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# Farmers' behavioural determinants of on-farm biodiversity management in Europe: a systematic review

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## Abstract
Agricultural intensification and landscape homogenisation are major drivers of biodiversity loss in European agricultural landscapes. Improvements require changes in farming practices, but empirical evidence on farmers' motivations underlying their on-farm biodiversity management remains fragmented. To date, there is no aggregated overview of behavioural determinants that influence European farmers' decisions to implement biodiversity-friendly farming practices. This study aims to fill this knowledge gap by conducting a systematic literature review of 150 empirical studies published between 2000 and 2022. We identified 108 potential determinants of farmers' behaviour, which were integrated into a multilevel framework. The results show that the farmers' decisions are complex and often non-directional processes, shaped by numerous external (at a society, landscape, community, and farm level) and internal factors. These factors are embedded in regional and cultural contexts. However, the analysis of study sites indicates that the spatial coverage of scientific evidence on biodiversity-friendly farming measures is uneven across Europe. Given the diversity of local and socio-cultural conditions, there is a need for public policies, including the European Union's Common Agricultural Policy, to address more specifically determinants encouraging biodiversity-friendly farm management. This entails reflecting culture-specific perspectives and incorporating experiential knowledge into multilevel policy design processes, as well as offering regionally adapted advice on measure implementation and biodiversity impacts.

**Keywords** Biodiversity management · Environmental perception · Agri-environment-climate measures (AECM) · Sustainable farming · Systematic literature review · Common Agricultural Policy (CAP)

### Abbreviations

| | |
|---|---|
| AECM | Agri-environment-climate measure |
| AES | Ari-environmental scheme |
| BFFM | Biodiversity-friendly farming measures |
| CAP | Common Agricultural Policy |
| EU | European Union |
| NUTS | Nomenclature of territorial units for statistics |
| WoS | Web of Science |
| WTA | Willingness to accept |

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## Introduction

There is a broad consensus among scientists, policy-makers, societal stakeholders, and the agricultural sector that the prevailing agricultural practices significantly contribute to the loss of biodiversity (Benton et al. 2021; CBD 2022; Dudley and Alexander 2017; EEA 2019). In the European Union (EU), public policies have long addressed agriculture-related biodiversity conservation by deploying strategies (Convention on Biological Diversity), legislative instruments (e.g., Natura 2000), incentives, such as agri-environment-climate measures (AECM) under the Common Agricultural Policy (CAP), and the provision of information through entities such as farm advisory services. Despite these efforts, the decline of biodiversity in agricultural landscapes has not

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been reversed yet (EEA 2019; Habel et al. 2019; Mackenzie 2020).

Farmers are at the heart of agricultural landscapes, and their actions have a significant impact on the prevalence and quality of habitats. They therefore play a critical role in determining the success or failure of biodiversity conservation. The importance of farmers' management decisions is increasingly recognised in government policies and programmes, spanning from a global to a local level. For instance, this recognition has been reflected in the United Nations Biodiversity Conference COP15 decision taken in Montreal in 2022 (CBD 2022), Objective 6 of the CAP legislation 2023–2027 (Mackenzie 2020), the guidelines for biodiversity-friendly management of the ÖPUL programme in Austria (BML 2023), or the Bavarian citizens' referendum for biodiversity in 2019 (LBV 2022). All these initiatives share an ambition to promote biodiversity-friendly farming measures (BFFM) that reduce land use intensity and restore valuable habitats in agricultural landscapes shaped by decades of landscape homogenisation and agricultural intensification. Understanding the determinants of farmers' decisions to adopt BFFM is essential for the development and implementation of new biodiversity-related incentives that are widely accepted.

Previous literature reviews have provided valuable insights into the motivational factors guiding farmers' decisions (e.g., Ahnström et al. 2008; Burton 2014; Dessart et al. 2019; Foguesatto et al. 2020; Knowler and Bradshaw 2007; Mozzato et al. 2018). Notably, the work by Dessart et al. (2019) distinctly identifies and analyses determinants of farmers' choices regarding various environmentally sustainable farming practices, defined as practices that provide positive externalities for biodiversity, water, soil, landscapes, and climate change mitigation, showing that these decisions are influenced by numerous distal and proximal factors. However, there is no systematic review that provides a comprehensive and replicable overview of the body of literature on the determinants of farmers to adopt practices specifically targeted at enhancing biodiversity. While many sustainable agricultural practices indirectly benefit biodiversity, even if this is not the primary objective, the peculiarities of biodiversity as a complex common good lead us to the assumption that the logic underpinning biodiversity-enhancing practices may differ from those, for example, aiming at soil water retention, erosion control, water purification, or carbon sequestration. This distinction is made due to the lively societal debates on biodiversity loss (e.g., LBV 2022), the ethical dimensions associated with biodiversity (e.g., Kelemen et al. 2013), emotional attitudes towards biodiversity (e.g., Herzon and Mikk 2007), and its contribution to landscape aesthetics (e.g., Hartel et al. 2017). Accordingly, determinants of decisions to implement BFFM, especially intrinsic motivations, are likely to display a distinguishing profile.

Farmers' management decisions primarily affect their farm or parts of it, which, in turn, are embedded in the wider agricultural landscape and a social environment. In contrast, biodiversity goals typically refer to landscape features and scales, often without direct farm-specific implications. Achieving targets at the landscape level by influencing decisions at a farm level, often by addressing practices at a plot level, requires a broad view of the multiple factors underlying the farmers' decisions. To the extent that biodiversity issues, landscapes, and socio-cultural environments are region-specific (Rois-Díaz et al. 2018; Vaz et al. 2021), possible regional variations in the determinants of farmer behaviour must also be taken into account. Yet, an aggregated overview of the regional coverage of studies on the determinants of biodiversity-related farming decisions has not been published.

Against this background, the current study addresses two primary research questions: (i) Which factors influence the European farmers' decisions to implement BFFM? (ii) Which regions are covered by the scientific literature in this field? By conducting a systematic review, we aim to deliver a comprehensive and structured set of behavioural determinants and to provide an integrated analytical framework. We further seek to gain insight into the spatial distribution of the study areas, which will help to identify potential spatial imbalances in the generation of knowledge on this subject within international scientific research. These objectives are approached by extracting, categorising, and synthesising factors that influence farmers' decisions to implement BFFM drawing on a systematic analysis of recent scientific literature, and by geographically assessing the distribution of the study regions.

The following sections describe the methodological steps involved in the systematic literature review and the composition of the data set. The results of the statistical analysis of the text corpus and the synthesis of the factors influencing farmers' BFFM decisions are then presented. The subsequent discussion section reflects on the findings and their policy implications before closing with concluding remarks.

## Methods

With this review, we aim to synthesise the existing scientific evidence on the determinants influencing farmers' decisions in relation to on-farm biodiversity management. To provide reliable, valid, and replicable results, we conducted a systematic literature review building on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al. 2021). This statement is intended as a structured guidance for reporting relevant steps of the method, such as selection of information sources, search strategies, definition of eligibility criteria for inclusion or

**Table 1** Final set of search terms divided into four categories

| Category | Search terms |
|---|---|
| Subjects | *Agricultural producer, farm manager, farmer, land/farm owner, peasant, rancher* |
| Determinants | *Attitude, awareness, belief, concepts, consciousness, favour, feeling, identity, imagination, intention, judgement, knowledge, liking, mindset, motivation, notion, opinion, perception, positioning, preference, rationality, recognition, sensibility, thoughts, understanding, view, willingness* |
| Operations | *Acceptance, adaptation, adoption, agreement, behaviour, choice, commitment, compromise, cooperation, decision, denial, engagement, participation, refusal, rejection, resistance, selection, uptake* |
| Targets | *Agroforestry, bat box, beetle bank, biodiversity, bird protection, buffer strip, conservation tillage, conservation/ecological/organic measure or farming or agriculture or cultivation, cover crops, crop diversification, crop rotation, direct sowing, drystone wall, ecological focus area, environmental/ecological scheme or measure or programme or policy or management or practice or intervention or payments, extensification, fallow land, field margin, field tree, flower strip, flowering meadow, hedgerow, insect hotel, intercropping, landscape element, late mowing, low stocking density, non-harvest, no-till, permanent/herb-rich grassland or pasture, pollinator habitat, reduced field size, reduction of pesticides or herbicides or fungicides or fertilisers or chemical inputs, silvopastoralism, skylark window, waterlogging, wetland restoration, wildlife conservation* |

**Table 2** Search term adjustment for covering word variations, plurals, and grammatical forms

| Category | Search terms |
|---|---|
| Subjects | *((agricultur* OR farm*) AND (owner* OR producer* OR manager*)), *farm*, (land AND owner*), *peasant*, *rancher** |
| Determinants | *attitude*, aware*, belie*, concept*, conscious*, favo*, …* |
| Operations | *accept*, adapt*, adopt*, agree*, behav*, choose* OR chose* OR choice, …* |
| Targets | *agroforest*, …, "ecological focus area*", (*ecolog* OR *environment*) AND (intervention* OR management* OR measure* OR … OR scheme*), …* |

exclusion of studies, data collection, and identification of potential biases. Beyond this, an exemplary methodical approach can be derived from the detailed recommendations, which formed the basis of our review process.

