adopt agroforestry practices in Brazil. However, farmers' intentions to implement sustainable practices are positively influenced when participating in a bird conservation program in Sweden (Josefsson et al., 2017). Finally, participation in a rangeland restoration program did not have an effect on rangeland management and restoration practices in Iceland, even if participants were more aware of the potential of such restoration, as shown by Petursdottir et al. (2017).

Reviewed studies also focused on *asymmetrical collaborations*, through programs offering information and advice by experts in ecology to interested farmers. Most of those programs are based on farmers' willingness to get involved, and their effects vary. For example, sustainability winegrowing programs are found to be effective in promoting pro-environmental behaviors, as shown by Márquez-García et al. (2019) in Chile and by Shaw et al. (2011) in California. Participation in a bird conservation project had a positive effect on farmers' knowledge about birds, but not on their conservation practices in Columbia (Lentijo & Hostetler, 2013). Boz (2016) also focused on participation in a specific program in Turkey, which provides precise on-farm advice and promotes sustainable practices, such as crop rotation, use of animal manure, or proper use of chemical fertilizers and pesticides, and found a positive

Table 2
Summary of findings of the different groups of collaboration on various pro-environmental behaviors and how they were measured. See the text for details. Effect symbols indicate a positive and significant effect (+), not significant (N), and negative and significant effect (−).

Group of collaboration	Type of collaboration	Country development status	Behavior	Measure of behavior	Connection between collaboration and behavior	Effect	Reference
Program Participation	Symmetrical	Developed	Invasive species management	Self-reported	Related	+	Drescher et al., 2019
			Land management and conservation practices		Direct		Forté-Gardner et al., 2004; Knook et al., 2020
						N	Petursdottir et al., 2017
					Related		Márquez-García et al., 2018
						N/+	Campbell et al., 2011
		Developing			Direct	+	Adimassu et al., 2013
				Intentions		+	Josefsson et al., 2017
			Adoption of agroforestry practices			+	Buyinza et al., 2020
						N	McGinty et al., 2008
	Asymmetrical	Developed	Land management and conservation practices	Self-reported	Direct	+	Márquez-García et al., 2019; Shaw et al., 2011
						N	Goodale et al., 2015
					Related	+	Boz, 2016; Byerly et al., 2021
		Developing			Direct	N	Lentijo and Hostetler, 2013
Technical Training	Symmetrical	Developed	Land management and conservation practices	Self-reported	Direct	+	Hillis et al., 2018
		Developing					Quang et al., 2019
	Asymmetrical	Developing	Agrochemical use	Self-reported	Direct	+	Cui & Liu, 2022; Liu, K. Shi et al., 2022
					Related		Matous & Todo, 2018; Yang et al., 2023
			Pest management		Direct	+	Liu, R. Shi et al., 2022; Flor & Singleton, 2011; Zhou et al., 2020
						N	Li & Jin, 2022
		Developed			Direct	+	Bager & Proost, 1997; Thomas et al., 1988
Technical Training	Asymmetrical	Developed	Pest management	Self-reported	Related	+	Ohmart, 2008
				Intentions	Direct		Jowett et al., 2022
			Land management and conservation practices	Self-reported	Related	+	Beedell & Rehman, 2000
					Undefined		Lubell & Fulton, 2007
		Developing			Direct		Ataei et al., 2022; Faridi et al., 2021; Gao et al., 2023; Xiuling et al., 2023
						N	Liu et al., 2023
Collaboration among farmers	Symmetrical	Developed	Livestock load	Measured	Related	+	Di Falco and Van Rensburg, 2008
			Pest management	Self-reported	Related	+	Bager & Proost, 1997; Ohmart, 2008
		Developing			Direct		Li & Jin, 2022
			Land management and conservation practices		Direct	+	Deng et al., 2022
					Related		Faridi et al., 2021; Liu et al., 2023
			Adoption of new technology	Intentions	Related	+	Sarkar et al., 2022
			Agrochemical use and pest management	Self-reported	Related	+	Yang et al., 2023
Peer influence	Symmetrical	Developed	Bioenergy crops adoption	Intentions	Direct	+	Huang et al., 2016
			Land management and conservation practices	Self-reported	Related	+	Byerly et al., 2021
		Developing			Direct		Gao et al., 2023; Liu et al., 2023; Ma et al., 2022
			Adoption of agroforestry practices	Intentions	Direct	+	Buyinza et al., 2020
			Pest management	Self-reported	Direct	+	Zhou et al., 2020
						N	Li & Jin, 2022
			Agrochemical use		Direct	+	Cui & Liu, 2022
					Related		Matous, 2015; Matous & Todo, 2018; Yang et al., 2023
	Asymmetrical			Measured	Direct		Vu et al., 2020

