

SUBMITTED ARTICLE OPEN ACCESS

A Scoping Review of Nudges for Enhancing Agricultural Policy

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Received: 2 February 2025 | **Revised:** 18 June 2025 | **Accepted:** 30 July 2025

Submitting Editor: Alessandro Bonanno

Funding: Open access publishing facilitated by Agroscope, as part of the Wiley – Agroscope agreement via the Consortium of Swiss Academic Libraries.

Keywords: boomerang effects | crowding out effects | defaults | disclosure of factual information | farmers' behavior | social norms

ABSTRACT

Following PRISMA guidelines, we conduct a scoping review on 18 empirical studies on nudging interventions for farmers in Europe and the USA. The evidence on the effectiveness of nudges is mixed. Some studies demonstrate positive outcomes, particularly when nudges are combined with other interventions; others report no effect or negative outcomes. We identified several gaps in the literature. For example, the cost-effectiveness, acceptability, persistence of behavioral change, and unintended effects of nudging interventions remain largely unexamined. Moreover, most studies have limited real-world applicability, and few use representative samples of farmers. Additionally, transparency is limited, for example, few studies are pre-registered and share data.

1 | Introduction

Despite their high costs, the effectiveness of agricultural policies in many countries is low, especially with respect to agri-environmental goals (Navarro and López-Bao 2018; Candel et al. 2021; Möhring et al. 2020; Pe'er et al. 2019). Currently, agricultural policy mostly uses three types of instruments: regulations, economic incentives, and information (Vedung 1998; Acciai and Capano 2020). Nudges are increasingly being proposed as additional instruments (Ferrari et al. 2019; OECD 2012, 2018). In contrast to traditional policy instruments, nudges explicitly aim to exploit cognitive biases. This characteristic may make nudges more effective and cost-efficient than traditional policy interventions (Benartzi et al. 2017; Sunstein 2018), for instance by improving farmers' participation in agri-environmental schemes (Kuhfuss, Préget, Thoyer, Hanley, Le Coent, and Désolé 2016; Kuhfuss, Préget, Thoyer,

and Hanley 2016) or by reducing the cost burden of regulations (Barnes et al. 2013). However, nudges may create “the false hope that problems can be tackled without imposing considerable costs” (Hagman et al. 2019). Existing reviews on nudges in general contexts are insufficient to draw conclusions for agricultural policy. Specifically, whether a nudge intervention can increase the effectiveness and efficiency of agricultural policy depends on its interactions with existing policy instruments and farmers' reactions to a mix of policies. Currently, we lack a coherent framework for investigating whether nudge interventions can improve the effectiveness and efficiency of agricultural policies. However, this knowledge would be important for the design of research projects and policies, and to close the existing research gaps in a targeted manner.

In this study, we provide insights into the currently available knowledge of nudges as agricultural policy interventions in

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high-income countries such as Europe, North America, and Australia and formulate conclusions for research and policymakers. First, we conceptually embed nudges as potential new policy instruments additional to traditional agricultural policy instruments and develop a framework for assessing the impact of nudge interventions on the effectiveness and efficiency of agricultural policies. Second, we conduct a scoping review and analyze the current literature on studies that have explicitly focused on nudge interventions as an agricultural policy instrument.

Previous research often distinguishes three main agricultural policy instruments: regulations, economic incentives, and information (Vedung 1998; Van Zanten et al. 2014; Acciai and Capano 2020). Regulations are measures undertaken by the government to steer farmers through rules and directives and to implement penalties or sanctions in cases of non-compliance with the regulations (Mack et al. 2024). Regulations eliminate (e.g., by banning pesticides or fertilizer application) or restrict (e.g., by setting quotas on livestock stocking numbers) the management options of farmers (Barnes et al. 2013). Economic instruments provide incentives or disincentives with the aim of promoting or discouraging a specific behavior by providing or withdrawing monetary resources (Ring and Schröter-Schlaack 2011). Examples are payments for voluntary participation in agri-environmental and animal welfare schemes or taxes or levies on inputs such as fertilizer or pesticides (Van Zanten et al. 2014). Information instruments comprise the communication of demands and reasons for or against a certain behavior and aim to persuade the decision-maker to adapt their behavior. No monetary resources are given or withdrawn and no binding instructions or regulations are introduced. The information aims to persuade the decision maker to adapt his or her actions. Information instruments also comprise boosts. According to Grüne-Yanoff and Hertwig (2016), “[boosts] attempt people by expanding (boosting) their competences and thus helping them to reach their objectives” in that “[the boosts] change the environment in which decisions are made [or] extend the repertoire of decision-making strategies, in skills, and knowledge, or do both.” An example in which boosts alter the decision context is when risk information is presented in a numerical format to enhance its comprehension (Congiu and Moscati 2022).

The literature identifies nudges as a potential additional fourth pathway for agricultural policy. Following Thaler and Sunstein (2008, 8), “a nudge is any aspect of the choice architecture that alters people’s behavior in a predictable way without forbidding any options or significantly changing their economic incentives.” In contrast to information instruments, nudges neither assume that an increase in the knowledge of decision-makers changes behavior by overcoming cognitive biases (which is the underlying assumption when using boosts; Grüne-Yanoff and Hertwig 2016), nor do they target features for which people have explicit preferences. Previous literature and policy makers have indicated high hopes for nudges (Ferrari et al. 2019; OECD 2018). However, whether nudges as new policy instruments can improve the efficiency and effectiveness of current agricultural policies remain unclear. For example, it depends on the design of the different policy instruments and on the farmers’ reactions to the mix of policy instruments. Yet, farmers’ reactions to policy instruments are always affected by

preferences and cognitive biases. For instance, risk and loss aversion (Tversky and Kahneman 1979, 1992) have been found to affect farmers’ production, input use, and insurance purchase decisions (e.g., Ali et al. 2020; Freudenreich and Musshoff 2022; He et al. 2019; Menapace et al. 2012), and farmers’ have been found to be on average risk and loss averse (Finger et al. 2023; Iyer et al. 2020). Moreover, time preferences matter. For example, Clot and Stanton (2014) showed that farmers with present-biased preferences were more likely to participate in Payments for Environmental Services, showing that hyperbolic discounting (present bias) (O’Donoghue and Rabin 1999) also matters in the agricultural context. Thus, a good understanding of farmers’ characteristics is crucial to designing effective and efficient policy instruments. To assess the potential of nudges to increase the efficiency and effectiveness of traditional agricultural policy, nudge interventions, their interactions with other policy instruments, and the reactions of farmers to the policy mix must be holistically analyzed. However, such a coherent framework that enables an overview of whether and how nudges designed as policy interventions can improve agricultural policy is missing.

We fill this gap here. First, we develop a coherent framework that integrates key factors that determine how nudges could improve the efficiency and effectiveness of agricultural policy, namely the context of the nudge, the design of the nudge, farmers’ characteristics, and farmers’ behavior toward nudges. This framework allows us to thoroughly assess the impact of nudges as a policy intervention in the agricultural context and identify knowledge gaps. Second, following PRISMA guidelines, we conduct a scoping review of studies conducted in Europe, North America, and Australia to synthesize existing empirical evidence on the potential of nudges in improving traditional agricultural policy instruments. With the scoping review (Munn et al. 2018), we assess the scope of the current literature, identify knowledge gaps, and investigate how research on the potential of nudges to enhance the effectiveness and efficiency of traditional agricultural policy instruments is conducted. We focused on studies conducted in these regions for two reasons. First, behavioral responses to policy incentives have been shown to differ across countries with different economic statuses (Accenture 2009; OECD 2012; Weigel et al. 2021). Second, innovative, low-cost yet effective instruments are of particular interest in countries with well-established policy frameworks that share similar goals, such as farmers’ adoption of conservation practices and agri-environmental schemes to reduce negative environmental effects and promote ecosystem services (OECD 2018; Pe’er et al. 2020; Schaub et al. 2023; Huber et al. 2024; Giuliani and Baron 2025), high administrative burdens (El Benni, Ritzel, and Mack 2024) and the need for budgetary discipline (Giuliani and Baron 2025). This makes it more meaningful for agricultural policy makers to compare the effect of nudges in similar socio-economic and policy contexts.

We identify five key findings. First, few studies evaluate nudges in real policy contexts, and the samples are often not representative of the farmer population. Second, the current evidence on the effectiveness of nudges is mixed, with studies showing both positive and negative unintended effects. Third, few studies have evaluated the costs of nudges, and thus we know little about their cost-efficiency. Fourth, there is currently insufficient understanding of whether farmers accept nudges, how

persistent behavior changes are, and unintended effects. Fifth, we find that only a minority of studies are pre-registered and make their original data available for replication purposes or meta-analysis. We identify important research gaps that need to be addressed in the future in order to draw conclusions about the potential of nudges to improve agricultural policy.

The remainder of this paper is structured as follows. Section 2 explores integrating nudges into traditional policies. Section 3 presents a framework for evaluating and designing the potential of nudges to increase the effectiveness and efficiency of agricultural policy. Section 4 outlines the scoping review methodology following PRISMA guidelines. Section 5 summarizes key findings, followed by a discussion in Section 6 and conclusions in Section 7.

2 | Embedding Nudge Interventions Into the Agricultural Policy Toolbox

In Table 1, we show how nudges are embedded as a potentially new agricultural policy instrument within traditional policy instruments. We order the different instruments, that is, regulations, economic incentives, nudges, and information according to their level of intrusiveness, following Ammann, Arbenz, et al. (2023). Regulations are most intrusive because they limit the farmer's options; for example, they usually prescribe farmers


what to do or not do. Economic instruments, such as taxes, levies, or subsidies, do not limit options but can hardly be avoided in farmers' decision-making contexts and affect available resources. Nudges do not restrict options or affect the availability of resources but explicitly exploit farmers' cognitive biases. Lastly, information is the least intrusive instrument, as it can be used or ignored willingly (Ammann, Arbenz, et al. 2023). The boundaries between the different policy instruments, especially between nudges and information, can become blurred¹.