## Systematic literature search

The initial literature search was conducted using the scientific databases Scopus and Web of Science (WoS) Core Collection, which generally cover most peer-reviewed academic publications. These sources offer the flexibility to accommodate a comprehensive string (approximately 880 words in this case), including various forms of interdependencies. Snowball sampling was used to add further relevant studies to the primary set. The formulation of search terms underwent an iterative process of testing terms based on both the knowledge from existing studies and assumptions, assessing the suitability of the records received, and making adjustments as necessary. The final set of search terms can be grouped into four categories (Table 1). While we acknowledge that the list of terms may not be exhaustive, it represents the refined state achieved after a series of fine-tuning steps.

In order to apply the terms independently of grammatical forms or word variations, they were converted into the format shown in Table 2. Expressions enclosed in quotation marks are requested as fixed phrases, while asterisks allow for flexible character combinations, including no characters. For certain terms, proximity to each other was considered during the search process, using the operators *W/n* or *PRE/n* in Scopus and *NEAR/n* in WoS. *W, PRE* and *NEAR* ensure that the respective terms remain within a maximum distance of *n* words from each other, with *PRE* additionally requiring the first term to precede the second. Finally, all search terms were merged into a single search string (see Fig. 5 in the Appendix), following the logic of *subject AND (determinant OR operation) AND target*. Within each category, terms were linked using the *OR* conjunction.

In formulating the search string, we aimed to strike a balance between comprehensively including relevant literature and avoiding an excessive number of results. This involved adjusting the terms for searches within titles, abstracts, and keywords, respectively. Additionally, we narrowed down the search within study abstracts by reducing the maximum distance between search terms, thereby significantly enhancing the accuracy of the retrieved records. The search string was extensively reviewed with fellow researchers who are engaged in the field. However, it was not subject to any pre-published protocol.

We decided to confine our search to studies with data collection from the year 2000 onwards, considering that agricultural policies, societal norms, and socio-economic conditions undergo constant change. We further restricted the search to documents written in either English or

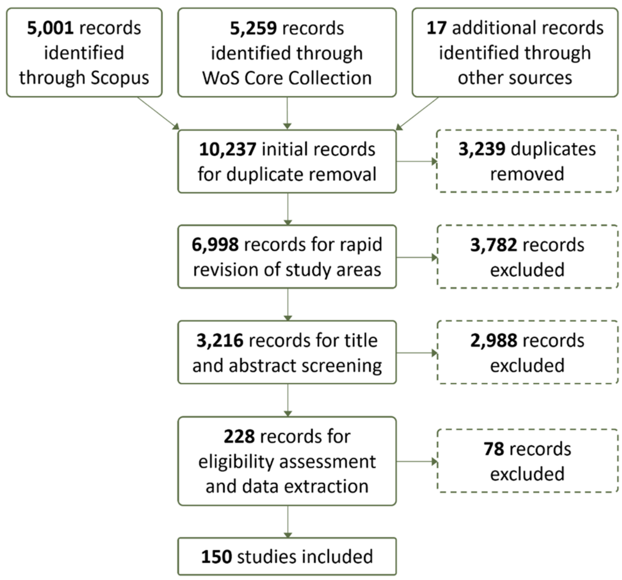



**Fig. 1** Identification, assessment, and selection process of relevant studies. *Source* Authors' compilation, based on the PRISMA scheme

German. The final literature search was executed in April 2022, yielding a total of 10,237 records, all of which were subsequently downloaded for further processing (see Fig. 1).

## Data analysis

Studies were considered for analysis if they met the following criteria: (1) the article was subjected to peer-review; (2) at least one study area is situated within Europe; (3) primary data were collected from farmers and farm decision makers, either through interviews or surveys conducted with them, or through panel data about them; (4) a link to biodiversity conservation is evident; and (5) the data collection had taken place after the year 2000.

Following the removal of duplicates, records were manually scanned for the study area (inclusion criterion 2). A total of 3,216 records remained for title screening (Fig. 1), wherein the focus was on the overall relevance of the topic and the link to biodiversity outcomes (criterion 4). Studies that were not excluded at the title screening stage were screened directly at the abstract level to verify inclusion criterion 3, and criterion 4 again. Finally, the publisher or journal was searched for confirmation of criterion 1. In case of doubt, articles were retained in the selection. The title and abstract screening procedures were conducted manually using CADIMA version 2.2.3 (Julius Kühn-Institut 2021), a software designed for systematic literature scanning. A subset of 10% was assessed by two researchers at each stage in order to ensure consistency in data selection.

## Data extraction

The remaining 228 articles were assessed at full-text level for their relevance to the first research question. At this stage, studies that did not meet criteria 2–4, but could not be decided based on the abstract, and studies that did not meet criterion 5 were excluded. As a result, a final selection of 150 studies, all in the English language, were retained for further analysis. The subsequent data analysis was divided into two main components.

The first part (descriptive statistics and spatial analysis) included a quantitative summary of the literature in terms of quantity, methods applied, sample sizes, and the locations of case studies. The geographical descriptions of study areas were translated into the basic regions of the Nomenclature of Territorial Units for Statistics (NUTS-2) (Eurostat 2021) as resolution. The spatial information was processed by using QGIS version 3.20 (QGIS Development Team 2021).

In the second part (synthesis of study findings), we extracted research findings to provide a broad overview of factors that influence farmers' adoption of BFFM. A sample (i.e. 10%) of selected studies was searched for relevant factors and coded accordingly. These codes were structured hierarchically into an initial set of codes, which was applied to the entire dataset and extended where necessary. The coded segments were then clustered, condensed, and structured through manual analysis of study findings and inductive category development. In contrast to a meta-analysis, the factors were not weighted in order to include studies with heterogeneous methodological approaches (see Xiao and Watson 2019). Instead, the factors were classified according to their direction of influence, i.e. whether they influence BFFM adoption positively or negatively.

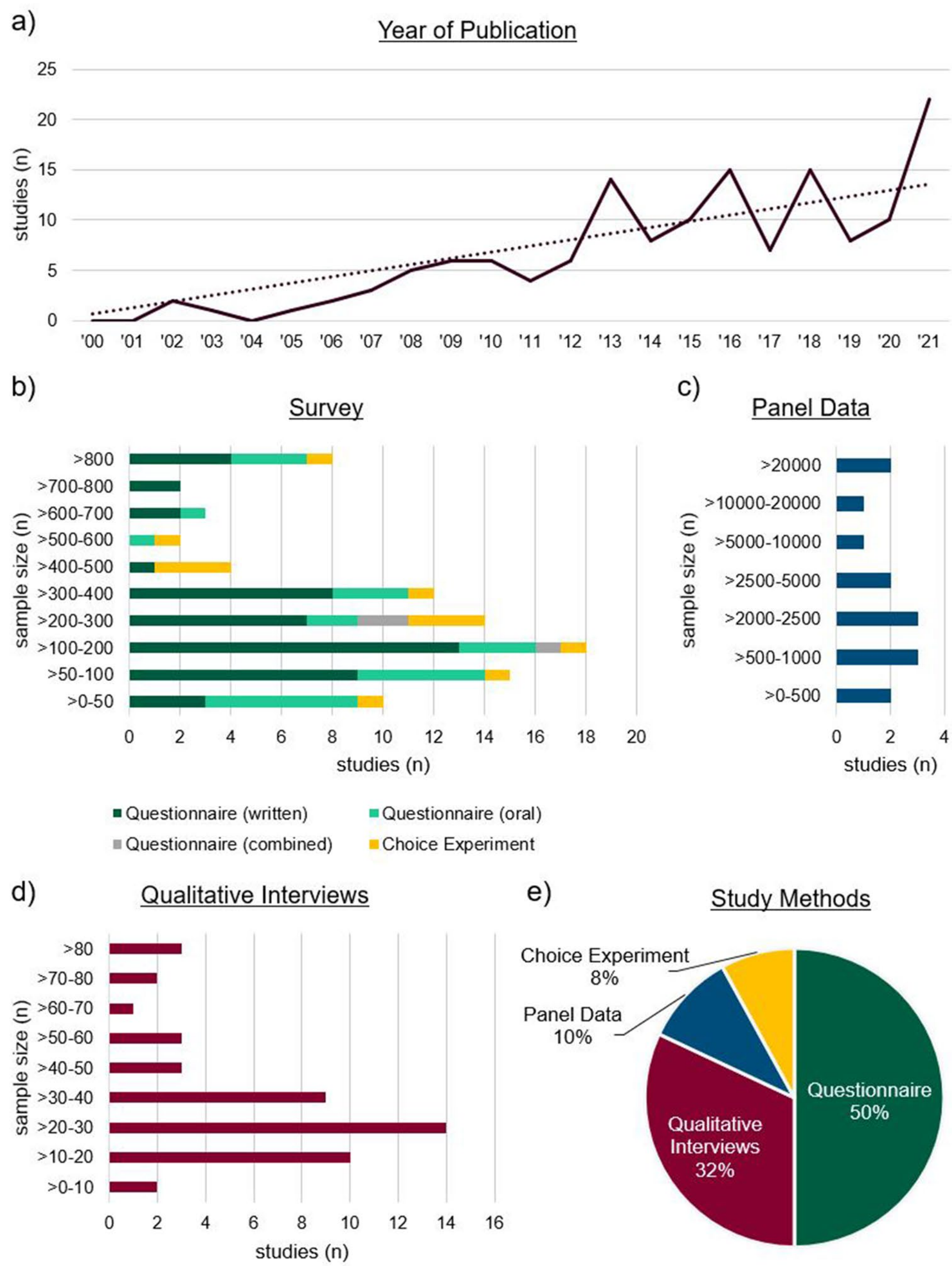
# Results

## Descriptive statistics and spatial analysis

Empirical scientific publications on the implementation of BFFM have displayed a noticeable upward trend since 2005 (Fig. 2a). The prevailing methods used in the literature corpus were surveys, including written and oral questionnaires, as well as choice experiments (Fig. 2b–e). Sample sizes varied widely, with an arithmetic mean of 329 and a median of 223 participants. As anticipated, qualitative interviews, employed in about one-third of the studies, had much smaller sample sizes (mean: 37, median: 25). Studies relying on panel data accounted for about 10% of total.