effect on only 6 out of 16 practices, the other 10 practices being equally used by program participants and non-participants. Byerly et al. (2021) studied farmers' participation in 5 major conservation programs that provide rental payment, financial resources, and assistance in the USA, and found that farmers adopt more biodiversity management practices, including cover crops, or hedgerows and native grasses planting when participating in those conservation programs. Goodale et al. (2015) studied a conservation program in Canada which provides visits, inventories, and personalized conservation reports to farmers and compared the use of various sustainable practices by program participants and non-participants. Interestingly, they found that only practices promoted by the program, namely riparian management and modified harvesting techniques, were more adopted by participants than non-participants but found no differences for the other 8 practices not promoted by the program.

The overall effect of program participation on farmers' pro-environmental behaviors is positive, even if a few studies found null effects. These differences seem to depend on various factors, such as farmers' proactive engagement, but also on the program itself, how advice is provided to farmers, and the region where the program is taking place. There is no clear difference between symmetrical and asymmetrical collaborations among program participation, both having in majority positive effects.

3.3.2. *Technical training*

Technical training is considered here as any collaboration between a farmer and an expert in ecology, in the context of a specific event, as opposed to program participation which involved a subscription to a program and thus a longer-term contract. We identified 21 studies investigating the effect of such technical training on farmers' pro-environmental behaviors. These trainings are provided to farmers by voluntary partnerships (Hillis et al., 2018; Ohmart, 2008), NGOs (Quang et al., 2019), Universities (Jowett et al., 2022; Matous & Todo, 2018; Quang et al., 2019; Thomas et al., 1988), agricultural cooperatives (Liu, R. Shi et al., 2022 ; Liu, K. Shi, et al., 2022;), Government (Bager & Proost, 1997; Cui & Liu, 2022; Faridi et al., 2021; Flor & Singleton, 2011; Li & Jin, 2022; Yang et al., 2023; Zhou et al., 2020), advisory groups (Ataei et al., 2022; Beedell & Rehman, 2000; Gao et al., 2023; Xiuling et al., 2023) or local agencies (Lubell & Fulton, 2007). As in the case of program participation, these technical trainings were classified into two different types: (i) symmetrical trainings, which takes into account farmers' expertise together with experts'; (ii) asymmetrical trainings, which gives direct information to farmers through workshops or personal advice.

Two articles highlight the effect of *symmetrical* training (Hillis et al., 2018; Quang et al., 2019), in two different ways. Hillis et al. (2018) focused on sustainability partnerships in California, which bring together people from many different fields such as growers, industry partners, or consumers, to propose different sustainable activities promotion such as field meetings, newsletters, or certification programs. They found that the probability of adoption of sustainable practices, such as disease, weed, or pest management, is positively associated with partnership participation, with a stronger effect for the least financially costly practices. Quang et al. (2019) estimated the effect of transformative learning in two different environments in Vietnam, both involving farmers to test new technologies and then demonstrate them with sample fields to other farmers. They found that this type of learning leads to changes in farmers' perceptions and agricultural practices.