Zooming into nudges, we group nudge interventions into three groups according to the mechanism of how they influence decisions: those providing decision information, those changing decision structure, and those providing decision assistance (table 1, based on the framework developed by Dolan et al. 2012²; Sunstein 2014; Münscher et al. 2016).

3 | Framework for Assessing the Potential of Nudges to Improve the Effectiveness and Efficiency of Agricultural Policy

Here, we show our framework of factors that should be considered when evaluating and designing nudges to improve the effectiveness and efficiency of agricultural policy (Figure 1). We focused on relevant literature from the fields of behavioral psychology, behavioral economics, agricultural and environmental

TABLE 1 | Embedding nudges in the toolbox of agricultural policy instruments.

Intrusiveness	Policy category	Examples for policy instruments	Intended effect on farmers' decisions
	Regulations	Bans/prohibitions, restrictions	Eliminating or restricting production options, for example, input use, stocking densities
	Economic instruments	Emission certificates	Changing ownership rights
		Incentives: subsidies (e.g., agri-environmental payments), tax reliefs	Incentivize certain behavior by providing monetary resources
		Disincentives: taxes/levies	Disincentivize certain behavior by withdrawing monetary resource
	Nudges ^a	(Re)framing, simplification, social norms (injunctive, descriptive), social signaling, messenger, salience, affect, priming	Providing decision information (i.e., Architectural nudges)
		Defaults (setting no-option defaults, changing default options), prompted choices, choice editing	Changing decision structure (i.e., Architectural nudges)
		Reminders, commitment (private, public), planning prompts, disclosure of factual information (e.g., warnings)	Providing decision assistance (i.e., Educative nudges)
	Information instruments	Boosts (education, training, information)	Increasing farmers' knowledge to overcome cognitive biases
		Labels (e.g., Geographical Indication)	Providing information for which (explicit) preference exist

^aCategorisation of nudging intervention following Münscher et al. (2016): Decision information refers to the way information is presented and influences subsequent decisions. Decision structure refers to the arrangement of options and the decision-making format. Decision assistance helps decision makers follow their intentions, remind individuals of the preferred alternatives in the decision situation, and foster deliberate commitment to beneficial actions. Decision assistance is also called an educative nudge, in contrast to non-educative, that is, architectural nudges (Sunstein 2022).

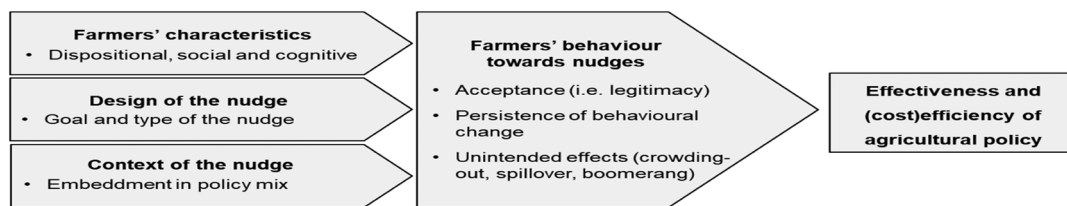


FIGURE 1 | Framework to assess the potential of nudges to improve the effectiveness and efficiency of agricultural policy.

economics, review studies, and politics (e.g., OECD) to provide a coherent framework from the literature of different disciplines. Individual aspects of the framework and the framework as a whole were discussed in several workshops with the entire team of authors until it reached its current form. In our framework, the effect of a nudge on the effectiveness and efficiency of agricultural policy is determined by (i) farmers' characteristics, (ii) the design of the nudge intervention, and (iii) how nudges are embedded alongside traditional policy instruments. All three factors determine farmers' behavior toward nudges and finally the effect of nudges on the effectiveness and efficiency of agricultural policy (Figure 1). The framework aims to show the interplay of factors that determine whether nudging interventions can improve the effectiveness and efficiency of agricultural policy. The framework should help in designing future empirical studies on nudge interventions in the agricultural context. Based on this framework, we formulate guiding questions for our scoping review (Section 4).

3.1 | Farmers' Characteristics

Farmer's decision making is of central importance for the effect of nudges. Dispositional factors such as personality, resistance to change, risk tolerance, moral and environmental concerns, and farmers' conservation and lifestyle, as well as economic objectives, affect farmers' behavior (Dessart et al. 2019). Furthermore, farmers' perceptions and social factors are crucial for the effectiveness of nudges, including the relationship between family members, the relationship with other farmers (whether or not they are perceived as peers), and the relationship with society at large (Dessart et al. 2019). For instance, the adoption and diffusion (also called spillover) of environmentally friendly production methods are affected by social ties within the farming community (Wang et al. 2023). Lastly, cognitive factors affect how farmers learn, understand, and perceive the different production measures the policy interventions aim to promote, for example, whether they are assessed as being risky, costly, and difficult to implement (Dessart et al. 2019). Thus, a good understanding of farmers' personal characteristics, including dispositional, social, and cognitive factors, is a prerequisite for developing nudge interventions that are targeted at specific agricultural policy objectives and tailored to the specific needs of the target group.

3.2 | Design of the Nudge

Different nudge interventions are available to influence farmers' behavior and improve the effectiveness and efficiency of agricultural policy (Table 1). There are different types of nudges, including those that provide decision information (e.g., social norm nudges),

those that change decision structure (e.g., defaults) and those that provide decision assistance (e.g., the disclosure of factual information). The different types of nudges can be implemented either as a single nudge instrument or combined with other nudges to form what we call a composite nudge. Moreover, nudge interventions can have different objectives, such as the adoption of an agri-environmental scheme to promote biodiversity or the adoption of a new production technology to reduce input use.

3.3 | Context of the Nudge

The effect of nudges on the effectiveness and efficiency of agricultural policy depends on whether nudges are designed dependent on or independent of other instruments. A nudge can be used as a stand-alone instrument (e.g., to reduce pesticide use) or as a combined instrument in which a nudge intervention complements another traditional instrument (e.g., to increase the acceptance of an existing agri-environmental program). Stand-alone nudge instruments target farmers' behavioral change as the outcome. In combined nudge instruments, the outcome is a response to another policy instrument; that is, the nudge aims to improve the outcome of another existing policy instrument.

3.4 | Farmers' Behavior Toward Nudges

We consider three aspects of farmers' behavior toward nudges (Figure 1): acceptance, persistence of behavioral change, and unintended effects (including crowding-out, spillover, and boomerang effects).

3.4.1 | Acceptance

To be successful, the nudge intervention must be accepted by farmers and society as a new agricultural policy instrument. Sunstein and Reisch (2019) defined broad principles of the legitimacy of nudges: public officials must promote legitimate ends, nudges must respect individual rights, be consistent with people's values and interests, must not manipulate people, should not take things from people (and give them to others) without their explicit consent, should be transparent rather than hidden, should not violate autonomy, and should produce welfare gains on net and maximize social welfare.

3.4.2 | Persistence of Behavioral Change

The effectiveness and efficiency of nudges also depend on whether they lead to a persistent behavioral change, for

example, by including feedback interventions. Previous studies have shown that behavioral changes are often not persistent but follow a cyclical pattern of action and backsliding, that is, people may react immediately to the policy intervention, but these efforts do not last, decaying after a while (Allcott and Rogers 2014). Therefore, it may take some time before a nudge is effective in the long term, and people have developed new habits. Previous research also shows that feedback interventions can support behavioral changes (Ehrhardt Martinez et al. 2010) and that habit formation takes, on average, two months for modified daily actions to become an automated process that no longer requires self-control (Lally and Gardner 2013). The persistence of behavioral changes is also affected by personal attitudes; for instance, a high degree of self-efficacy is positively correlated with the adoption and stability of the behavior (Schwarzer and Luszczynska 2008). Some policy interventions may also depend on farm family life cycles (e.g., Potter and Lobley 1996), becoming more effective as major life events approach, such as retirement and the takeover of the farm by a successor. Changing life events have been found to decrease resistance to change (Schäfer et al. 2012), disrupt the environment in which decisions are made (Darnton et al. 2011), and make people more receptive to new information and more prone to behavioral changes (Verplanken and Roy 2016).

3.4.3 | Unintended Effects

Nudges can also lead to unintended effects on farmers' behavior, including crowding-out, spillover, and boomerang effects affecting the efficiency and effectiveness of agricultural policy. Crowding-out effects occur when people respond to a nudge with psychological reactance, in which they feel manipulated into making certain decisions (Brehm and Brehm 2013), or when the nudge reduces the utility of a prosocial behavior, that is, an altruistic behavior may be perceived as less altruistic when being nudged (Grad et al. 2021). The crowding-out of one policy by another has been investigated for different policy interventions, for example, between subsidies and bank loans (Ciaian et al. 2012), crop subsidies and insurance uptake (Miglietta et al. 2020), subsidized insurances and participation in conservation program (DeLay 2019) or different insurance products (Van Asseldonk et al. 2018). Spillover effects include (a) "behavioral spillover," in which the nudge targeting a particular behavior also affects another different behavior (Thøgersen 1999; Truelove et al. 2014), and (b) "pattern spillover," in which (the targeted behavior of) a non-targeted group of farmers is affected by the nudge. Positive and negative behavioral spillover effects can be distinguished (Maki et al. 2019; Thøgersen and Ölander 2003). Positive spillovers are generated if more environmentally friendly behavior in the targeted field leads to more environmentally friendly behavior in another (untargeted) field. Negative spillovers (also called rebound effects) occur when major efforts in one field of action lead to less effort in others, that is, environmentally friendly behavior in one field may be compensated for with less effort in another. Boomerang effects occur if farmers adjust their behavior in an undesirable direction because of policy intervention. For instance, provided with a descriptive social norm on pro-environmental behavior, individuals who,

ex ante, show a high pro-environmental behavior may move closer to the (lower) norm they perceive as currently prevailing among their peers (Schubert 2017). Boomerang effects can be counteracted by complementing the descriptive norm with an implicit injunctive norm (Allcott and Rogers 2014; Schubert 2017) or conveying injunctive norms through framing (Demarque et al. 2015).