As shown in Table 3, the most frequent object of research was the general uptake of agri-environmental schemes

**Fig. 2** Year of publication, sample size, and methods used in the studies reviewed. N = 150 studies. *Source* Authors' analysis




(AESs) that directly or indirectly target biodiversity (26%), succeeded by the transition to organic farming (14%), and biodiversity conservation and habitat creation (10.7%). Several studies analysed the adoption of these practices within the framework of theoretical concepts, such as the theory of planned behavior (20), Bourdieu's theory of capital (5), and the self-determination theory of human motivations (2).

Figure 3 illustrates the spatial distribution of study areas at a NUTS-2 level. The map reveals an uneven coverage of European regions. Numerous empirical studies have been carried out in central and western Europe, especially in eastern and northern Germany, the Netherlands, Flanders (Belgium), Switzerland, England, and northern Italy. In contrast, vast areas of eastern and south-eastern Europe are clearly under-represented within the international academic literature. We could not find any relevant study for Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Iceland, Kosovo, Latvia, Lithuania, Luxembourg, Moldova, Montenegro, North Macedonia, Slovakia, and the Ukraine.

**Table 3** Object of research of the selected studies. *Source* Authors' analysis

| Category | Object | n | % |
|---|---|---|---|
| Schemes | AES general | 39 | 26.0 |
| | Collaborative AES | 9 | 6.0 |
| | Result-based AES | 5 | 3.3 |
| | AES without government support | 2 | 1.3 |
| | | 55 | 36.7 |
| General farming approach | Organic farming | 21 | 14.0 |
| | Sustainable technologies and practices | 13 | 8.7 |
| | Traditional extensive farming | 3 | 2.0 |
| | Agroecology | 3 | 2.0 |
| | | 40 | 26.7 |
| Specific measures | Biodiv. conservation and habitat creation | 16 | 10.7 |
| | Pesticide reduction | 10 | 6.7 |
| | Crop diversification and crop rotation | 7 | 4.7 |
| | Agroforestry | 6 | 4.0 |
| | Bird protection | 4 | 2.7 |
| | Conservation tillage/no-till | 4 | 2.7 |
| | Ecological Focus Areas, hedges, buffer strips, field margins | 4 | 2.7 |
| | Extensification | 3 | 2.0 |
| | Wetland recreation | 1 | 0.7 |
| | | 55 | 36.7 |
| $\Sigma$ | | 150 | 100 |

## Synthesis of study findings

The factors identified in the literature as influencing farmers' decisions regarding the adoption or non-adoption of BFFM are broadly divided into external influencing factors to which farmers are exposed (Table 4) and internal behavioural factors associated with the individual, such as personality traits, emotions, values, and experiences (Table 5). The external factors most frequently indicated as significant (quantitative methods) or important (qualitative methods) were the influence of neighbouring farmers (24 studies), societal pressures and demands (21), social networks (19), bureaucracy (19), flexibility in contracts and management (18), financial compensation (18), and financial benefits (17). Conversely, the most commonly disclosed individual/internal factors were attitudes towards the environment (19), age (17), experience with measures (16), perceived behavioural control (16), self-identity (16), and the perceived importance of landscape and nature conservation (15).

While Tables 4 and 5 provide a categorised overview of relevant factors, their causal and logical linkages are still vague. We have therefore systematised the categories presented in the tables along hierarchical levels according to the scale at which they affect farmers (Fig. 4). The following three subsections describe behavioural determinants along these levels: (1) society, community, and landscape, (2) farm, and (3) individual.

### Society, community, and landscape levels

At the society, community, and landscape levels, a multitude of factors play a role in shaping farmers' decisions regarding the adoption of BFFM. These factors can be categorised into several key areas: policies, societal and cultural influences, economic considerations and market dynamics, informational aspects, and regional conditions including the physical landscape. These factors affect the farmers' decisions externally.

Policies exert a significant impact on the adoption of BFFM, and the design of management contracts is pivotal within this realm. Incentive contracts, such as those for AECM, should have clear and consistent guidelines that are straightforward, easy to understand, and stable (Gütschow et al. 2021; Karali et al. 2014; Łuczka and Kalinowski 2020). Uptake increases when contracts are adapted to local conditions and farming practices. This is likely to be the case when policies are rooted in bottom-up initiatives or enable farmers to participate in the design process, ensuring that their knowledge and views are reflected in the policy.

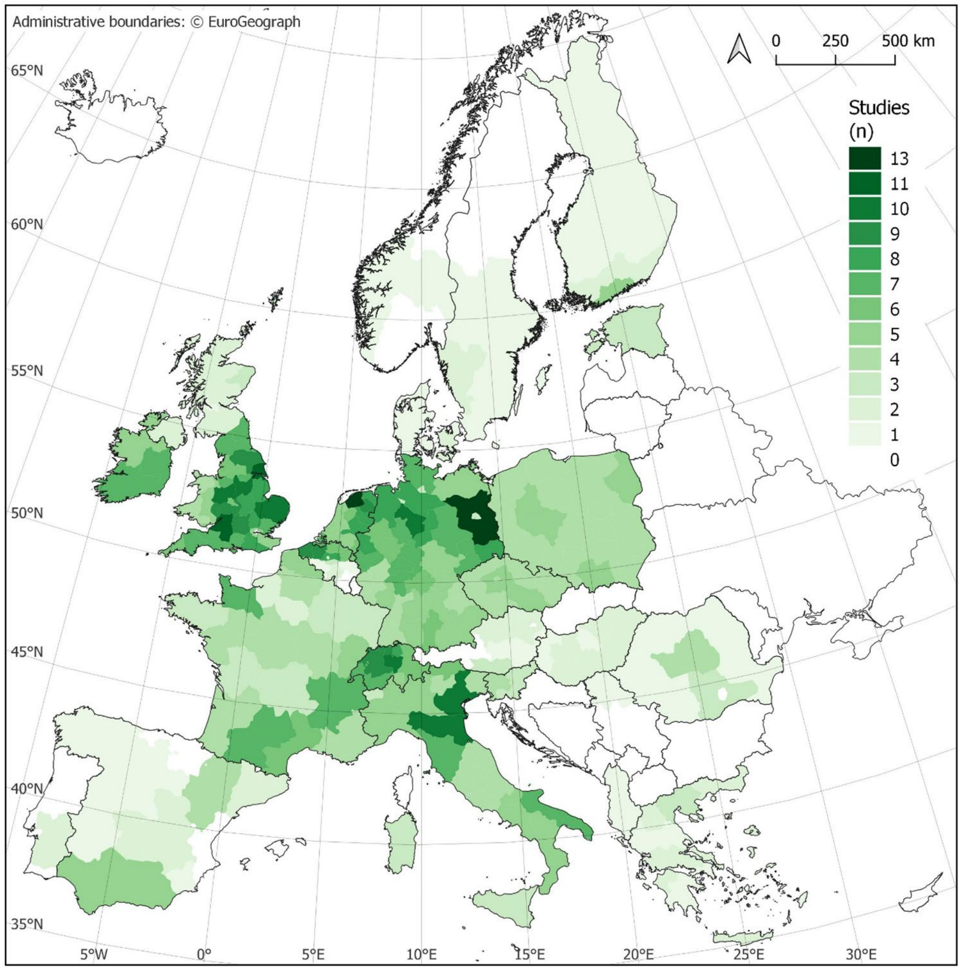



**Fig. 3** Spatial distribution of study areas of the articles reviewed based on NUTS-2 level regions. *Source* Authors' analysis

Adaptability to different agricultural practices could reduce the effort of policy implementation and associated transaction costs. This is critical, given the positive impact of low transaction costs on biodiversity management contract acceptance (Karali et al. 2014; Möhring and Finger 2022; Rois-Díaz et al. 2018; Sattler and Nagel 2010; Schneeberger et al. 2002; Schneider et al. 2010; Wezel et al. 2018, 2021). Unsurprisingly, higher workload and bureaucratic burdens are negatively correlated with measure adoption (see Table 4).

The uptake of BFFM can also be enhanced by increasing flexibility. Flexibility entails adjusting contracts, such as contract duration, or affording more adaptable management approaches, for example, by reducing restrictions on the minimum widths of measures and the choice of seed mixes in the case of field margins (Mante and Gerowitt 2009). A lack of flexibility in contracts and management options pose significant barriers to AECM uptake.

The influence of advisors on farmers is underscored by several studies. Farmers commonly seek guidance and support from a variety of sources, including policy representatives, farm advisors, scientists, technicians, and biodiversity advisors. Among these advisors, biodiversity advisors have been observed to have a strong positive effect on farmers' willingness to adopt BFFM (Gabel et al. 2018).