Nineteen articles concentrate on *asymmetrical* trainings (Thomas et al., 1988; Bager & Proost, 1997; Beedell & Rehman, 2000; Lubell & Fulton, 2007; Ohmart, 2008; Flor & Singleton, 2011; Matous & Todo, 2018; Zhou et al., 2020; Faridi et al., 2021; Ataei et al., 2022; Cui & Liu, 2022; Jowett et al., 2022; Li & Jin, 2022; Liu, R. Shi et al., 2022 ; Liu, K. Shi, et al., 2022 ; Gao et al., 2023; Liu et al., 2023; Xiuling et al., 2023; Yang et al., 2023), and the majority of them found positive effect on various pro-environmental behaviors. Four studies focused on agrochemical use: Matous and Todo (2018) compared the same technical training given at various distances from farmers' hometowns in Indonesia and found that further training has the highest effect on organic fertilizer use. This study is highly interesting, as the authors added the influence of the distance between training and farmers' hometowns and thus the collaboration between people with different farming habits. Cui and Liu (2022) found a positive effect of technical services provided by the government on farmers' chemical fertilizers reduction behaviors in China, which was also found by both Liu, K. Shi et al. (2022) and Yang et al. (2023), who both examined Chinese farmers' organic fertilizers use when participating in technical trainings. Technical trainings provided by government-affiliated agricultural technicians in China were also found to decrease the use of pesticides by Zhou et al. (2020), and technical trainings provided by agricultural cooperatives, which group various farmers together, have also a positive effect on biopesticide adoption in higher educational-level group, as found by Liu, R. Shi et al. (2022). Xiuling et al. (2023) compared various types of technical training, focusing on online versus offline trainings, and found an overall positive impact on farmers' water-saving irrigation technology adoption, depending on farmers' demographics such as age, education level, and farm size. This was confirmed by Gao et al. (2023), who compared traditional versus new agricultural technology trainings and also found a positive impact of both trainings, depending on the same demographics. Finally, Liu et al. (2023) also focused on Chinese farmers and found that agricultural extension training attendance had no impact on farmers' rice-crayfish integrated system adoption. Land management practices were also found to be positively influenced by technical trainings in other countries: Beedell and Rehman (2000) focused on advisory groups providing technical trainings to farmers in the United Kingdom and found that participants have consistently higher self-reported pro-environmental behaviors than non-participants. Technical trainings held by the Ministry of Agriculture has a positive effect on water and soil conservation measure adoptions in Iran, as found by Faridi et al. (2021), and also on general intentions to adopt practices of conservation agriculture, as found by Ataei et al. (2022). Lubell and Fulton (2007) looked at technical trainings provided by experts from local agencies in the USA and found a positive effect on best agricultural management practices adoption, such as orchard plantation. Seven studies focused on pest management practices: Bager and Proost (1997) and Thomas et al. (1988) studied the effect of consulting with an extensionist and scouting services provided by specialists, respectively. Bager and Proost (1997) found a reduction in pesticide use for farmers in close contact with extensionists in Denmark, but not in the Netherlands, while Thomas et al. (1988) found a positive effect on the advised integrated pest management practices in the USA. Ohmart (2008) studied the effect of a workbook given to farmers to self-assess their integrated farming practices in the USA and found an increase in integrated pest management use after this workbook was implemented. Flor and Singleton (2011) studied the impact of a campaign promoting Ecological Based Rodent Management (EBRM) practices in the Philippines and found that farmers participating in the intensive campaign, comprising consultations with rat experts, visits by extension staff, demonstrations of the recommended methods and exposure to the promotional material have a significant and positive impact on farmers' EBRM adoption. Li and Jin (2022) and Yang et al. (2023) both focused on Chinese farmers' pesticide use. While Yang et al. (2023) found a positive impact of technical trainings provided by the government on farmers' biopesticide use, Li and Jin (2022) found no effect of technical training participation. Finally, Jowett et al. (2022) found that technical training participation had a positive impact on future intentions to adopt integrated pest management practices in the United Kingdom.

Overall, technical training seems to be effective in promoting farmers' pro-environmental behaviors. There is no difference between symmetrical and asymmetrical collaborations, both having positive effects. However, there is a bias towards asymmetrical collaboration in this category, as many more studies focused on it compared to symmetrical ones.