3.5 | Effectiveness and (Cost) Efficiency of Agricultural Policy

The main question in studies that investigate nudges is their effectiveness, that is, whether and to what extent the nudge intervention affects farmers' behavior. Furthermore, one of the key arguments for using nudges as a new policy instrument is cost efficiency. Therefore, it is important to assess whether the nudge intervention is less costly to achieve policy goals compared to another policy instrument or whether the use of a nudge could increase the cost efficiency of existing policy instruments. For instance, with regard to regulations, previous research has found a high level of resistance (Barnes et al. 2013; Macgregor and Warren 2006), an aversion to responsibility (Nguyen et al. 2006; Popp and Rodriguez 2007), a lack of knowledge (Bosch et al. 1995; Nimmo Smith et al. 2007; Sang and Birnie 2008), and a high perceived administrative burden (Mack et al. 2021; Mack et al. 2024; Ritzel et al. 2020). Implementing a nudge that facilitates farmers' compliance with regulations and reduces the perceived administrative burden could reduce the private and public transaction costs of agricultural policy.

4 | Methodological Approach to the Scoping Review

Here, we conduct a scoping review to synthesize existing empirical evidence on the role of nudges in improving agricultural policy and identify knowledge gaps. Scoping reviews differ from systematic reviews in their purpose and methods (Munn et al. 2018; Tricco et al. 2018). Systematic reviews aim to critically assess the feasibility, appropriateness, meaningfulness, and effectiveness of clearly defined questions or one specific treatment (e.g., policy instrument) including risk-of-bias assessments or meta-analysis. In contrast, a scoping review aims to provide an overview of the scientific evidence on a certain topic by identifying knowledge gaps, scoping a body of literature, clarifying concepts, or investigating research conducted (Munn et al. 2018; Tricco et al. 2018). Through the scoping review, we investigate how research on nudge interventions for agricultural policy is conducted and identify and analyze knowledge gaps with regard to the effect of nudge interventions on the effectiveness and (cost)efficiency of agricultural policy. We formulate guiding questions for our scoping review in accordance with the framework developed earlier (Figure 1) and extract information to answer these questions from the literature on nudging in the farming context, that is, each article included in the scoping review is screened according to these guiding questions (Table 2).

We follow the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses, Moher et al. 2015) guidelines for scoping reviews (Tricco et al. 2018) and

TABLE 2 | Guiding questions for the scoping review.

Farmers' characteristics	Farmers' behavior toward nudges	Effectiveness and (cost) efficiency of agricultural policy
Were the dispositional and/or social and/or cognitive characteristics of farmers described and/or assessed?	Was the acceptance of farmers toward the nudge intervention, the persistence of the nudge intervention, and the unintended effects, that is, crowding-out, spillover, or boomerang effects assessed?	Were the costs of the nudge intervention assessed, and what conclusions on cost efficiency were drawn?
Design of the nudge Which kinds of nudge interventions (e.g., defaults, social norms, etc.) were assessed? Was a single nudge used or a combination of different nudges, that is, a composite nudge? What was the goal of these interventions (e.g., reducing pesticide use and promoting biodiversity)?		
Context of the nudge Has the nudge intervention been assessed against the real policy context, recognizing that there may be interactions between nudges and traditional policy instruments (e.g., stand-alone vs. combined nudge intervention)?		
Research design and data accessibility What methodological approach was used, that is, data collection and data analysis methods? Is the raw data publicly available for further investigation, for example, for replication studies?		

conducted a literature search on nudges in the farming context in Europe, North America, and Australia. As the term “nudge” was introduced by Thaler and Sunstein in 2008 and following the review paper by Ferrari et al. (2019), we considered publications from 2008 onwards. We conducted the search on December 20, 2023.

Criteria for inclusion were: (1) articles written in English, (2) studies conducted in Europe, North America, or Australia, (3) empirical and original analysis of a nudge with farmers, and (4) peer-reviewed studies. We used the databases Web of Science, Scopus, and PubMed and searched with the following terms: farm* OR agricultur* AND nudg*. In Scopus, we searched article titles, abstracts, and keywords and limited the search to European countries, North America, and Australia, as well as articles, reviews, data papers, and notes. In PubMed, we searched the terms in titles and abstracts (a keyword search is not provided by this database) and selected article types (classical article, comparative study, observational study) and species (humans). In Web of Science, we used a topic search (including a search in titles and abstracts) in the core collection.

Figure 2 shows the PRISMA flowchart of our search strategy. The first search indicated 296 records, of which 116 were removed after checking for duplicate records. Next, we screened abstracts and titles and kept records conducted in Europe, North America, or Australia. This resulted in 41 articles, for which we assessed eligibility to be included in the scoping review based on the full text. After the full-text screening, 17 articles were included in the scoping review³. Finally, one article was added manually, which was published in the Journal of the Agricultural and Applied Economic Association but not yet indexed in the databases above.

5 | Results

Here, we present the results of the scoping review by providing information on the research designs and data availability of the studies reviewed before answering the guiding questions derived from the framework.

5.1 | Research Designs and Data Accessibility of the Reviewed Studies

The effects of nudge interventions on farmers' behavior have only recently been studied, with the majority of studies published in 2022 ($N=3$) and 2023 ($N=7$) (see Figure 3 and Table 3). The experimental methods⁴ used varied widely, including randomized controlled trials ($N=5$), laboratory experiments ($N=4$), and lab-in-the-field experiments ($N=9$), and most of the studies were conducted in France, Germany, and the United States (Figure 3). When specific farm types were selected for the study, they were mostly crop production farms ($N=7$). Only one study with an explicit focus on livestock farms was carried out (Davidson and Goodrich 2023). The sample sizes ranged from 63 to 950,014 farmers (mean: 52,180, median: 377). The number of observations was often small, and the statistical power of various analyses was low

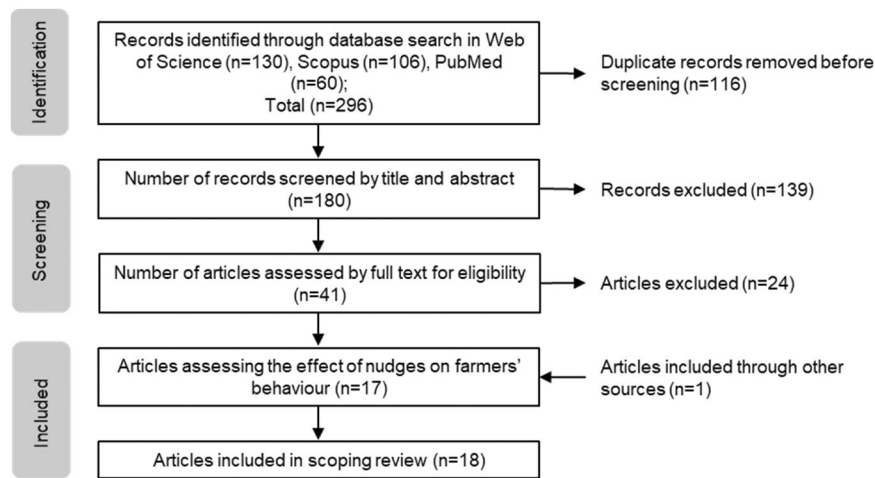


FIGURE 2 | PRISMA flow chart for the scoping review.

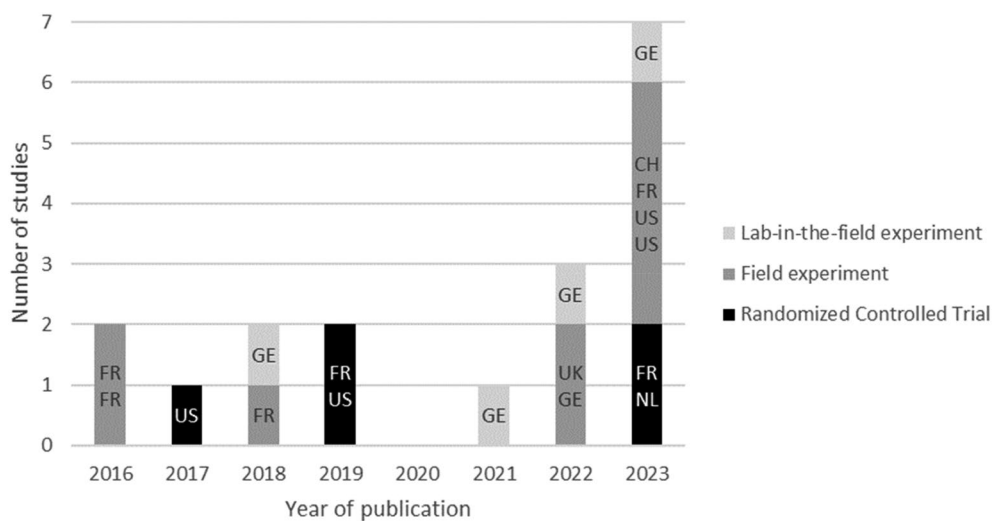


FIGURE 3 | Number of studies per country and experimental approach used. Country codes: CH—Switzerland; FR—France; US—United States of America; GE—Germany; UK—United Kingdom; NL—The Netherlands.

(see also Ferraro and Shukla 2023). Furthermore, the data were often unavailable for other researchers. Only 3 of the 18 studies provided open access to the original farm-level data, and only 5 studies had the design and hypothesis, at least for some of the analyses, pre-registered (Chabé-Ferret et al. 2019; Davidson and Goodrich 2023; Rommel et al. 2023; Wallander et al. 2023; Zachmann et al. 2023)⁵.