Farmers' decisions on whether or not to adopt BFFM are not made in isolation, but are embedded in a social context. Individual behaviour is influenced by societal norms, which are shaped by the socio-cultural environment and expressed through the social pressure "to adhere to the rules of the game" (Riley et al. 2018, p. 643), and embodied in the individual's habitus.[1] This pressure is, in turn, created by public opinion and concerns. Many farmers have to cope with these conditions in order to sell their products and secure societal acceptance. Depending on the context, societal pressures can push farmers in opposing directions, such as the perceived pressure to be productive (Home et al. 2018) versus the pressure to produce food to a high environmental standard (Cusworth 2020). The same applies to the traditions and customs

[1] Following the conceptualisation of Bourdieu (1977, p. 72), the habitus constitutes the historical framework that shapes individual actions and collective practices, reflecting the continuity of societal norms and behaviours through time.

**Table 4** External factors influencing farmers' adoption of BFFM. Column A: level referred to; Column B: category; Column C: subcategory; Column D: positive (+) or negative (−) influenceon adoption; Column E: sources; Column F: number of studies that substantiate the respective factor. *Source* Authors' analysis of n =150 stuties

| A | B | C | | D | E | F |
|---|---|---|---|---|---|---|
| Policy | Measure design | Contract features | Result-based | + | Fleury et al. (2015), Šumrada et al. (2022), Wezel et al. (2018) | 3 |
| | | | Participation and co-design | + | Busse et al. (2019), de Krom (2017), Giomi et al. (2018), Stupak et al. (2019) | 4 |
| | | | Clear, coherent guidelines | + | Gütschow et al. (2021), Karali et al. (2014) | 2 |
| | | | Complexity | − | Hannus and Sauer (2021a), Kociszewski et al. (2020) | 2 |
| | | | Stable laws and regulations | + | Gütschow et al. (2021), Karali et al. (2014), Łuczka and Kalinowski (2020) | 3 |
| | | | Sanctions and controls | − | de Vries et al. (2019), Karali et al. (2014) | 2 |
| | | | Direct payments | + | Fleury et al. (2015), Karali et al. (2014) | 2 |
| | | Flexibility in contracts and management | | + | Breustedt et al. (2013), Burton et al. (2008), Busse et al. (2019), Christensen et al. (2011), Coyne et al. (2021), Defrancesco et al. (2018), Espinosa-Goded et al. (2010), Franks and Emery (2013), Koesling et al. (2012), Kuhfuss et al. (2016a), Łuczka and Kalinowski (2020), Mante and Gerowitt (2009), Mazurek-Kusiak et al. (2021), Mettepenningen et al. (2013), Ruto and Garrod (2009), Schneeberger et al. (2002), Siepmann and Nicholas (2018), Wezel et al. (2018) | 18 |
| | | Contract duration | | + | Sardaro et al. (2016), Sutherland et al. (2013) | 2 |
| | | | | − | Karali et al. (2014), Ruto and Garrod (2009) | 2 |
| | | Adaptation to farming specificities | | + | Burton et al. (2008), Coyne et al. (2021), de Krom (2017), Fienitz (2018), Fleury et al. (2015), Guillem and Barnes (2013), Hannus and Sauer (2021a), Mante and Gerowitt (2009), van Herzele et al. (2013) | 9 |
| | | Additional effort for farmers | Transaction costs | − | Casagrande et al. (2016), Lakner et al. (2020), Lojka et al. (2022), Mante and Gerowitt (2009), Schneider et al. (2010), Theocharopoulos et al. (2012), van Herzele et al. (2013) | 7 |
| | | | Higher workload | − | Karali et al. (2014), Kociszewski et al. (2020), Möhring and Finger (2022), Rois-Díaz et al. (2018), Sattler and Nagel (2010); Schneeberger et al.(2002), Schneider et al. (2010), Wezel et al. (2018, 2021) | 9 |

**Table 4** (continued)

| A | B | C | | D | E | F |
|---|---|---|---|---|---|---|
| | | | Bureaucracy | − | Chèze et al. (2020), Coyne et al. (2021), Emery and Franks (2012), Fienitz (2018), Franks et al. (2016), Karali et al. (2014), Kociszewski et al. (2020), Lojka et al. (2022), Łuczka and Kalinowski (2020), Mante and Gerowitt (2009), Mazurek-Kusiak et al. (2021), Pavlis et al. (2016), Rois-Díaz et al. (2018), Ruto and Garrod (2009), Schneeberger et al. (2002), Schroeder et al. (2013), Siepmann and Nicholas (2018), van Herzele et al. (2013), Wezel et al. (2018) | 19 |
| | | | Ease of implementation | + | Bartulović and Kozorog 2014; Calvet et al. 2019; Defrancesco et al. 2008; Fleury et al. 2015; Hannus and Sauer 2021b; Mettepenningen et al. 2013; Sattler and Nagel 2010; Schneider et al. 2010 | 8 |
| | | Impact on other farming activities | | − | de Krom (2017), Karali et al. (2014), Lakner et al. (2020), Mante and Gerowitt (2009), Sattler and Nagel (2010) | 5 |
| | Policy interaction | Support and advice | | + | Franks et al. (2016), Franks and Emery (2013), Hannus and Sauer (2021a), Kuhfuss et al. (2016a), Lojka et al. (2022), Mazurek-Kusiak et al. (2021), Mills et al. (2017), Punzano et al. (2021), Schneeberger et al. (2002), Schroeder et al. (2013), Šumrada et al. (2022), Theocharopoulos et al. (2012), Wezel et al. (2018) | 13 |
| | | Influence of advisors | | ± | Bijttebier et al. (2018), Gabel et al. (2018), Mills et al. (2017) | 3 |
| Society and culture | Society | Societal norms | | ± | Burton et al. (2008), Cusworth (2020), Khamzina et al. (2021), Kuhfuss et al. (2016b), Mills et al. (2017), Riley et al. (2018), van Dijk et al. (2016), Westerink et al. (2021) | 8 |
| | | Societal pressures and demands | | ± | Banerjee et al. (2021), Busse et al. (2021), Cusworth (2020), de Krom (2017), de Vries et al. (2019), Donati et al. (2015), Fleury et al. (2015), Gatto et al. (2019), Hannus and Sauer (2021b), Home et al. (2018), Karali et al. (2014), Kociszewski et al. (2020), Kuhfuss et al. (2016b), Mills et al. (2017), Mzoughi (2011), Papadopoulos et al. (2018), Punzano et al.(2021), Schroeder et al. (2015), van Dijk et al. (2015), van Herzele et al. (2013), Westerink et al. (2021) | 21 |
| | Culture | Traditions, values, and beliefs | | ± | Babai et al. (2021), Bartulović and Kozorog (2014), Fleury et al. (2015), Hartel et al. (2017), Karali et al. (2014), Mills et al. (2017), Roellig et al. (2016), Rois-Díaz et al. (2018), Schoonhoven and Runhaar (2018) | 9 |

**Table 4** (continued)

| A | B | C | D | E | F |
|---|---|---|---|---|---|
| | Social environment | Social networks (integration, knowledge sharing, trust) | + | Alló et al. (2015), Babai et al. (2021), Barreiro-Hurlé et al. (2010), Capitanio et al. (2011), Casagrande et al. (2017), de Krom (2017), de Vries et al. (2019), Ducos et al. (2009), Guillem and Barnes (2013), Home et al. (2018), Mills et al. (2017), Punzano et al. (2021), Rois-Díaz et al. (2018), Siepmann and Nicholas (2018), Skaalsveen et al. (2020), Triste et al. (2018), Unay-Gailhard et al. (2015), van Dijk et al. (2016), Westerink et al. (2021) | 19 |
| | | Community (social pressures and norms) | ± | Läpple and Kelley (2013), van Herzele et al. (2013) | 2 |
| | | Cooperation (existing structures) | + | Barreiro-Hurlé et al. (2010), Capitanio et al. (2011), de Krom (2017), de Vries et al. (2019), Franks et al. (2016), van Dijk et al. (2016), Westerink et al. (2021) | 7 |
| | | Neighbouring farmers (influence, judgements, relationship) | ± | Alló et al. (2015), Babai et al. (2021), Bakker et al. (2021), Bonke and Musshoff (2020), Calvet et al. (2019), Cullen et al. (2020), Cusworth (2020), de Krom (2017), Defrancesco et al. (2008), Defrancesco et al. (2018), Despotović et al. (2019), Emery and Franks (2012), Fienitz (2018), Franks et al. (2016), Gatto et al. (2019), Hansson et al. (2012), Koesling et al. (2012), Kuhfuss et al. (2016b), Poltimäe and Peterson (2021), Punzano et al. (2021), Sereke et al. (2016), Sutherland et al. (2012), van Herzele et al. (2013), Westerink et al. (2021) | 24 |
| | | Family (influence, support) | ± | Mills et al. (2017), Schneeberger et al. (2002), Schroeder et al. (2015) | 3 |
| Economy | Financial incentives | Financial benefits | + | Barghusen et al. (2021), Breustedt et al. (2013), Fienitz (2018), Genghini et al. (2002), Graves et al. (2017), Hannus and Sauer (2021b), Home et al. (2014), Karali et al. (2014), Kociszewski et al. (2020), Kuhfuss et al. (2016a), Mills et al. (2017, 2018), Papadopoulos et al. (2018), Schoonhoven and Runhaar (2018), Wąs et al. (2021), Wezel et al. (2018), Wynne-Jones (2013) | 17 |
| | | Compensation | + | Busse et al. (2019), Busse et al. (2021), Christensen et al. (2011), de Krom (2017), Defrancesco et al. (2008), Granado-Díaz et al. (2022), Hansson et al. (2012), Karali et al. (2014), Łuczka and Kalinowski (2020), Malá and Malý (2013), Mante and Gerowitt (2009), Papadopoulos et al. (2018), Roellig et al. (2016), Schneeberger et al. (2002), Stobbelaar et al. (2009), Unay-Gailhard and Bojnec (2015), van Herzele et al. (2013), Wezel et al. (2021) | 18 |
| | | Economic viability | + | Bartulović and Kozorog (2014), Mills et al. (2018) | 2 |