3.3.3. *Collaboration among farmers*

Nine studies focused on collaboration among farmers, be it through cooperation with other farmers (Faridi et al., 2021), common management of lands (Deng et al., 2022; Di Falco & Van Rensburg, 2008; Li & Jin, 2022; Liu et al., 2023; Sarkar et al., 2022; Yang et al., 2023) or study groups (Bager & Proost, 1997; Ohmart, 2008). All papers from this category were classified as symmetrical collaboration.

Four papers measured collaboration in a self-reported way (Faridi et al., 2021; Li & Jin, 2022; Liu et al., 2023; Yang et al., 2023), asking farmers to state whether they cooperate with other farmers or not, or whether they are members of a cooperative. Faridi et al. (2021) found a marginally significant positive effect of collaboration on the water and soil conservation measures adoption. Li and Jin (2022) and Liu et al. (2023) also found that cooperative membership had a positive impact on pesticide use and rice-crayfish integrated system adoption, respectively.

Also when not self-reported, cooperative membership was found to have a positive effect on groundwater protection behaviors by Deng et al. (2022). However, Yang et al. (2023) found no impact of cooperative membership on organic fertilizer use or on biopesticide use. Two studies focused on the effect of collective management on farmers' pro-environmental behaviors (Di Falco & Van Rensburg, 2008; Sarkar et al., 2022) and in both studies, groups of farmers manage their land together and make decisions together. Sarkar et al. (2022) focused on cooperative organizations and their effect on farmers' intentions to adopt environmentally friendly technology and found positive results. Di Falco and Van Rensburg (2008) focused on common grazing resource management in Ireland and found that collaboration in these commonages positively influences livestock load, involving a decrease in livestock load with collaboration. The effect of study groups is also found to be positive, as shown by Bager and Proost (1997) and Ohmart (2008), who reported a significant effect on pesticide use and pest-management, respectively. The study groups were organized by a third party in Ohmart's (2008) study. The only not significant result was for farmers from the Netherlands in the study of Bager and Proost (1997), who found that group discussion had a positive effect on farmers' attitudes and knowledge towards pesticide use, but not on behaviors per se.

In sum, collaboration among farmers seems to be a promising tool to promote pro-environmental behaviors, as most of the studies found a positive effect. However, there is a lack of studies focusing on this, as shown by the low number of reviewed articles classified in this category.

3.3.4. Peer influence

The effect of peers on farmers' pro-environmental behaviors has been studied in thirteen of the reviewed papers (Buyinza et al., 2020; Byerly et al., 2021; Cui & Liu, 2022; Gao et al., 2023; Huang et al., 2016; Li & Jin, 2022; Liu et al., 2023; Ma et al., 2022; Matous, 2015; Matous & Todo, 2018; Vu et al., 2020; Yang et al., 2023; Zhou et al., 2020) and the majority found a significantly positive effect. This category of collaboration is slightly different from the others, as there is not always a proper interaction between farmers. However, it is still interesting to review such studies because farmers are indirectly influenced by their peers, as in some studies farmers are positively interdependent in terms of information exchange, even if they are not directly interacting. It was thus decided to keep these studies, even if they do not exactly fit the definition of direct collaboration. Peer influence is measured in different ways, from considering neighbors' pro-environmental behaviors in farmers' decision-making (Buyinza et al., 2020; Cui & Liu, 2022; Gao et al., 2023; Huang et al., 2016; Liu et al., 2023; Ma et al., 2022; Zhou et al., 2020), visioning a video of farmers relating their experience with organic fertilizer use (Vu et al., 2020), the influence of discussions among farmers (Li & Jin, 2022; Matous & Todo, 2018; Yang et al., 2023) or farmers' self-reported source of information concerning pro-environmental practices (Byerly et al., 2021; Matous, 2015).