Although the representativeness of the study participants for the population is crucial, we found that representativeness was often biased, for example, due to self-selection. A number of studies were based on samples that differed from the farm population by being younger, better educated, and larger, already adopting agri-environmental measures to a larger extent, or better off in terms of income (Buchholz and Musshoff 2021; Howley and Ocean 2022; Kuhfuss, Préget, Thoyer, and Hanley 2016; Massfeller et al. 2022; Ouvrard et al. 2023; Rommel et al. 2023). Studies based on a representative sample were conducted in close cooperation with administrative authorities (Chabé-Ferret et al. 2019; Chabé-Ferret et al. 2023; Czap et al. 2019; Dirkmaat

et al. 2023; Wallander et al. 2017; Wallander et al. 2023) or farmers' associations (Zachmann et al. 2023).

Injunctive social norm nudges describe what other group members think people should do (prescriptive) or not do (proscriptive) (Buchholz and Musshoff 2021; Cialdini 2007). Descriptive social norm nudges describe what other group members do (Howley and Ocean 2022; Kuhfuss, Préget, Thoyer, Hanley, Le Coent, and Désolé 2016; Kuhfuss, Préget, Thoyer, and Hanley 2016). Social signaling increases reputation, that is, one's social status (Blanchflower and Oswald 2004; Howley and Ocean 2022).

5.2 | Context of Nudge—Embedment of Nudges in the Policy Context

Scientific evidence on the impact of nudges in the context of agricultural policy is scarce (Tables 4 and 5). In two-thirds of the studies, the decision options for farmers actually existed (and are not fictitious). Revealed preferences providing higher certainty

TABLE 3 | Studies that evaluated the effect of nudge interventions on farmers' behavior in European and U.S. agriculture.

No.	Authors	Country	Farm type	Sample size	Sample representativeness	Data collection (sampling)		Pre-registered	Goal of the nudge	Nudge category and intervention	Implementation of nudges of intervention
						Method	Method				
1	Buchholz and Musshoff (2021)	Germany	Winter wheat, silage maize	145	No	Convenience sample (own mailing list)	Laboratory experiment	No	Reduce pesticide use	Disclosure of factual information (warning) ^a	Traffic light labelling pesticide intensity
2	Chabé-Ferret et al. (2019) ^b	France	Maize, soybean, sunflower, other cereals, tobacco, vegetables	Experiment 1: 152 Experiment 2: 239	Yes	Water company data	Randomized controlled trial	Yes	Reduce water use	Social norm, (descriptive, partly combined with injunctive) ^c	Weekly mobile text message informing farmers on their water consumption
3	Chabé-Ferret et al. (2023)	France	All farms	20,374	Yes	Administrative database	Randomized controlled trial	No	Adoption of agri-environmental scheme	Disclosure of factual information (program information) ^a ; Social norm (descriptive) ^c ; simplification (pre-stamped reply form) ^c ; salience (information letter) ^c	Letters to farmers
4	Czap et al. (2019)	U.S.	All farms	18,244	Yes	Administrative database	Randomized controlled trial	No	Adoption of an agri-environmental scheme	Disclosure of factual information ^a , social norm (descriptive) ^c	Letters to farmers
5	Davidson and Goodrich (2023)	U.S.	Livestock or hay producers	263	No	Convenience sample (merged with data from administrative database)	Lab-in-the-field experiment	Yes	Adoption of an index insurance	Framing ^c	Framed information to a computer software

(Continues)

TABLE 3 | (Continued)

No.	Authors	Country	Farm type	Sample size	Sample representativeness	Data collection (sampling)	Method	Pre-registered	Goal of the nudge	Nudge category and intervention	Implementation of nudges intervention
6	Dirkmaat et al. (2023)	The Netherlands	All farms	28,557 (2016); 19,733 (2017)	Yes	Administrative database	Randomized controlled trial	No	Support in keeping deadlines of administration and reduce peak times	Reminder (to deliver data) ^a , pre-commitment (set a non-binding target date) ^a , pre-commitment (choosing non-binding target date) ^a ; simplification (checklist) ^c ; disclosure of factual information (early handling treatment) ^a	Letters to farmers
7	Howley and Ocean (2022)	UK	All farms	1800	No	Administrative database	Lab-in-the-field experiment	No	Adoption of worker safety and animal health apps	Social norm (injunctive) ^c , social signaling ^c	Framed questionnaire using Likert scales
8	Kuhfuss, Préget, Thoyer, Hanley, Le Coent, and Désolé (2016)	France	All farms	395	No	Administrative database	Lab-in-the-field experiment	No	Adoption of agri-environmental scheme	Social norm (descriptive) ^c ; framing (positively and negatively framed social norm) ^c	Framed questionnaire using Likert scales
9	Kuhfuss, Préget, Thoyer, and Hanley (2016)	France	Wine	290	No	Administrative database	Lab-in-the-field experiment	No	Adoption of agri-environmental scheme (reduce herbicide use)	Social norm (combined injunctive and descriptive) ^c	Questionnaire including a choice experiment

(Continues)

TABLE 3 | (Continued)

No.	Authors	Country	Farm type	Sample size	Sample representativeness	Data collection (sampling)	Method	Pre-registered	Goal of the nudge	Nudge category and intervention	Implementation of nudges of nudges intervention
10	Massfeller et al. (2022) ^d	Germany	Arable farming	63	No	Convenience sample (recruited by agricultural weeklies)	Lab-in-the-field experiment	No	Adoption of agri-environmental scheme	Social norm (descriptive) ^c	Framed questionnaire using Likert scales
11	Michels et al. (2023)	Germany	Fruits	67	No	Convenience sample (mailing list from fruit grower organization)	Laboratory experiment	No	Reduce pesticide use (increase compliance with regard to the 14-day pre-harvest interval rule after the pesticide application)	Factual information (warning) ^a ; social norm (descriptive) ^c	Framed information to the online business game
12	Ouvrard et al. (2023)	France	All farms	1272	No	Administrative database	Lab-in-the-field experiment	No	Reduce water use (adoption of water meter to reduce water losses)	Cocktail nudge combining reminder ^a , priming ^c and commitment ^a ; social norm (descriptive) ^c	Questionnaire including a discrete choice experiment
13	Pellegrin et al. (2018)	France	All farms	328	No	Administrative database	Lab-in-the-field experiment	No	Adoption of agri-environmental scheme	Affect, salience (the identifiable victim effect aims to motivate prosocial behavior) ^c	Framed questionnaire using Likert scales
14	Peth et al. (2018)	Germany	Arable production	163	No	Convenience sample (own mailing list)	Laboratory experiment	No	Reduce nutrient runoffs (reduce non-compliance with the minimum-distance-to-water rule)	Disclosure of factual information ^a , social norm (descriptive) ^c	Framed information to the online business game

(Continues)

TABLE 3 | (Continued)

No.	Authors	Country	Farm type	Sample size	Sample representativeness	Data collection (sampling)	Method	Pre-registered	Goal of the nudge	Nudge category and intervention	Implementation of nudges of nudges intervention
15	Rommel et al. (2023) ^{b,d}	Germany	All farms	358	No	Panel data from German market research company	Laboratory experiment	Yes	Support of cooperation between farmers	Social norm (descriptive) ^c , disclosure of factual information ^a	Framed information to the Public Goods Game
16	Wallander et al. (2017)	U.S.	All farms with cropland	950,014	Yes	Administrative database	Randomized controlled trial	No	Adoption of agri-environmental scheme	Reminder ^a , social norm (descriptive) ^c	Letters to farmers
17	Wallander et al. (2023) ^b	U.S.	All farms with cropland	701	Yes	Administrative database	Lab-in-the-field experiment	Yes	Adoption of agri-environmental scheme	Default ^c , disclosure of factual information ^a	
18	Zachmann et al. (2023) ^{b,d}	Switzerland	Grapevine	436	Yes	Convenience sample (Swiss wine association)	Lab-in-the-field experiment	Yes	Reduce pesticide use (adoption of fungus-resistant wine varieties)	Disclosure of factual information (on toxicity of fungicides) ^a	Framed questionnaire using Likert scales

^aNudge providing decision assistance.
^bPre-registered experiment.
^cNudge providing decision information.
^dThe data is openly accessible.
^eChanging decision structure.

about the actual effect of a nudge intervention (compared to stated preferences) were assessed only in the five randomized controlled studies. Seven studies were clearly not conducted in a real policy context; that is, they analyzed farmers' stated preferences for a hypothetical, non-existent (fictitious) policy.

TABLE 4 | Studies that analyzed nudge intervention in a real or fictitious policy context ($N=18$).

	Policy context	
	Real (11/18)	Fictitious (7/18)
Farmers' revealed preferences (5/18)	<ol style="list-style-type: none"> 1. Chabé-Ferret et al. (2019) 2. Chabé-Ferret et al. (2023) 3. Czap et al. (2019) 4. Dirkmaat et al. (2023) 5. Wallander et al. (2017) 	n.a.
Farmers' stated preferences (13/18)	<ol style="list-style-type: none"> 1. Davidson and Goodrich (2023) 2. Kuhfuss, Préget, Thoyer, Hanley, Le Coent, and Désolé (2016) 3. Michels et al. (2023) 4. Peth et al. (2018) 5. Wallander et al. (2023) 6. Zachmann et al. (2023) 	<ol style="list-style-type: none"> 1. Buchholz and Musshoff (2021) 2. Howley and Ocean (2022) 3. Kuhfuss, Préget, Thoyer, and Hanley (2016) 4. Massfeller et al. (2022) 5. Ouvrard et al. (2023) 6. Pellegrin et al. (2018) 7. Rommel et al. (2023)

Furthermore, none of the studies described or discussed other policy instruments in addition to those analyzed that could affect farmers' decision making and thus indirectly influence the potential impact of the nudge intervention investigated.