**Table 4** (continued)

| A | B | C | | D | E | F |
|---|---|---|---|---|---|---|
| | Farm improvement | Input reduction | | + | Bartulović and Kozorog (2014), Bijttebier et al. (2018), Łuczka and Kalinowski (2020), Mzoughi (2011), Theocharopoulos et al. (2012), Wynne-Jones (2013) | 6 |
| | | Improved soil quality | | + | Casagrande et al. (2016), Guillem and Barnes (2013), Kathage et al. (2022), Lojka et al. (2022), Poltimäe and Peterson (2021) | 5 |
| | | Products | Higher quality | + | Giomi et al. (2018), Łuczka and Kalinowski (2020), Mazurek-Kusiak et al. (2021), Papadopoulos et al. (2018), Theocharopoulos et al. (2012), Wynne-Jones (2013) | 6 |
| | | | Additional products | + | Hartel et al. (2017), Rois-Díaz et al. (2018), Vuillot et al. (2016) | 3 |
| | | Economic risk reduction | | + | Mzoughi (2011), Pavlis et al. (2016) | 2 |
| | Markets | Access to markets | | + | Bonke and Musshoff (2020), Busse et al. (2021), Casagrande et al. (2017), Gütschow et al. (2021), Home et al. (2018), Kociszewski et al. (2020), Łuczka and Kalinowski (2020) | 7 |
| | | Market pressure | | − | Busse et al. (2021), Schoonhoven and Runhaar (2018) | 2 |
| | | Higher product prices | | + | Kociszewski et al. (2020), Łuczka and Kalinowski (2020), Theocharopoulos et al. (2012) | 3 |
| | | Opportunity costs (profitability of production-oriented practices) | | − | Bonke and Musshoff (2020), Borremans et al. (2016), Granado-Díaz et al. (2022), Kociszewski et al. (2020), Koesling et al. (2012), Łuczka and Kalinowski (2020), Punzano et al. (2021), Schneeberger et al. (2002), Theocharopoulos et al. (2012) | 9 |
| Information | Information | Access to information | | + | Casagrande et al. (2016), Karali et al. (2014), Marques et al. (2015), Pavlis et al. (2016), Toma and Mathijs (2007), Zhllima et al. (2021) | 6 |
| | | Sources of information | | ± | Dinis et al. (2015), Soini and Aakkula (2007), Sutherland et al. (2013 | 3 |
| | Uncertainty | Uncertainty of policy outcomes | | − | Łuczka and Kalinowski (2020), Schroeder et al. (2013), Wezel et al. (2018), Wynne-Jones (2013) | 4 |
| | | Production risks | | − | Bakker et al. (2021), Bonke et al. (2021), Chèze et al. (2020), Damalas (2021), Finger (2014), Lojka et al. (2022), Łuczka and Kalinowski (2020), Möhring and Finger (2022), Schneeberger et al. (2002) | 9 |
| Nature and region | Natural conditions | Biophysical conditions | | ± | Czajkowski et al. (2021), Dinis et al. (2015), Garini et al. (2017), Karali et al. (2014), Marques et al. (2015), Sattler and Nagel (2010) | 6 |
| | | Climate change | | ± | Babai et al. (2021), Bane et al. (2021) | 2 |
| | | Suitability for agriculture | Less favoured areas | + | Rois-Díaz et al. (2018), Russi et al. (2016), Wynne-Jones (2013), Zimmermann and Britz (2016) | 4 |
| | | | Mountain areas | + | Bartulović and Kozorog (2014), Borsotto et al. (2008), Capitanio et al. (2011) | 3 |

Table 4 (continued)

| A | B | C | | D | E | F |
|---|---|---|---|---|---|---|
| | Region | Geospatial regions | | ± | Bijttebier et al. (2018), Bonke et al. (2021), Dinis et al. (2015), Ducos et al. (2009), Espinosa-Goded et al. (2010), Kathage et al. (2022), Malá and Malý (2013), Pascucci et al. (2013), Pavlis et al. (2016), van Herzele et al. (2013) | 10 |
| | | Cultural regions | | ± | Pavlis et al. (2016), Rois-Díaz et al. (2018) | 2 |
| | | Proximity to protected areas | | + | Bartulović and Kozorog (2014), Schroeder et al. (2013) | 2 |
| Farm characteristics | farm features | Farm type | Grassland and livestock farming | + | Barreiro-Hurlé et al. (2010), Borsotto et al. (2008), Capitanio et al. (2011), Cullen et al. (2020), Defrancesco et al. (2008), Ducos et al. (2009), Peerlings and Polman (2009), Polman and Slangen (2008), Zimmermann and Britz (2016) | 9 |
| | | | Arable farming | − | Barroso and Pinto-Correia (2014), Lojka et al. (2022), Unay-Gailhard and Bojnec (2016) | 3 |
| | | | | + | Wossink and Wenum (2003) | 1 |
| | | | Permanent crops | − | Capitanio et al. (2011), Defrancesco et al. (2008), Genghini et al. (2002), Zimmermann and Britz (2016) | 4 |
| | | | Horticulture | − | Zimmermann and Britz (2016) | 1 |
| | | | Mixedfarming | + | Wąs et al. (2021) | 1 |
| | | Land ownership (not leased) | | + | Borremans et al. (2016), Borsotto et al. (2008), Karali et al. (2014), Lojka et al. (2022), Mante and Gerowitt (2009), Rois-Díaz et al. (2018), Schneeberger et al. (2002), Stupak et al. (2019), Zhllima et al. (2021) | 9 |
| | | Farm size | | + | Defrancesco et al. (2018), Dinis et al. (2015), Ducos et al. (2009), Murphy et al. (2014), Pavlis et al. (2016), Peerlings and Polman (2009), Poltimäe and Peterson (2021), Schroeder et al. (2013), Šumrada et al. (2022), Unay-Gailhard and Bojnec (2016), Zimmermann and Britz (2016) | 11 |
| | | | | − | Capitanio et al. (2011), Lojka et al. (2022), Malá and Malý (2013), Sardaro et al. (2016) | 4 |
| | | Land fragmentation | | + | Sardaro et al. (2016), van Herzele et al. (2013) | 2 |
| | | Field characteristics | High productivity | − | Borsotto et al. (2008), Hansson et al. (2012), Hynes and Garvey (2009), Rois-Díaz et al. (2018), Russi et al. (2016) | 5 |
| | | | Marginal, small parcels, slope | + | Lakner et al. (2020), Rois-Díaz et al. (2018), van Herzele et al. (2013) | 3 |

**Table 4** (continued)

| A | B | C | | D | E | F |
|---|---|---|---|---|---|---|
| | Farm management | Farming style | Degree of intensification | − | Breustedt et al. (2013), Ducos et al. (2009), Finger and El Benni (2013), Genghini et al. (2002), Granado-Díaz et al. (2022), Hynes and Garvey (2009), Murphy et al. (2014), Sardaro et al. (2016), Schmitzberger et al. (2005), Zimmermann and Britz (2016) | 10 |
| | | | Diversification | + | Barroso and Pinto-Correia (2014), Genghini et al. (2002) | 2 |
| | | | Organic farming | + | Borsotto et al. (2008), Casagrande et al. (2017) | 2 |
| | | Farm succession | Presence of a successor | + | Karali et al. (2014), Schneeberger et al. (2002) | 2 |
| | | | | − | Granado-Díaz et al. (2022) | 1 |
| | | | Family farm | + | Defrancesco et al. (2018), Ingram et al. (2013) | 2 |
| | | Impact of the measure | Expected negative influence on farm production | − | Chèze et al. (2020), Franks et al. (2016), Mante and Gerowitt (2009), Marques et al. (2015), Mazurek-Kusiak et al. (2021), Mills et al. (2018), Möhring and Finger (2022), Punzano et al. (2021), Sattler and Nagel (2010), Wynne-Jones (2013) | 10 |
| | | | Compatibility with farming system and development plan | + | Borsotto et al. (2008), Calvet et al. (2019), Coyne et al.(2021), Ingram et al. (2013), Mills et al. (2018) | 5 |
| | | | Availability of suitable machinery and technology | + | Bijttebier et al. (2018), Casagrande et al. (2016), Casagrande et al. (2017), Garini et al. (2017), Graves et al. (2017), Łuczka and Kalinowski (2020), Mante and Gerowitt (2009), Möhring and Finger (2022), Schneider et al. (2010) | 9 |
| | Finances | Income | Gross margin and household income | − | Barreiro-Hurlé et al. (2010), Defrancesco et al. (2008), Murphy et al. (2014), Sardaro et al. (2016), Wąs et al. (2021) | 5 |
| | | | | + | Borsotto et al. (2008) | 1 |
| | | | Off-farm income | + | Barroso and Pinto-Correia (2014), Chèze et al. (2020), Defrancesco et al. (2008), Granado-Díaz et al. (2022), Karali et al. (2014), Peerlings and Polman (2009), Wossink and Wenum (2003) | 7 |
| | Labour | Hours of work on the farm | | + | Murphy et al. (2014), Pavlis et al. (2016) | 2 |
| | | Family labour | | + | Calatrava Leyva et al. (2007), Dinis et al. (2015), Wąs et al. (2021) | 3 |
| | | Labour force and labour productivity | | + | Casagrande et al. (2017), Kathage et al. (2022), Malá and Malý (2013) | 3 |