Seven articles measured peer influence in a self-reported way (Byerly et al., 2021; Cui & Liu, 2022; Li & Jin, 2022; Liu et al., 2023; Ma et al., 2022; Matous, 2015; Yang et al., 2023). Byerly et al. (2021) asked farmers to state their source of information for sustainable practices, while Matous (2015) asked them to specifically name the people from whom they seek advice to create a social network of the interactions between farmers but also with other people, such as experts. Byerly et al. (2021) found a positive effect of peer influence on biodiversity management practices adoption. In the case of Matous (2015), they analyzed the internal, external, and reciprocal links among different groups of farmers in Indonesia, functioning as organizations and comprising approximately 20 farmers per group. He found that a lack of reciprocal links and extra-group links are related to a lack of conservation efforts and unproductive practices, respectively. Whether farmers exchange with peers was found to have a positive impact on organic fertilizer use depending on farm size by Yang et al. (2023), however, no effect was found on pesticide use by Li and Jin (2022). In the case of Cui and Liu (2022), Ma et al. (2022), and Liu et al. (2023), farmers had to state whether their surroundings (neighbors, friends, relatives) adopted various pro-environmental behaviors such as chemical fertilizer reduction or rice-crayfish integrated system adoption, and all found positive impact on farmers' own pro-environmental behaviors, depending on the farm scale for Cui and Liu (2022). The effect of neighbors was found to be highly important in four studies (Buyinza et al., 2020; Gao et al., 2023; Huang et al., 2016; Zhou et al., 2020). In addition to testing the effect of direct technical training on farmers, Zhou et al. (2020) tested the effect of neighbors' technical training on farmers and found that when their neighbors participated in the training, farmers decreased their pesticide use. In the same trend, Buyinza et al. (2020) investigated how neighbors to farmers who actively participated in a conservation project were influenced and found that social norms have a high effect on intentions to integrate trees into coffee plantations. In the case of Huang et al. (2016), they based all their analysis on a model simulation, taking into account neighbors' behavior concerning bioenergy crop adoption, and found that farmers tend to manage their land in the same way as their neighbors. Finally, Gao et al. (2023) analyzed how the number of neighbors adopting fertigation technology affected the time to adopt them and found an overall positive effect, depending on farmers' age, education level, and farm size. Matous and Todo (2018) analyzed the social networks of farmers according to the distance to the training site, and found that farmers trained further were more trusted by their non-trained peers concerning organic fertilizer adoption, because they had access to new knowledge not available in their communities. Lastly, Vu et al. (2020) focused on the effect of a 3-min video of farmers sharing their experience with organic fertilizer use and found that farmers are more likely to shift their fertilizer use to organic one after watching the testimony.

Overall, farmers seem to be highly influenced by their peers, tending to adapt their farming practices accordingly. This last category is more difficult to classify between symmetrical and asymmetrical collaboration, as no exact details on the interaction between farmers and peers were given. However, we considered that when farmers are discussing together practices (Li & Jin, 2022; Matous & Todo, 2018), referring to their source of information (Byerly et al., 2021; Matous, 2015), or when they are taking into account their neighbors' behaviors (Buyinza et al., 2020; Cui & Liu, 2022; Gao et al., 2023; Huang et al., 2016; Liu et al., 2023; Ma et al., 2022; Yang et al., 2023; Zhou et al., 2020), the collaboration is symmetrical. On the contrary, when no clear interaction happens, as in the case of watching a video (Vu et al., 2020), the collaboration was defined as asymmetrical.

3.3.5. Countries development status

Interestingly, differences emerged when comparing research conducted in developed and developing countries. We observed that developed countries place a greater emphasis on program participation, with 12 studies dedicated to this aspect compared to only 4 for developing countries. On the other hand, developing countries studied more technical trainings, with 15 articles exploring this facet, in contrast to 7 in developed countries. Concerning the type of collaboration, developing countries are more focused on symmetrical collaboration, as evidenced by 21 articles against 10 for developed countries. Asymmetrical collaboration shows a more balanced distribution, with 15 studies in developing countries and 12 in developed ones. Additionally, we noted a temporal difference in research distribution. Older papers tend to be concentrated in developed countries, while younger publications are more prevalent in developing countries.