Less than half of the studies ($N=7$) analyzed the effect of a stand-alone nudge intervention on farmers' behavior (Table 5). In eight studies, nudge interventions were combined with economic incentives (Chabé-Ferret et al. 2023; Czap et al. 2019; Davidson and Goodrich 2023; Kuhfuss, Préget, Thoyer, Hanley, Le Coent, and Désolé 2016; Ouvrard et al. 2023; Pellegrin et al. 2018; Wallander et al. 2017; Wallander et al. 2023), three studies combined nudge interventions with regulations (Dirkmaat et al. 2023; Michels et al. 2023; Peth et al. 2018).

5.3 | Design of the Nudge—Goal and Type of the Nudge Intervention

Scientific evidence of nudges in the context of agricultural policy exists for interventions that provide decision-making information and decision support. We found only one study that analyzes a nudge intervention that changes the decision structure, namely a default (Wallander et al. 2023). Social norm nudge interventions and disclosure of factual information are most often assessed (in total, a treatment including a social norm nudge was found 17 times and treatment including a factual information was found 16 times, note that one study can contain multiple interventions). We find that little is known about all other nudge interventions (Figure 4).

Overall, 77% of the studies analyze “green nudge” interventions ($N=14$), which aim to encourage farmers to adopt environmentally friendly behavior by signing up to agri-environmental schemes ($N=8$), reducing pesticide ($N=3$) and water ($N=2$) and nutrient run-off ($N=1$). One study each analyzed the effect of nudges on meeting deadlines for administrative purposes, the adoption of digital apps, the promotion

TABLE 5 | Studies on nudges combined with traditional policy instruments and/or other nudges ($N=18$).

	Nudge intervention	
	Combined with traditional policy instruments (13/18)	Stand-alone (7/18)
Single nudge (12/18)	<ol style="list-style-type: none"> 1. Davidson and Goodrich (2023) 2. Kuhfuss, Préget, Thoyer, and Hanley (2016) 3. Ouvrard et al. (2023) 4. Pellegrin et al. (2018) 5. Wallander et al. (2017) 6. Wallander et al. (2023) 	<ol style="list-style-type: none"> 1. Buchholz and Musshoff (2021) 2. Chabé-Ferret et al. (2019) 3. Kuhfuss, Préget, Thoyer, Hanley, Le Coent, and Désolé (2016) 4. Massfeller et al. (2022) 5. Rommel et al. (2023) 6. Zachmann et al. (2023)
Composite nudge (i.e., different nudge interventions combined) (8/18)	<ol style="list-style-type: none"> 1. Chabé-Ferret et al. (2023) 2. Czap et al. (2019) 3. Dirkmaat et al. (2023) 4. Michels et al. (2023) 5. Peth et al. (2018) 6. Wallander et al. (2017) 7. Wallander et al. (2023) 	<ol style="list-style-type: none"> 1. Howley and Ocean (2022)

of cooperation among farmers, and the adoption of an index insurance.

Seven of the 18 studies assessed the effect of composite nudges, in which different nudge interventions were combined (one of these studies additionally assessed a single nudge intervention). These composite nudges comprise the combination of a social norm nudge with the disclosure of factual information (Czap et al. 2019; Michels et al. 2023; Peth et al. 2018), a social norm nudge with salience and simplification (Chabé-Ferret et al. 2023), a social norm nudge with a reminder (Wallander et al. 2017), salience with pre-commitment (Dirkmaat et al. 2023), and the combination of a social norm and social signaling nudge (Howley and Ocean 2022).

5.4 | Farmers' Characteristics

Figure 5 shows how many of the reviewed studies assessed the sociodemographic characteristics and dispositional, cognitive,

and social factors of farmers. It shows that even though social norm nudges were one of the most often researched nudge interventions (Section 5.3), social factors affecting farmers' decision making or farmers baseline perception about social norms are hardly assessed in the reviewed studies. The same holds true for cognitive factors.

Most ($N=12$) of the studies provided information on the sociodemographic characteristics of farms and farmers; the five RCT studies and one Lab-in-the-field experiment did not (Chabé-Ferret et al. 2023; Czap et al. 2019; Kuhfuss, Préget, Thoyer, Hanley, Le Coent, and Désolé 2016; Kuhfuss, Préget, Thoyer, and Hanley 2016; Wallander et al. 2017; Wallander et al. 2023). The most often collected information was the farmers' age, education, and gender, as well as farm size, farm type, household size, and region. Only a few studies also assessed information on farm succession, workers, the production type organic, association membership, subsidies received, or whether the farm was operated as a part-time or full-time farm.

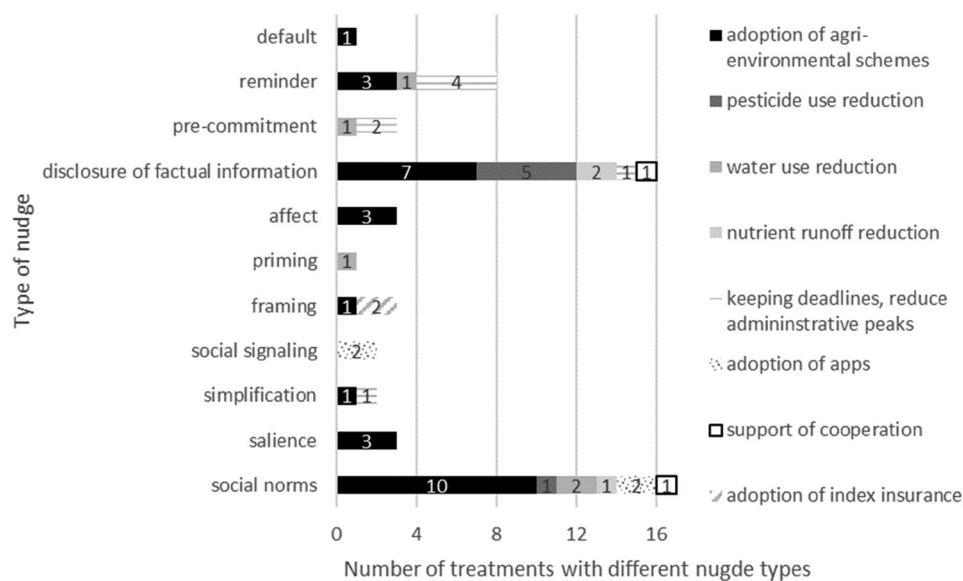


FIGURE 4 | Number of analyzed nudge interventions per nudge type and policy goal. The number of nudge interventions is measured in treatments (59) and is thus higher than the number of studies (18), as most studies analyzed more than one type of nudge using different treatments, and nudge interventions were analyzed as single or composite nudges. A composite nudge is defined as a combination of different nudge interventions.

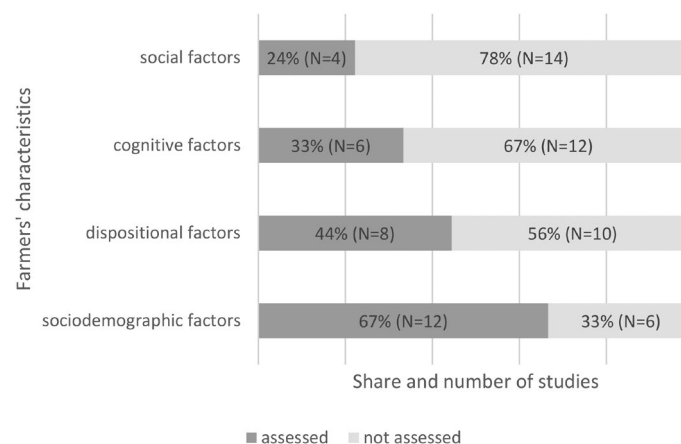


FIGURE 5 | Number and share of the studies that assessed different farm and farmers' characteristics.

Less than half ($N=8$) of the studies collected information on dispositional factors influencing farmers' decision making. Risk attitudes were most often assessed ($N=7$). Other factors recorded were non-pecuniary altruistic motivations (Kuhfuss, Préget, Thoyer, Hanley, Le Coent, and Désolé 2016), law-abiding attitudes (Michels et al. 2023; Peth et al. 2018), environmental attitudes (Massfeller et al. 2022; Zachmann et al. 2023), time preferences (Zachmann et al. 2023), locus of control (Massfeller et al. 2022; Zachmann et al. 2023), and self-efficacy (Zachmann et al. 2023).

Six studies assessed farmers' cognitive factors, including the difficulty of an administrative task (Dirkmaat et al. 2023), pecuniary motivations (Kuhfuss, Préget, Thoyer, Hanley, Le Coent, and Désolé 2016), knowledge (Massfeller et al. 2022), familiarity with an index insurance (Davidson and Goodrich 2023), operating success (Peth et al. 2018), farmers' awareness and use (of fungicide-resistant grapes), expected savings (in fungicides), control measures, and the use of different pesticides (Zachmann et al. 2023).

Four studies assessed the social factors of farmers, including social acknowledgment and better life quality (Kuhfuss, Préget, Thoyer, Hanley, Le Coent, and Désolé 2016), farmers' norms (Massfeller et al. 2022), cooperation with other farmers (Rommel et al. 2023), and the source of information (Zachmann et al. 2023).

5.5 | Farmers' Behavior Toward Nudges

Hardly any scientific evidence on farmers' behavior toward nudges exists. Only one study explicitly investigated the acceptance and persistence of behavioral change of the nudge intervention (Dirkmaat et al. 2023), crowding-out (Howley and Ocean 2022), and pattern spillover effects (Chabé-Ferret et al. 2023). Boomerang effects were not explicitly investigated (i.e., as initial objective of the study) in any of the studies, but five studies indicate that such effects exist (Chabé-Ferret et al. 2019; Michels et al. 2023; Pellegrin et al. 2018; Peth et al. 2018; Zachmann et al. 2023).

Dirkmaat et al. (2023) found that for all treatments assessed (reminders, social norm nudges, simplification, disclosure of factual information, and pre-commitment nudges), more than 90% of the farmers reported positive to very positive experiences. (Non-binding) Pre-commitment, simplification, and the disclosure of factual information were experienced more positively than the social norm nudge. Of all respondents, 38%–39% of the farmers were encouraged to take action. In the same study, no learning effects were observed in farmers' responses to the nudge intervention from 1 year to the next, meaning that the desired behavioral change in the nudge intervention was not persistent.