**Table 5** Internal factors influencing farmers' adoption of BFFM. Column A: level referred to; Column B: category; Column C: subcategory; Column D: positive (+) or negative (−) influence on adoption; Column E: sources; Column F: number of studies that substantiate the respective factor. *Source* Authors' analysis of n =150 studies

| A | B | C | | D | E | F |
|---|---|---|---|---|---|---|
| Individual characteristics of farmers | Individual attributes | Age | | − | Barroso and Pinto-Correia (2014), Bonke et al. (2021), Calatrava Leyva et al. (2007), Capitanio et al. (2011), Defrancesco et al. (2018), Ducos et al. (2009), Hynes and Garvey (2009), Malá and Malý (2013), Murphy et al. (2014), Pavlis et al. (2016), Peerlings and Polman (2009), Rois-Díaz et al. (2018), Sardaro et al. (2016), Schroeder et al. (2013), Šumrada et al. (2022), Toma and Mathijs (2007), Zimmermann and Britz (2016) | 17 |
| | | Gender (female) | | + | Defrancesco et al. (2008), Dinis et al. (2015), Malá and Malý (2013), Sardaro et al. (2016) | 4 |
| | | Health | Health condition | + | Hounsome et al. (2006), Karali et al. (2014) | 2 |
| | | | Health concerns | + | Garini et al. (2017), Kociszewski et al. (2020), Kubala et al. (2008), Petrescu-Mag et al. (2019) | 4 |
| | | Skills and knowledge | | + | Home etal. (2018), Lojka et al. (2022), Marques et al.(2015), Menozzi et al. (2015), Mills et al. (2017), Pavlis et al. (2016), Power et al. (2013), Punzano et al. (2021), Rois-Díaz et al. (2018), Schneeberger et al. (2002), Schoonhoven and Runhaar (2018), Soini and Aakkula (2007), Šumrada et al. (2022), Theocharopoulos et al. (2012) | 14 |
| | | Education | | + | Barreiro-Hurlé et al. (2010), Barroso and Pinto-Correia (2014), Calvet et al. (2019), Ducos et al. (2009), Hevia et al. (2021), Mack et al. (2020), Pavlis et al. (2016), Peerlings and Polman (2009), Zhllima et al. (2021) | 9 |
| | | | | − | Defrancesco et al. (2008), Sardaro et al. (2016) | 2 |
| | | Ideology and agenda | Production | − | Busse et al. (2021), Lakner et al. (2020), Lojka et al. (2022), Schmitzberger et al. (2005) | 4 |
| | | | Sustainability | + | Siepmann and Nicholas (2018), Stobbelaar et al. (2009), Theocharopoulos et al. (2012), Triste et al. (2018) | 4 |
| | | | Independency | − | Burton et al. (2008), Emery and Franks (2012), Mills et al. (2017) | 3 |
| | | | Job satisfaction | + | Kociszewski et al. (2020), Sattler and Nagel (2010) | 2 |
| | | Risk aversion | | − | Bonke et al. (2021), Karali et al. (2014), Mante and Gerowitt (2009), Möhring and Finger (2022) | 4 |
| | Perception of biodiversity-friendly farming measures | Positive attitudes towards the measure | | + | Bonke and Musshoff (2020), Donati et al. (2015), Ducos et al. (2009), Josefsson et al. (2017), Lokhorst et al. (2011), Polman and Slangen (2008), van Dijk et al. (2015, 2016), Wauters et al. (2010), Wauters et al. (2016) | 10 |

**Table 5** (continued)

| A | B | C | | D | E | F |
|---|---|---|---|---|---|---|
| | | Perceived environmental effectiveness | | + | Bonke and Musshoff (2020), Calvet et al. (2019), Fienitz (2018), Franks et al. (2016), Guillem and Barnes (2013), Hansson et al. (2012), Home et al. (2014), Karali et al. (2014), Mante and Gerowitt (2009), Mettepenningen et al. (2013), Möhring and Finger (2022), Sattler and Nagel (2010), Siepmann and Nicholas (2018), Stupak et al. (2019) | 14 |
| | | Previous experience with similar measures | | + | Bonke et al. (2021), Breustedt et al. (2013), Busse et al. (2019), Cusworth (2020), Defrancesco et al. (2008), Defrancesco et al. (2018), Dinis et al. (2015), Home et al. (2014), Lakner et al. (2020), Mante and Gerowitt (2009), Menozzi et al. (2015), Punzano et al. (2021), Schroeder et al. (2013), Unay-Gailhard et al. (2015), Westerink et al. (2021), Wossink and Wenum (2003) | 16 |
| | | Perceived behavioural control | | + | Bakker et al. (2021), Bonke and Musshoff (2020), Damalas (2021), Despotović et al. (2019), Fienitz (2018), Josefsson et al. (2017), Khamzina et al. (2021), Läpple and Kelley (2013), Lojka et al. (2022), Lokhorst et al. (2011), Lokhorst et al. (2014), Menozzi et al. (2015), van Dijk et al. (2015, 2016), Wauters et al.(2016), Zhllima et al. (2021) | 16 |
| Social positioning | Identity | Self-identity | | ± | Burton et al. (2008), Busse et al. (2019), Cullen et al. (2020), de Krom (2017), Hartel et al. (2017), Home et al. (2014), Josefsson et al. (2017), Lokhorst et al. (2011), Łuczka and Kalinowski (2020), Mills et al. (2017), Stobbelaar et al. (2009), van Dijk et al. (2015), van Herzele et al. (2013), Wauters et al. (2016), Westerink et al. (2021), Wynne-Jones (2013) | 16 |
| | | Being a 'good' farmer | In terms of production | − | Burton et al. (2008), Busse et al. (2021), de Krom (2017), Mills et al. (2017), Schneider et al. (2010), Westerink et al. (2021) | 6 |
| | | | In terms of environmental performance | + | Cusworth (2020), Westerink et al. (2021) | 2 |
| | | | measure visibility and gain of social prestige | + | Burton et al. (2008), Karali et al. (2014), Kociszewski et al. (2020), Riley et al. (2018) | 4 |
| | Social norms | Perception and adoption of social norms | | ± | Bonke and Musshoff (2020), Donati et al. (2015), Home et al. (2014), Lokhorst et al. (2011), Mills et al. (2017), Mzoughi (2011), van Dijk et al. (2016) | 7 |
| | | Moral norms | Productivism | − | Home et al. (2018), Mills et al. (2017) | 2 |
| | | | Concern for future generations | + | Fleury et al. (2015), Mills et al. (2017, 2018), Sattler and Nagel (2010), Schoonhoven and Runhaar (2018), Stobbelaar et al. (2009) | 6 |
| | | | Measure as legitimacy to produce | + | de Krom (2017), de Vries et al. (2019), Mzoughi (2011), Sattler and Nagel (2010) | 4 |

**Table 5** (continued)

| A | B | C | | D | E | F |
|---|---|---|---|---|---|---|
| | | | Moral obligation and cultural heritage | + | Barghusen et al. (2021), Davies and Hodge (2006), Fleury et al. (2015), Garini et al. (2017), Hansson et al. (2012), Hartel et al. (2017), Menozzi et al. (2015), Mills et al. (2017, 2018), Roellig et al. (2016), van Herzele et al. (2013), Vuillot et al. (2016), Wauters et al. (2016) | 13 |
| | | | Preserving the family farm | + | Bartulović and Kozorog (2014), Bouttes et al. (2019) | 2 |
| | | Trust in institutions | | + | Busse et al. (2019), Calvet et al. (2019), de Vries et al. (2019), Ducos et al. (2009), Fienitz (2018), Peerlings and Polman (2009), Sutherland et al. (2013) | 7 |
| Environmental perceptions | Perception of nature | Attitudes towards the environ-ment | Pro-environmental attitudes | + | Barreiro-Hurlé et al. (2010), Capdevila (2020), Defrancesco et al. (2018), Ducos et al. (2009), Fleury et al. (2015),Granado-Díaz et al. (2022), Guillem and Barnes (2013), Karali et al. (2014), Kubala et al. (2008), Kuhfuss et al. (2016b), Lokhorst et al. (2014), Mills et al. (2017), Papadopoulos et al. (2018), Poltimäe and Peterson (2021), Power et al. (2013), Russi et al. (2016), Stobbelaar et al. (2009), Wossink and Wenum (2003), Zhllima et al. (2021) | 19 |
| | | | Environmental concerns | + | Bakker et al. (2021), Barghusen et al. (2021), Best (2010), Hevia et al. (2021), Łuczka and Kalinowski (2020), Mills et al. (2018), Poltimäe and Peterson (2021) | 7 |
| | | Knowledge of nature and biodiversity | | + | Burton et al. (2008), Czajkowski et al. (2021), Hansson et al. (2012), Schoonhoven and Runhaar (2018), Stupak et al. (2019), Toma and Mathijs (2007) | 6 |
| | | Perceived importance of landscape and nature conservation | | + | Bartulović and Kozorog (2014), Birge and Herzon (2014), Chèze et al. (2020), Giomi et al. (2018), Karali et al. (2014), Kociszewski et al. (2020), Mazurek-Kusiak et al. (2021), Mzoughi (2011), Rois-Díaz et al. (2018), Sereke et al. (2016), Stobbelaar et al. (2009), Theocharopoulos et al. (2012), van Herzele et al. (2013), Wezel et al. (2018), Zhllima et al. (2021) | 15 |
| | | Perceived threats from nature | | ± | Bijttebier et al. (2018), Casagrande et al. (2016), Emery and Franks (2012), Franks et al. (2016), Mante and Gerowitt (2009), Mills et al. (2018), Möhring and Finger (2022), Schneeberger et al. (2002), Schneider et al. (2010), Stupak et al. (2019), Toma and Mathijs (2007), Wossink and Wenum (2003), Zhang et al. (2018) | 13 |