4. Discussion

This review has analyzed an increasing body of literature on the effect of collaboration on farmers' pro-environmental behaviors. Empirical research has focused on various types of collaboration, which were classified into four groups: program participation, technical trainings, collaboration among farmers, and peer influence. Overall, collaboration has a positive effect on farmers' pro-environmental behaviors, as 33 studies had strictly positive results, while the other 11 found either no effect or various effects depending on the pro-environmental behaviors or on the program studied (Table 2), confirming the first hypothesis stating that collaboration has a positive effect on farmer's pro-environmental behaviors.

It is worth noting that none of the studies included in the present review reported a negative effect of collaboration on pro-environmental behaviors. However, this could be due to potential confounding factors or methodological limitations of the studies, as highlighted in Table 1. One potential source of bias is the presence of selection bias among various included studies, especially the ones about program participation. Moreover, the majority of reviewed studies relied on self-reported measures to assess pro-environmental behaviors. Although self-reporting is a prevalent method for behavior measurement in the current literature, its validity is still debated, as discussed in the review by Kormos and Gifford (2014) and identified by Koller et al. (2023). Additionally, six studies included in the present review used intentions as a proxy for actual pro-environmental behaviors. While intentions are known to be linked to behaviors as reported by the Theory of Planned Behaviors by Ajzen (1991), there is a gap between intentions to behave and actual behaviors, as reviewed by Sheeran and Webb (2016) and found for farmers by Zhou et al. (2023). Given these considerations, it is imperative to keep in mind the potential disparities between reported intentions and observed behaviors when drawing conclusions from the studies.

No clear difference could be highlighted between symmetrical and asymmetrical collaborations in the various categories, both having positive and null impacts, rejecting the second hypothesis stating that the proportion of studies reporting a positive effect would be larger in studies focusing on symmetrical collaboration. However, a lack of symmetrical collaborations was highlighted in technical trainings.

The studies varied in terms of collaboration, pro-environmental behaviors measured, or type of analysis done, making it difficult to draw overall conclusions. Such high variability among studies shows that they do not belong to an established field with uniform methods, measures, and protocols, but on the contrary, to a whole new subject that is studied in various ways and without a clear experimental approach. Moreover, few studies fitted the inclusion criteria, showing the emergence of this subject in the scientific literature. This review is thus the first to summarize the effect of collaboration on farmers' pro-environmental behaviors, at least to our knowledge. The analysis done is thus purely qualitative, allowing a sensible synthesis, but preventing the estimation of the relative strength of the different categories and types of collaboration in determining farmers' pro-environmental behaviors.

Some reviewed studies found no effect on farmers' pro-environmental behaviors, but on other factors, such as knowledge (Lentijo & Hostetler, 2013), engagement in other collaborative activities (Petursdottir et al., 2017), or awareness of the importance of pro-environmental behaviors such as restoration (Petursdottir et al., 2017). Even if it does not reach behavioral change yet, these results are promising as the collaboration has a positive effect on factors that could influence behaviors. Indeed, it is known that knowledge and involvement affect the behaviors (Meinhold & Malkus, 2005), suggesting that, in the long term, collaboration may positively influence the behaviors as well.

Within studies finding a positive effect of collaboration, we highlighted several recurring factors that may have a major role to play in promoting farmer's pro-environmental behaviors. One of them is the importance of farmer's proactive engagement. This is particularly highlighted by Drescher et al. (2019), who showed that only programs involving farmers in the management plan and in the long-term have an impact on their conservation behaviors. Being engaged in the decision-making, farmers are more concerned and feel more connected to the environment, which increases their pro-environmental behaviors. This was shown in a meta-analysis by Mackay and Schmitt (2019), who examined whether connection to nature could promote pro-environmental behaviors, analyzing both correlational data and experimental manipulations. They found a positive association between nature connection and pro-environmental behaviors, across various measurements, samples, and demographic characteristics. Pro-active engagement will also increase farmers' awareness and knowledge about the environment and the importance of preserving it, which is a key point in increasing pro-environmental behaviors. As found by Lentijo and Hostetler (2013), one of the main barriers to conservation practices adoption is a lack of environmental awareness, together with a lack of environmental knowledge. Regarding this, it is essential to take into consideration farmer's expertise and to involve them in the decision-making when planning collaborations with them. It is also essential to give them access to information about the environment and its conservation, increasing the communication between the various actors of the collaboration.