Howley and Ocean (2022) found little evidence to suggest that significant crowding-out occurs when an injunctive social norm nudge was combined with a social signaling nudge (i.e., a composite nudge) in an experiment about farmers' stated adoption behavior of a worker safety or an animal health app.

The results of the five studies suggest that boomerang effects might exist. Reactance or defense reactions were found at least in a sub-group of the respective samples when farmers were nudged by the disclosure of factual information (Michels et al. 2023; Peth et al. 2018; Zachmann et al. 2023), social norm nudges (Michels et al. 2023; Peth et al. 2018; Chabé-Ferret et al. 2019), affect, and salience nudge (Pellegrin et al. 2018). In terms of spillover effects, Chabé-Ferret et al. (2023) explicitly investigated the spillover effects of patterns from farmers nudged with a composite nudge comprising salience, social norms, and simplification to non-nudged farmers but found none.

5.6 | Effectiveness and (Cost)Efficiency of Nudges

Combined nudges, that is, nudges combined with traditional policy instruments, seem to be more effective than stand-alone nudges (Figure 6). Ten of the eleven studies that analyzed combined nudges found significant effects on farmers' behavior (only Pellegrin et al. (2018) did not find a significant effect;

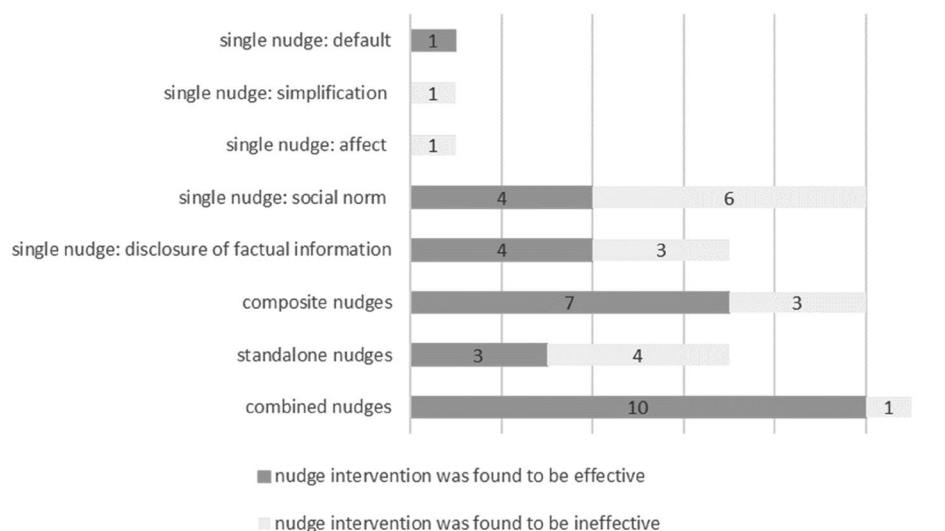


FIGURE 6 | Number of studies that assessed the effectiveness of single, composite, and combined nudges. Composite nudges differ from single nudges in that they combine different nudge interventions. Combined nudges combine a nudge intervention with a traditional policy instrument, whereby the nudge intervention can include single and composite nudges.

compare Table 5). Of the seven studies that analyzed stand-alone nudges, that is, nudges not combined with a traditional policy instrument, only three found significant effects (Buchholz and Musshoff 2021; Howley and Ocean 2022; Kuhfuss, Préget, Thoyer, Hanley, Le Coent, and Désolé 2016).

Furthermore, composite nudges—defined as a combination of different nudges—were found to be more effective than single nudges, with 7 of the 10 studies that evaluated composite nudges finding significant effects (Figure 6)⁶. Less clear results were observed for single nudges. The disclosure of information was found to be effective in four studies (Buchholz and Musshoff 2021; Czap et al. 2019; Davidson and Goodrich 2023; Michels et al. 2023) and not effective in three other studies (Dirkmaat et al. 2023; Zachmann et al. 2023; Wallander et al. 2023). Single social norm nudges were more often found to be ineffective than effective. Six out of ten social norm nudge interventions evaluated showed insignificant results (Chabé-Ferret et al. 2019; Howley and Ocean 2022; Massfeller et al. 2022; Michels et al. 2023; Ouvrard et al. 2023; Rommel et al. 2023), one showed a detrimental effect (Peth et al. 2018), and three showed significant positive effects (Kuhfuss, Préget, Thoyer, Hanley, Le Coent, and Désolé 2016; Kuhfuss, Préget, Thoyer, and Hanley 2016; Rommel et al. 2023). Two studies that analyzed an affect nudge (Pellegrin et al. 2018) and a simplification nudge (Dirkmaat et al. 2023) found that these nudges were ineffective in changing farmers' behavior. One of the two studies evaluating a salience nudge found a significant positive effect on farmers' behavior, while the other found no effect (Pellegrin et al. 2018).

To date, there is little scientific evidence on the cost-effectiveness of nudge interventions in the agricultural policy context. Of the 18 studies reviewed, 12 did not assess the costs of the nudge intervention analyzed. However, the other six found that the nudges evaluated were cost-effective (Chabé-Ferret et al. 2023; Czap et al. 2019; Dirkmaat et al. 2023; Kuhfuss, Préget, Thoyer, and Hanley 2016; Wallander et al. 2017; Wallander et al. 2023). By dividing the cost of sending letters by the number of additional contracts generated by sending these letters, Chabé-Ferret et al. (2023) showed that the disclosure of factual information was most cost-effective, with 101.53 Euro per agri-environmental contract signed. By comparing the costs of sending letters with the increase in application rates, Czap et al. (2019) showed that the disclosure of factual information on an agri-environmental program led to costs of US\$116 for an additional application and argued that this is more cost-effective than spending the same amount of money via financial incentives for the same program. Dirkmaat et al. (2023) found that all of the nudge interventions they evaluated (including pre-commitment, simplification, and disclosure of factual information) were cost-effective because they could be added to the reminder letters that were sent to farmers every year anyway without additional costs. Using a choice experiment, Kuhfuss, Préget, Thoyer, and Hanley (2016) found that the willingness to accept an agri-environmental program was significantly higher, with a collective bonus of an amount greater than the bonus value, suggesting that a collective bonus might be cost-effective. Wallander et al. (2017), simulating expected benefit-cost ratios for each sign-up for different auction scenarios, found that a reminder letter for the renewal of expiring agri-environmental contracts led to

the reduction in annual rental costs of between 10× and 2× the letter costs. In a lab-in-the-field experiment using a simulated sign-up auction, Wallander et al. (2023) demonstrated that even a small enrollment due to nudging generates significant benefits and that the default resulted in savings of over US\$30 million per sign-up to an agri-environmental program.

6 | Discussion

In this section, we discuss the research gaps identified in our scoping review on the potential of nudges to improve the effectiveness and efficiency of agricultural policy.

6.1 | Lack of Sample Representativeness

Current studies on nudge interventions in the agricultural policy context are often based on samples that are not representative of the whole farm population and often comprise higher shares of younger and better educated farmers with larger farms and comparatively good incomes who participate in agri-environmental schemes (Buchholz and Musshoff 2021; Howley and Ocean 2022; Kuhfuss, Préget, Thoyer, and Hanley 2016; Massfeller et al. 2022; Ouvrard et al. 2023; Rommel et al. 2023). Even if these farmers are at best representative of the future generation of farmers, it is important to acknowledge that these farmers are likely to respond differently to nudge interventions, thus biasing the analysis of the impact of nudge interventions on the effectiveness and efficiency of agricultural policy. For example, Massfeller et al. (2022) found that farmers who had already adopted agri-environmental measures were less responsive to specific nudge interventions, while Howley and Ocean (2022) found that farmers with lower levels of education were more receptive to nudge interventions.

Of course, as long as the participation in surveys is voluntary, the problem of self-selection bias remains in many studies, which is why a thorough comparison between the sample and the population must be provided to allow for a proper discussion of these results. In interpreting the results, representativeness is important not only in relation to the sample as a whole but also in relation to the different treatments, for which samples may differ unintentionally due to farmers' self-selection or by chance. For instance, Kuhfuss, Préget, Thoyer, and Hanley (2016) found differences in farm characteristics and farmers' motivation across treatments, and Zachmann et al. (2023) found differences in farmers' time preferences across treatments.

Research and government agencies should collaborate to select representative samples and address the tension between representativeness and data richness without increasing the administrative burden of government surveys. As both farmers and administrative bodies recognize the need to reduce the administrative burden, and as the demand for evidence-based policies grows while research funding remains limited, improved coordination between the administrative and research sectors is crucial. This coordination should entail providing researchers with access to representative administrative samples and leveraging research funding to motivate farmers to participate in scientifically sophisticated government surveys.

Studies conducted in cooperation with administrative authorities (Chabé-Ferret et al. 2019; Chabé-Ferret et al. 2023; Dirkmaat et al. 2023; Wallander et al. 2017; Wallander et al. 2023) or farmers' associations (Zachmann et al. 2023) have been shown to be more representative. Moreover, while some of these studies used randomized controlled trials—the gold standard to detect causal inference—they often contained little information on farms and farmers' characteristics, highlighting a need for more comprehensive data collection within RCTs. Addressing this gap, Weigel et al. (2021) found that monetary incentives and reminders were effective but also costly approaches to improve the effectiveness of farmer recruitment. Thus, closer cooperation between researchers and government agencies in the design and recruitment of farmer surveys seems to be a promising way to make better use of limited financial and human resources.