**Table 5** (continued)

| A | B | C | | D | E | F |
|---|---|---|---|---|---|---|
| | Perception of the landscape | Landscape as an indicator of production skills | | – | Burton et al. (2008), Burton (2012), de Krom (2017), Schneider et al. (2010), Westerink et al. (2021) | 5 |
| | | Aesthetic preferences | General importance of aesthetics | ± | Burton (2012), Busse et al. (2019), Lojka et al. (2022), Rois-Díaz et al. (2018), Soini and Aakkula (2007), Stobbelaar et al. (2009), Wynne-Jones (2013) | 7 |
| | | | Landscape elements | + | Garini et al. (2017), Hartel et al. (2017), Lojka et al. (2022), Stobbelaar et al. (2009), van Herzele et al. (2013) | 5 |
| | | | 'tidy' landscape | – | Bijttebier et al. (2018), Burton (2012), Graves et al. (2017), Schneider et al. (2010) | 4 |

of previous generations, which may be in harmony or at odds with biodiversity conservation objectives. However, there has been an increase in environmental awareness and a change in consumption patterns across Europe throughout the last years and decades (Kociszewski et al. 2020), leading to positive feedback and the social recognition of BFFM. Social rewards contribute to satisfying the need for recognition in the community and society (Fleury et al. 2015; Hannus and Sauer 2021b) and to a higher job satisfaction (Karali et al. 2014), and as such are strong incentives for farmers. By implementing BFFM, farmers feel empowered to counter the negative public perception attached to agriculture, promoting a positive image of farming to the local community and the public (Busse et al. 2021; de Krom 2017).

The implementation of BFFM is generally more likely if farmers succeed in building up bridging social capital,[2] i.e. ties across socio-cultural divisions and different social fields, by gaining recognition for their agri-environmental work from other regional actors (de Krom 2017). The farmers' integration into social networks generally has a positive effect on measure adoption. This holds true for both farming networks (Capitanio et al. 2011; Casagrande et al. 2017; de Vries et al. 2019) and environmental associations that exert peer pressure on their members to adapt (van Dijk et al. 2016). The importance of social relationships, however, goes beyond professional networks. It refers more broadly to the positive effect of the general connectedness of farmers with other actors in their area (e.g., Capitanio et al. 2011; de Krom 2017; Triste et al. 2018), based on knowledge exchange (Casagrande et al. 2017) and, subsequently, reduced transaction costs arising from uncertainty about measure implications (Barreiro-Hurlé et al. 2010). Accordingly, BFFM adoption is negatively affected by isolation from social networks and other farmers (Capitanio et al. 2011; Home et al. 2018; Mills et al. 2017).

Farmers tend to be concerned about their reputation among neighbours and the appreciation of farming practices by neighbouring farmers, valuing their opinions and experiences (Defrancesco et al. 2008; Despotović et al. 2019; Sereke et al. 2016). Positive relationships with neighbours who have experiences with BFFM encourage adoption. Moreover, farmers often compare their own fields with those of others, creating a network of social control (Westerink et al. 2021). However, there is evidence that this peer pressure incites farmers "to maintain their AES land tidy" and "consider it their responsibility to forestall negative impacts

[2] Social capital is referred to as "the aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition—or in other words, to membership in a group—which provides each of its members with the backing of the collectively-owned capital, a 'credential' which entitles them to credit, in the various senses of the word" (Bourdieu 1986, 248f.).

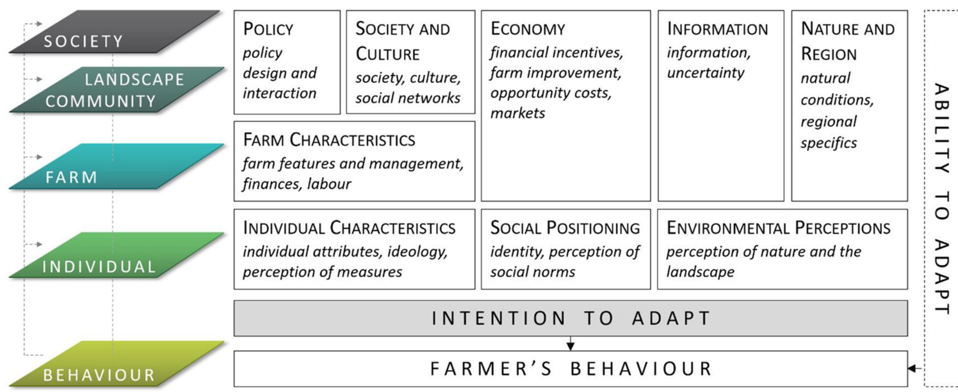



**Fig. 4** Multilevel framework of factors influencing farmers' decisions to implement BFFM. *Source* Authors' compilation, based on n = 150 studies

of their AES land on the agricultural productivity of neighbouring farms" (de Krom 2017, p. 356).

Economic, informational, natural, and regional factors also belong to the macro level, but reach down to the farm level. Economic incentives are important drivers for participation in biodiversity-oriented farming programmes. The level of financial compensation and the anticipated benefits have a profound impact on adoption decisions. The higher the prospective remuneration, the greater the willingness to participate. Payments, beyond covering expenses and opportunity costs, contribute to profit maximisation, farm viability, and reduced economic risks (Table 4). Participation could further increase marginal returns by reducing inputs, such as fuel, fertilisers, and pesticides (Bartulović and Kozorog 2014; Bijttebier et al. 2018; Łuczka and Kalinowski 2020; Mzoughi 2011; Theocharopoulos et al. 2012; Wynne-Jones 2013), and providing additional opportunities to earn higher incomes by improving product quality or serving niche markets (Giomi et al. 2018; Hartel et al. 2017; Łuczka and Kalinowski 2020; Mazurek-Kusiak et al. 2021; Papadopoulos et al. 2018; Rois-Díaz et al. 2018; Theocharopoulos et al. 2012; Vuillot et al. 2016; Wynne-Jones 2013). The compatibility of payment levels with specific site conditions and farm specialisation presents a particular challenge, especially for intensive horticultural production characterised by high revenue per hectare. If expected opportunity costs far exceed compensation, measures are unlikely to be accepted (e.g., Bonke and Musshoff 2020; Borsotto et al. 2008; Granado-Díaz et al. 2022; Hansson et al. 2012).

While local, regional, and specialised markets offer potential for biodiversity-related niche products, many farmers contend in international markets, intensifying production pressures. These pressures is particularly strong regarding the farmers' main crops (Busse et al. 2021). Decisions to introduce new crops depend on access to market infrastructure and viable value chains. Exemplarily, the cultivation of alternative flowering and pollinator-attracting crops, such as alfalfa, sunflowers, or faba beans, is often limited by the access to crop-specific markets (Busse et al. 2021).

The risks associated with implementing new BFFM strategies closely tie to information availability. A lack of, or limited access to, relevant and comprehensible information creates uncertainty, which reduces the willingness to adopt these measures (Casagrande et al. 2016; Karali et al. 2014; Marques et al. 2015; Pavlis et al. 2016; Toma and Mathijs 2007; Zhllima et al. 2021). The same applies to information originating from sources that are perceived as untrustworthy (Sutherland et al. 2013).

The category of regional factors includes diverse dimensions of regions, such as administrative and cultural regions, landscapes, or natural regions with their biophysical conditions. The latter are mainly related to climate, water availability, topography, vegetation, and regional soil conditions. Farmers in mountainous regions (Bartulović and Kozorog 2014; Borsotto et al. 2008; Capitanio et al. 2011) or those cultivating marginal land or land that is relatively unfavourable for agricultural purposes tend to display greater willingness to engage in schemes rewarding BFFM (Rois-Díaz et al. 2018; Russi et al. 2016; Wynne-Jones 2013; Zhllima et al. 2021). This can be attributed to the generally lower opportunity costs. Thus, regional disparities in adoption rates reflect differences in natural conditions, but also in political, socio-economic, and cultural environments. In essence, explanatory determinants such as socio-cultural factors are highly dependent on the region (Rois-Díaz et al. 2018), which is reflected in spatial patterns of land use practices.

## Farm level

The farm level covers those factors pertaining to the farm as a distinct business entity. Among these aspects, farm type has received considerable attention. Grassland and livestock farms show notably higher rates of BFFM adoption than other farm types, whereas farms engaged in vegetable or permanent crop cultivation show rather low adoption rates (Capitanio et al. 2011; Defrancesco et al. 2008; Genghini et al. 2002; Zimmermann and Britz 2016). Whether arable farming is positively or negatively correlated with measure implementation could not be clearly established due to conflicting results.