Linked to their engagement, it is also essential to increase farmers' awareness of the effect of such collaboration. As described by Knook et al. (2020), farmers participating to Participatory Extension Programs show higher levels of pro-environmental practices adoption but did not attribute this change to their participation. Increasing their consciousness of the utility of such programs will promote a sense of concreteness to their actions, which may have a positive effect on their intentions to behave pro-environmentally (Van Lange & Huckelba, 2021). This could be emphasized through collaboration with scientists, who can directly measure the impact of pro-environmental behaviors on the ecosystem. They can then give direct feedback to farmers, increasing their awareness of the utility and impacts of their efforts. However, this type of collaboration seems to be understudied, as only one study focusing on this type of collaboration was found in the present review (Forté-Gardner et al., 2004). There is thus a clear need for empirical research on the effect of collaboration between scientists and farmers on the latter's pro-environmental behaviors. Future research could also consider collaborations involving scientists, farmers, but also non-scientists (Woutersen et al., 2022), and assess the effects of such collaborations on pro-environmental behavior.

All reviewed studies had a clear connection between collaboration and behavior, except for one which was undefined. As the majority of studies found a positive effect, it is hard to draw conclusions on the difference between direct and related connections. However, it is interesting to note that direct connection seems to be important, as highlighted in some studies, especially by Goodale et al. (2015) who found that only practices promoted by the program are positively influenced by program participation. This is consistent with Ajzen's (1988) principle of compatibility, whereby the constructs (e.g., the content of a training course) measured in association with a specific behavior should involve the same target (see also Sok, Borges, Schmidt, & Ajzen, 2021). For actions to be concrete and relevant, the goal of the collaboration must have a clear link with farmers' practices and behaviors. Farmers need to understand why they are acting in a certain way and what is the goal of their actions. Future collaborations with farmers should thus make sure that the advice given is relevant and achievable. This is supported by studies focusing on several different sustainable practices, not interconnected with one another and not directly linked to the collaboration, which found null results (Boz, 2016; Goodale et al., 2015; Lentijo & Hostetler, 2013; Li & Jin, 2022; Liu et al., 2023; Márquez-García et al., 2018; McGinty et al., 2008; Petursdottir et al., 2017). It is thus important to increase the relevance between advice and practices.

Another interesting result is the effect of peers on farmers' pro-environmental behaviors. Farmers seem to be highly reliant on their peers, be it from study groups, cooperation between them, or mere exposure to neighbors' behavior. This was already demonstrated that in-group interactions are highly efficient in promoting pro-environmental attitudes and behaviors in various studies (reviewed in Fielding &

Hornsey, 2016). This shows the importance of collective actions and management in the agricultural world, as suggested by Pretty (2003) and Batáry et al. (2015). Knowing that governmental programs' objectives to decrease biodiversity loss are not efficient and not specific enough (Batáry et al., 2015; Kaligarič et al., 2019), there is an opportunity to improve their functioning, shifting their focus from individual level to collaborative projects. This would allow the progression from disconnected actions to increased interactions between farms and ecological structures, achieving objectives at the landscape scale in contrast to the farm scale (Whittingham, 2007; EEA, 2010; Pe'er et al., 2014). Focusing on collective and collaborative endeavors and raising awareness among groups of farmers could lead more easily and efficiently to environmental changes, especially knowing that social norms have a positive impact on pro-environmental behaviors (Farrow et al., 2017) and that peer influence is highly important in farmers' decision-making.