6.2 | Lack of Understanding of How Farmers' Characteristics Affect Their Behavior Toward Nudges

Existing studies collect little data on farmers' characteristics. This is especially true for social factors, followed by cognitive and dispositional factors. Social factors relate to farmers' interactions with others and can be exploited through injunctive social norm nudges (Buchholz and Musshoff 2021; Cialdini 2007), descriptive social norm nudges (Czap et al. 2019; Howley and Ocean 2022; Kuhfuss, Préget, Thoyer, Hanley, Le Coent, and Désolé 2016; Kuhfuss, Préget, Thoyer, and Hanley 2016; Wallander et al. 2017), social signaling (Blanchflower and Oswald 2004; Howley and Ocean 2022), and messenger nudges (Cialdini 2007; Dolan et al. 2012). The design of these nudge interventions relies on a good understanding of farmers' social factors.

A better understanding of farmers' cognitive factors is important if new sustainable production methods are to be promoted through nudges. For instance, Zachmann et al. (2023) found that farmers' beliefs about whether fungus-resistant varieties are better for the environment influenced their intended planting rate. Knowledge of farmers' cognitive factors could therefore improve the targeting of nudges.

With regard to dispositional factors, future research should use standardized scales to assess the more stable characteristics of farmers (Malle 2011) to allow comparative studies on the effectiveness of different nudge interventions. Although several methods for assessing farmers' risk preferences have been validated in an agricultural context (Iyer et al. 2020; Finger et al. 2022; Finger et al. 2023), this is not the case for other dispositional factors.

The interaction between socio-demographic, social, cognitive, and dispositional factors is also important when assessing nudge interventions. For instance, Massfeller et al.'s (2022) results suggest that farmers' decisions to participate in agri-environmental schemes may be less susceptible to social norms but are better addressed at the cognitive level, while farmers who participate in agri-environmental schemes respond to social norms.

6.3 | A Number of Possible Nudge Interventions Have Not Yet Been Analyzed in an Agricultural Context

Many of the possible nudges have not yet been analyzed in the context of agricultural policy. We find a lack of knowledge related to nudge interventions changing the decision structure, with only one study in the United States assessing the effect of a default (Wallander et al. 2023). Previous research outside of agriculture has shown that defaults can help bridge the gap between intention and behavior (Münscher et al. 2016; Sunstein and Reisch 2019) and that the optimal default depends on the population being analyzed (Dolan et al. 2012). However, it has also been shown that defaults are often not accepted (Sunstein and Reisch 2019). Prompted or compulsory choices were found to be better suited than default rules when people had highly heterogeneous preferences and a strong propensity to procrastinate (Carroll et al. 2009). Therefore, they may be well-suited to more effectively achieve one or the other agricultural policy goal.

With respect to the goal of nudges and given that 77% of the studies in our scoping review analyzed nudges related to agri-environmental policy goals (i.e., green nudges), a research gap exists on nudge interventions that aim to improve animal welfare, even though this is perceived as one of the most important goals of agricultural policy by European citizens (Ammann, Mack, et al. 2023; Amann et al. 2024; El Benni, Irek, et al. 2024). In addition, nudges can serve as a cost-effective policy instrument for reducing the administrative burden of farmers and government authorities when implementing agricultural policy. For example, they can simplify compliance with agricultural regulations. The study by Dirkmaat et al. (2023) provides promising results in this regard. Reducing the administrative burden associated with agricultural policy would also increase farmers' acceptance of these policies, thus contributing to greater effectiveness (Mack et al. 2021; El Benni, Ritzel, and Mack 2024). Further, the results of our review also suggest that there is potential for composite nudges (i.e., a combination of different nudges as opposed to single nudges) to improve the effectiveness and efficiency of agricultural policy. The reviewed studies evaluated a variety of composite nudges, but systematic surveys are needed to provide scientific evidence of their effects on farmers' behavior.

6.4 | Studies on Nudge Interventions in a Real Policy Context Are Rare

We find a lack of scientific evidence on the effects of nudges on farmers' behavior in a real policy context. When analyzing the effects of nudges on farmers' behavior, most studies have assessed stated (rather than revealed) preferences and often fictitious (rather than real) decision options. Although often difficult and costly to conduct (El Benni et al. 2023), more studies using randomized controlled trials are needed to provide evidence on the effects of nudges in a real policy context. To better align research with evidence-based policy-making, a balance must be struck between scientifically rigorous methods and the practical relevance of the research questions addressed (El Benni et al. 2023). Research and policy-making must collaborate more closely to ensure research is more useful for policy-making. One

possible solution would be to formalize this collaboration within a behavioral unit that systematically assesses the potential of nudges for agricultural policy.

Our results further suggest that there is potential for combining nudges with traditional policy instruments to improve the effectiveness and efficiency of agricultural policy. A promising application was shown by Dirkmaat et al. (2023), who combined nudges (reminders, social norm nudges, pre-commitment, information disclosure and simplification) with (direct payment) regulations and found that farmers perceived the nudges positively and were encouraged to submit administrative data earlier before the deadline, thereby reducing administrative peaks. Reducing the administrative burden associated with the direct payment system has been the subject of recent protests by farmers (Matthews 2024; Finger et al. 2024) and combining tasks related to direct payment obligations with nudge interventions, such as simplification or reminders, could help farmers with administrative tasks while reducing the perceived administrative burden by reducing psychological costs (Ritzel et al. 2020).

6.5 | Lack of Knowledge of Farmers' Behavior Toward Nudges and the Potential of Nudges to Improve the Effectiveness and (Cost) Efficiency of Agricultural Policy

Our review shows that combined nudges, that is, nudges combined with traditional policy instruments, seem to be more effective than stand-alone nudges, but more studies are needed to provide a solid scientific evidence base. The six studies that assessed the costs of nudges found them to be cost-effective, but more evidence is needed. To improve understanding of the cost-effectiveness of nudges, standardized metrics should be developed. This would be particularly important for studies conducted in a real policy context, where the costs (e.g., the cost of sending letters to farmers) and benefits (e.g., the number of farmers enrolled in agri-environmental schemes as a result of the letters) can be measured. In terms of farmers' behavior in response to nudges, our results show a large knowledge gap. We identify an urgent need to generate knowledge on farmers' acceptance of different nudge interventions, the persistence of behavior changes due to nudges, and unintended effects, including crowding out, spillover, and boomerang effects. Only one study has examined the acceptance of non-agricultural nudges among farmers in Sweden and found remarkably lower approval rates of nudge interventions compared to the general public (Colen et al. 2024). Future studies should pay more attention to unintended effects, such as boomerang effects, which appear to be relevant but have not yet been explicitly analyzed in studies of nudge interventions. It is also important to know the size of the target group to be reached, as even effective nudge interventions may fail to improve the overall efficiency and effectiveness of agricultural policy if only a minority of the target group responds to the nudge.

The full range of experimental approaches should be used to evaluate the potential of nudges. Laboratory experiments conducted in a highly controlled environment isolated from nuisance factors could be especially helpful in gaining a deeper understanding of the interrelation between farmers' characteristics

and nudge interventions, as they are characterized by higher internal validity and allow for replications (Lefebvre et al. 2021). Lab-in-the-field experiments provide relatively cheap and rapidly obtained information on potential ways to improve a policy (Colen et al. 2016), which can be particularly useful when different potential nudge designs need to be compared. Based on the results of Lab-in-the-field experiments, randomized controlled trials can be set up to overcome problems of Lab-in-the-field experiments with internal validity, that is, isolating the causal relationship (El Benni et al. 2023; Harrison and List 2004).

In addition, the results of the scoping review show that there is a lack of knowledge about the overall potential of nudges to increase the effectiveness and cost-efficiency of agricultural policy. This overall potential is determined by the size of the group of farmers reached, the effect on the outcome of interest (e.g., environmental benefits) and the costs of the nudge intervention itself. Previous studies in the non-agricultural context found that the marginal value of public funds varies significantly across regions for a nudge aimed at reducing U.S. households' energy consumption (e.g., Allcott 2011; Hahn et al. 2024). In the agricultural context in our review, none of the studies explicitly assessed the marginal effectiveness of nudges, that is, the additional effects of nudges with increased public spending. Chabé-Ferret et al. (2023) found that from the 100% treated farmers, about 2% changed their behavior and entered an environmental contract, providing implicit evidence that the scaling potential of nudges can be low. However, Chabé-Ferret et al. (2023) also suggest diffusion effects of nudges, though the evidence is not strong. Future empirical studies should examine the scaling potential of nudges in agricultural contexts.

6.6 | The Need for Open Data and Open Science to Increase the Quality and Reliability of Research

Open access to original data and transparency about research methods and designs are key to improving the quality and efficiency of research and, thus, scientific evidence for policy-making (Finger et al. 2025). However, our review shows that neither data nor pre-registration of registered reports (Arpinon and Lefebvre 2024) are freely available for most of the studies. Only a minority of the three studies provided access to the original data (Massfeller et al. 2022; Rommel et al. 2023; Zachmann et al. 2023) and four studies pre-registered their experimental designs (Le Coent et al. 2017 for the study of Chabé-Ferret et al. 2019; Rommel et al. 2023; Wallander et al. 2023; Zachmann et al. 2023) whereby we also found pre-registered studies that had not yet been published (Barreiro-Hurle 2023) or were just recently published (Feisthauer et al. 2024).

This current lack of openness in research prevents the use of a range of possible research methods for agricultural policy analysis, such as replication studies or meta-analyses (El Benni et al. 2023). Replication studies are a powerful tool for providing scientific evidence for policy-making by verifying results (i.e., significance, direction, and effect sizes in original studies), revealing underlying uncertainties, or uncovering errors (Ferraro and Shukla 2023; Finger et al. 2023; El Benni et al. 2023). Open access to data allows for meta-analyses that empirically synthesize the results of multiple studies on the

same question. Such analyses can overcome the lack of power of individual studies, assess combined effect sizes and significance levels for the combined results of multiple studies, and thereby provide the most reliable estimates of the effects of policies (El Benni et al. 2023).