Our systematic review encompasses studies from both developed and developing countries. As the goal of the review was to provide a comprehensive overview of the scientific literature, no selection based on the country was made. However, it is essential to keep in mind that pro-environmental behaviors are highly influenced by the cultural context, as reviewed by Tam and Milfont (2020). This was also demonstrated by Wang et al. (2023) for farmers. Moreover, farming systems are radically different between developing and developed countries. Thus, findings from developed countries are not necessarily generalizable to developing ones, and vice versa. These regional nuances underscore the need for context-specific approaches in collaborative pro-environmental initiatives. Interestingly, we found differences in collaboration groups according to the development status of the countries. Overall, developing countries focused more on technical trainings, while developed countries studied more program participation. This potentially highlights the different ways of action according to the development status. Moreover, we found that older studies are concentrated in developed countries, while more recent studies are made in developing countries, highlighting an increased interest in sustainable farming systems in developing countries.

Overall, the results of this review allow a first analysis of what is currently studied on the collaboration between farmers and other people. Collaboration is a mean to increase farmers' pro-environmental behaviors, even if it is essential to keep in mind that effects are not always fond with experimental designs and pre-post measures, which would allow to assess efficacy in terms of behavior change. Future research can expand this analysis in various ways. First, only peer-reviewed articles were included, as the goal was to estimate the current state of knowledge on the impact of collaboration on farmers' pro-environmental behaviors and what is lacking in the empirical research. Through a meta-analysis, it would be possible to take into account other types of literature, such as grey literature, increasing the different types of collaboration considered, decreasing the publication bias towards positive results, and assessing quantitatively the results. Moreover, most of the articles reviewed are from journals related to environmental, biological, agricultural, and social sciences, and only a few of them are related to economics, always with a focus on ecology. This leads to a bias toward ecological studies, together with the fact that most of the studies focus on conservation programs. However, farmers are subject to various pressures, in particular from industries, consumers, or for financial reasons, pushing them towards anti-environmental behaviors. They are thus facing a strong dilemma between increased yields and reduced impact on the environment. It would be interesting to analyze the effect of such pressures on their behaviors, to estimate farmers' struggle, and to consider all impacting factors in farmers' decision-making. However, these types of collaboration seem to be understudied, or at least were not reflected in our search.

Finally, farmers are part of a specialized group within society, characterized by their close relationship with and responsibilities towards the natural environment. Their whole profession and decision-making processes are deeply entwined with the environment. This intrinsic connection makes them peculiar as compared with other population groups. As a result, findings regarding pro-environmental behaviors among farmers may not readily extend to other groups of the population, such as urban residents or industrial workers. Therefore, while collaboration may yield positive results within the farming community, it is essential to exercise caution when extrapolating these findings to broader societal contexts.

5. Conclusion

The objective of this paper was to assess the role of collaboration in promoting farmers' pro-environmental behaviors, focusing on symmetrical versus asymmetrical collaboration. This approach gives insights about what could be relevant to developing future research directions, but also how collaborations between experts from different fields can be improved. This review found an overall positive effect of collaboration on farmers' pro-environmental behaviors, and no negative effect, which is highly encouraging for future collaborations. However, no difference between symmetrical and asymmetrical collaboration was found. Summarizing the most impacting factors, future collaborations should focus on proactively involving farmers in the decision process. They should concentrate on groups of farmers and not individually, as farmers are highly reliant on their peers. Moreover, it is important to clearly communicate the objectives of the collaboration and to target precise behaviors that are achievable for farmers. And finally, it is essential that farmers are aware of the positive impacts of such collaboration on the environment, to motivate them towards pro-environmental behaviors.

CRediT authorship contribution statement

Estelle Milliet: Conceptualization, Data curation, Investigation, Methodology, Writing – original draft, Writing – review & editing, Formal analysis, Project administration, Visualization, Software. **Céline Plancherel:** Conceptualization, Data curation, Writing – review & editing. **Alexandre Roulin:** Conceptualization, Funding acquisition, Supervision, Writing – review & editing. **Fabrizio Butera:** Conceptualization, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare no competing interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvp.2023.102223.

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