However, the reliability of meta-analysis results depends on the underlying pool of studies, which are often subject to publication bias, that is, that nonsignificant results are systematically less likely to be published (Fanelli 2010). Publication bias is a challenge for meta-analyses to produce reliable results. For example, in a meta-analysis of more than 200 studies of nudges in different behavioral domains (e.g., food, environment, health, finance, etc.), Mertens et al. (2022) found moderate publication bias toward positive results and nudges being effective. Using a different method to account for publication bias, Maier et al. (2022) challenged the findings of Mertens et al. (2022) and found strong evidence of publication bias in most behavioral domains. They concluded that after correcting for this bias, there is no evidence that nudges are effective as a tool to change behavior. To avoid publication bias, pre-registration and especially registered reports are useful tools that should be adopted more often by editors and researchers (Arpinon and Lefebvre 2024).

6.7 | Limitation of the Study

Our analysis was focused on studies conducted in Europe, Northern America, and Australia. The exclusion of economically less developed countries from the scoping review, the restricted search term to identify studies (i.e., the focus on nudges), and the use of the vote-counting method in the analysis of the identified studies can be seen as limitations of the present study, which we will discuss in the following.

We focused on studies from high-income industrial countries with similar agricultural economic and policy environments as they face similar challenges related to their well-established complex policy frameworks and are searching for solutions to reduce administrative burdens, negative environmental effects, and high financial constraints. We aimed for this context-specificity to allow for a certain degree of external validity for agriculture in high-income industrial countries (Weigel et al. 2021), but the focus may also affect the scope and applicability of our results for countries with different economic and policy settings (OECD 2012; Accenture 2009). Future research may expand this scope. Our scoping review can be used as a basis for future systematic reviews (Munn et al. 2018) and the framework developed provides a general concept that can be applied to different contexts. Future studies, once more empirical studies are available, shall also use meta-analyses to analyze the impact of nudges on the effectiveness and efficiency of agricultural policies with higher robustness. Note, however, that the aim of our scoping review was to assess the scope of the current literature, identify knowledge gaps, and investigate how research on nudges in the agricultural context is conducted.

The search string used for the literature search was strict, that is, papers that did not contain the terms farm* OR agricultur* AND nudg* in the title and abstract were not included. This was done

as the term “nudge” has been used to describe a specific type of policy intervention, as defined by Thaler and Sunstein (2008), and including studies that use this term explicitly ensures transparency, reproducibility, and consistency of our scoping review. Including studies that do not explicitly use the term “nudge” would have required subjective, full-text screening to identify qualifying interventions, which would reduce the transparency and reproducibility of our search and inclusion criteria. The narrow search string can be considered a limitation, and other search strategies may have identified additional studies that did not consider themselves to apply nudges (and thus did not use this term). To ensure that we had found all relevant papers, we compared our literature list with the lists of an existing review paper (Ferrari et al. 2019) and a current EU project PRUDENT (Promoting Green Nudging for Sustainable Agriculture and Forestry) and found that we had identified the same studies and two additional studies through our search. We therefore believe that we are able to provide valuable insights into the current literature on the use of nudges as an agricultural policy intervention with the chosen focus. However, researchers interested in the behavioral biases that nudge interventions aim to exploit (e.g., probability weighting or risk aversion) or in developing a specific nudge intervention (e.g., a social norm nudge) would need to screen the available literature using different search strings. However, this scoping aimed to map the current body of literature on nudge interventions for farmers, clarify concepts, and identify knowledge gaps that should be addressed in future research.

We use the vote-counting method to summarize and interpret the results of the different studies in our scoping review. We count studies that found significant (positive or negative) and insignificant effects of nudges on farmers' behavior in order to draw conclusions about the effectiveness and cost-efficiency of nudges. However, many of the studies analyzed in our scoping review are underpowered. Therefore, our results must be interpreted with caution (Chabé-Ferret 2022) and, in particular, show the high degree of heterogeneity with respect to the methods used and the nudge interventions analyzed in the agricultural context. Future meta-analyses aimed at assessing the effectiveness and efficiency of nudges in agricultural policy should take into account potential publication bias, the sampling noise in the individual studies, and use consistency tests that account for the statistical power of the individual studies (e.g., Berchialla et al. 2021).

7 | Conclusion

Based on a framework developed in this study, we conducted a scoping review of 18 studies that used behavioral experiments with farmers to assess the potential of nudges to improve the effectiveness and efficiency of agricultural policy. Our findings show important research gaps. First, we find that there is limited real-world applicability in existing studies. For example, only a few studies have tested nudges in a real-world policy context, and the samples of farmers used are often not representative. Second, we find mixed evidence on the effectiveness of nudges. While some studies suggest that nudges have a positive impact, especially when combined with other nudges or traditional policy instruments, others report no effect or even

unintended negative outcomes, such as boomerang effects. Third, the few studies that estimate the costs of nudges suggest that they are cost-effective. Fourth, we identify a limited understanding of farmers' behavioral responses to nudges, including their acceptance, the persistency of behavioral changes, and any unintended effects. Fifth, existing research lacks transparency and reproducibility, that is, only a few studies are pre-registered or provide original data. Our analysis highlights critical gaps that need to be addressed in future research to better understand the potential of nudges to improve agricultural policy outcomes. Researchers aiming to analyze the potential of nudge interventions in agricultural policy are encouraged to use the framework developed in this study. This will ensure that their work is coherent and consistent in terms of terminology and can be incorporated into the existing toolbox of agricultural policy instruments. This will also facilitate proper meta-analysis on this topic in the future.

From a policymaking perspective, our review reveals high potential for nudges to serve as cost-effective instruments in agricultural policy, especially when combined with traditional policy instruments and different types of nudges. Policymakers could leverage nudges to improve the outcome of existing (traditional) policies by combining nudges with traditional policy instruments or targeting multiple desired behavioral changes of farmers with composite nudges, that is, by combining different nudges. In designing nudge instruments, a solid understanding of farmers' characteristics, the acceptability of the nudges by farmers, expected persistence of behavioral change, and unintended responses by farmers are all important factors for consideration. However, the knowledge gaps we identify in our review limit a full understanding of the potential of nudges to improve the effectiveness and efficiency of agricultural policy, and more research is needed to provide scientific evidence for policymaking.

Advancing evidence-based agricultural policy requires targeted action, such as facilitating researcher access to representative administrative samples and allocating research funding to support farmer participation in voluntary surveys by incorporating proven recruitment strategies. By taking these steps, researchers can generate robust and representative results that strike a balance between quality and feasibility. This will ultimately inform more effective agricultural policies while reducing the additional administrative burden of government surveys. A behavioral unit within governmental agricultural agencies could facilitate data collection and approval procedures that enable representative field experiments with farmers, including randomized controlled trials, and support evidence-based policymaking by institutionalizing behavioral knowledge in agricultural policy and supporting rigorous policy evaluations.

Acknowledgments

The authors thank Petyo Bonev for interesting discussions and literature references on unintended behavioral effects of nudges that were considered in the development of the framework. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. Open access publishing facilitated by Agroscope, as part of the Wiley - Agroscope agreement via the Consortium Of Swiss Academic Libraries.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Endnotes

¹ For instance, nudges affect characteristics that people would normally claim not to care about. Thus, a central distinction between nudges and boosts (i.e., information) is the mechanism through which each is supposed to affect behavior (Grüne-Yanoff et al. 2018). First, whereas nudges instrumentalizes or harness cognitive biases, boosts aim to overcome human cognitive limitations. Second, nudges target the choice environment and boosts often target the decision-makers heuristics directly. Accordingly, Grüne-Yanoff et al. (2018) distinguished boosts from nudges as follows: "a nudge intervenes on people's choice environment and harnesses a certain heuristic to bring about a specific behavioral change; a boost intervenes on people's heuristic repertoires and expands that repertoire to bring about a specific behavioral change".

² Note that the study by Dolan et al. (2012) is the basis for the Ag-E MINDSPACE framework which categorizes behavioral insights that apply to agri-environmental research (Palm-Forster et al. 2019; Palm-Forster and Messer 2021).

³ The rather extensive search terms yielded a large number of results pertaining to consumers, students, and the discussion (but not empirical application) of nudges as a potential policy instrument, rather than the desired focus on empirical studies with farmers. These studies were excluded from the scoping review as they do not fit our inclusion criteria.

⁴ Following Colen et al. (2016), Lefebvre et al. (2021) and El Benni et al. (2023) experiments can be distinguished according to their experimental subjects (e.g., farmers or students), the experimental environment (e.g., laboratory or natural context) and type of experimental setting (e.g., discrete choice experiment or experimental game or randomized controlled trials). For our scoping review, we distinguish between three main types of experiments as follows: (i) Randomized controlled trials, that is, experiments conducted in real-world settings, where farmers are treated with real policy options in their natural context; such randomized controlled trials, (ii) Laboratory experiments, that assess the behavior of participants in a controlled environment, (iii) Lab-in-the-field-experiments, that are positioned between randomized controlled trials and laboratory experiments, and are highly relevant economic experiments for agricultural policy evaluation. With lab-in-the-field-experiments farmers are asked about their preferences within the farmers' natural environment but no real policy option is implemented and only stated preferences can be assessed.

⁵ To find the pre-registered studies, we carefully read the papers and conducted an automated search for the terms 'pre' and 'regist'. Using this approach, we identified one study that used the term pre-analysis (Davidson and Goodrich 2023) and four studies that used the term pre-registration (Chabé-Ferret et al. 2019; Rommel et al. 2023; Wallander et al. 2023; Zachmann et al. 2023).

⁶ The composite nudges studied comprised the combinations of a reminder with social norm nudge (Dirkmaat et al. 2023; Wallander et al. 2017), a reminder with pre-commitment (Dirkmaat et al. 2023), reminder with priming and commitment (Ouvrard et al. 2023), the combination of two social norm nudges (Howley and Ocean 2022), the combination of the disclosure of factual information and a social norm nudge (Czap et al. 2019; Peth et al. 2018). In one study a composite nudge that combined a salience nudge with a social norm nudge was found to significantly negatively affect the targeted behavior (Chabé-Ferret et al. 2023).

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