Another extensively studied yet ambiguous factor is farm size. Some studies have found larger farms to be more likely to implement BFFM (Defrancesco et al. 2018; Dinis et al. 2015; Ducos et al. 2009; Murphy et al. 2014; Pavlis et al. 2016; Peerlings and Polman 2009; Poltimäe and Peterson 2021; Schroeder et al. 2013; Šumrada et al. 2022; Unay-Gailhard and Bojnec 2016; Zimmermann and Britz 2016), while others propose the opposite (Capitanio et al. 2011; Lojka et al. 2022; Malá and Malý 2013; Sardaro et al. 2016). This heterogeneity could be influenced by regional discrepancies in the average farm size (Lastra-Bravo et al. 2015) and the resources available in terms of finance, land, and labour. The high level of fixed transaction costs of biodiversity schemes, for example, may explain the lower uptake rates among the smallest farms (Ducos et al. 2009), especially when suitable machinery and technology are not available and have to be purchased.

Field characteristics also play a role in BFFM adoption. BFFM are more commonly applied on parcels with low agricultural productivity due to factors such as low soil quality or steep slopes, resulting in low opportunity costs. These measures are perceived as an interesting option for marginal or highly fragmented plots, as well as other sites with unfavourable conditions, such as shaded plots near woodland, wet soils along streams, or poorly accessible corners (van Herzele et al. 2013). Again, this can be explained by the low opportunity costs associated with such sites.

Furthermore, farms that are managed at a high degree of intensification show low rates of BFFM adoption. Conversely, farmers of extensive, diversified farms or organic farmers tend to be far more willing to implement BFFM (e.g., Borsotto et al. 2008; Casagrande et al. 2017), with the latter potentially linked to farming orientation or identity. Measure acceptance is also higher among family-owned farms producing primarily on owned land as opposed to rented land, as well as among farmers benefiting from additional off-farm income (Table 4).

### Individual level

The majority of the articles reviewed (n = 118) point to the importance of individual factors in explaining farmers' decisions whether to implement BFFM. Almost all studies that included age as a variable found younger farmers to be more likely to adopt measures than their older peers. However, age per se is not a plausible causal factor. Some studies have, for example, discovered a positive influence of farmers' good health, which is often related to age. Mettepenningen et al. (2013) noted an increase in the likelihood of engagement in schemes up to the age of 42, followed by a decline, as young farmers are often resource-constrained and older farmers are more reluctant to introduce new practices. Furthermore, female farmers are more likely to participate than their male colleagues, indicating underlying gender differences in attitudes and perceptions (Defrancesco et al. 2008; Dinis et al. 2015; Malá and Malý 2013; Sardaro et al. 2016).

Research consistently highlights the positive influence of general and agricultural education levels on the adoption of BFFM. This relationship may be elucidated by an enhanced understanding of the implications and requirements associated with specific agricultural measures (Barreiro-Hurlé et al. 2010). Indeed, farming competencies and technical knowledge exert a positive impact on the adoption of BFFM. Previous experience with AESs tends to further improve uptake rates. Farmers acquire skills and often positively change their attitudes towards the schemes during their participation, which, in turn, lowers the threshold for subsequent participation (Cusworth 2020; Westerink et al. 2021). Education, skills, and experience increase their perceived behavioural control (self-efficacy), i.e. farmers' perceived own capability to carry out the measure properly, which, along with the perceived environmental effectiveness of the measures, is an important factor for their implementation (Table 5).

Various factors determining the adoption of BFFM relate to different aspects of intrinsic motivation. These are shaped by an individual's farming philosophy (Mills et al. 2017), religious or holistic vision of life (Stobbelaar et al. 2009), and perception of social norms (Mills et al. 2017). Productivist worldviews, often expressed as the 'need to feed the world', essentially reduce the willingness to accommodate biodiversity on one's own land (Home et al. 2018; Mills et al. 2018). Alternatively, for some farmers, the integration of environmentally sustainable measures serves to legitimise their agricultural production, granting them a 'social license to produce' (de Krom 2017). Injunctive social norms include perceived moral obligations to produce food or to conserve farmland, the environment, and the cultural heritage of the landscape, as observed in the case of terraces in Italy (Garini et al. 2017) or traditional wood pastures in Romania (Hartel et al. 2017) and Estonia (Roellig et al. 2016). Farmers who identifying as 'custodians' preserving the land for future generations or those who perceive biodiversity and nature conservation as a moral obligation towards their families or society have stronger motivations to care for their natural environment and the species that inhabit it. This sentiment is reinforced if a farmer attributes accountability for environmental problems to agriculture (Karali et al. 2014; van Herzele et al. 2013; Zhllima et al. 2021).

Farmers' self-identity as a behavioural factor has been linked to the concept of a 'good farmer', which describes processes of social recognition. In order to be recognised as competent by peers, farmers adhere to perceived 'rules of the game'. Violations may be socially sanctioned in form of public blame or social isolation, resulting in a loss of social and cultural capital (Cusworth 2020). Multiple studies underline that farmers are concerned with maintaining their image as a 'good farmer' (Burton et al. 2008; Busse et al. 2021; Cusworth 2020; de Krom 2017; Karali et al. 2014; Kociszewski et al. 2020; Mills et al. 2017; Riley et al. 2018; Schneider et al. 2010; Westerink et al. 2021). This concept's connotations are profoundly contextual, with European agricultural discourse historically dominated by a narrative of high productivity and economic efficiency that stems from the ethos of minimising waste and maximising production (Burton et al. 2008), which negatively affects farmers' intentions to adopt conservation measures. Nevertheless, doing the job well increasingly implies a commitment to the responsibility towards biodiversity and society (Westerink et al. 2021), resulting in a more diverse picture in which a "good farmer is mindful of the intersection of proper business and environmental management and is skilful […] and knowledgeable […] to manage their farm in a way to not effect unnecessary or problematic environmental damage" (Cusworth 2020, p. 169). In this sense, higher environmental standards are endorsed by social norms, leading to a greater acceptance of BFFM.

Farmers' perceptions of biodiversity and nature in general, as well as positive attitudes towards and concern for the environment in particular are significant determinants of the adoption of conservation practices. A strong correlation emerges between a farmer's sense of connection to nature and their willingness to preserve it (Lokhorst et al. 2014). Similarly, knowledge of nature and biodiversity (Czajkowski et al. 2021; Stupak et al. 2019), an understanding of ecosystems (Burton et al. 2008; Schoonhoven and Runhaar 2018), and awareness of environmental problems (Toma and Mathijs 2007) positively influence the adoption of BFFM. In contrast, perceived risks from nature reduce the willingness to implement BFFM. Taking weed and pest control as an example, BFFM can be perceived as boosting or reducing the number of harmful organisms. Associating near-natural conditions with higher pest occurrence can dramatically lower farmers' willingness to promote such conditions (Chèze et al. 2020; Schneeberger et al. 2002) and lead to high pesticide use (Zhang et al. 2018). Biodiversity might be viewed as disorderly (Burton 2012) and as an outcome of poor agricultural practices (de Krom 2017; Westerink et al. 2021). Conversely, when biodiversity and agricultural production are not seen as mutually exclusive (de Krom 2017; Stupak et al. 2019) and when biodiversity is acknowledged for its potential contributions to pest control (Mills et al. 2018), a more integrated, positive notion of biodiversity and farming may emerge. High levels of biodiversity can even be associated with skilled farm work (Westerink et al. 2021), nudging farmers to demonstrate their respective ability.

The visibility of farming outcomes within the agricultural landscape holds significance for farmers as they represent their skills (Burton 2012; Westerink et al. 2021), particularly in the vicinity of their main farm or homestead (Riley et al. 2018). Accordingly, aesthetic preferences have been found to be strong behavioural drivers for farmers. Landscape elements, such as trees (Hartel et al. 2017; Lojka et al. 2022; Stobbelaar et al. 2009) or hedges (van Herzele et al. 2013), and flowers (Stobbelaar et al. 2009; van Herzele et al. 2013) are commonly perceived as aesthetically pleasing by both society and farmers. However, across regional and cultural boundaries, farmers—especially those with a strong production focus—tend to prefer 'tidy' landscapes (Burton 2012; Westerink et al. 2021), which is why they often describe ploughed, empty fields as visually appealing (Bijttebier et al. 2018; Schneider et al. 2010). Many farmers strive for regular, symmetrical plots with straight lines, an even, dense, and healthy crop, no weeds, and no stagnant water (Burton 2012; de Krom 2017; Schneider et al. 2010; Westerink et al. 2021). Such conditions are associated with efficiency and are classified as indicators of high yields. From this perspective, conservation practices are seen as 'messy', irregular, disorganised, and improperly managed (Burton et al. 2008; Schneider et al. 2010). Furthermore, the effects of tractor work, for example, are visible and easy to evaluate, whereas an increase in biodiversity is less tangible and, therefore, seems less suitable for demonstrating farming skills (Burton 2012). Shared perceptions of desirable agricultural landscapes lead to social pressure because farmers judge each other based on production efficiency indicators and, in this sense, gain or lose social and symbolic capital. These conditions appear to significantly reduce farmers' willingness to adopt BFFM on their fields.

### Barriers and obstacles

Farmers' intentions are a necessary but not sufficient condition for the implementation of BFFM. In particular, a lack of knowledge, advice, and information, or of technical capacity are critical barriers to measure adoption that are relevant beyond the farmers' intentions (Bonke and Musshoff 2020; Casagrande et al. 2016; Mills et al. 2017). Geographical location, landscape, and environmental conditions also limit the scope for action (Karali et al. 2014). Potential barriers that limit farmers' ability and prevent them from actually implementing BFFM exist at all levels.

## Discussion

### Systematising the complexity of farmers' biodiversity management decisions

Our study confirms that there are complex decision-making processes at the core of on-farm biodiversity management, potentially influenced by multiple factors on a continuum of levels. Farmers' decisions are not solely driven by economic reasoning, and simplistic concepts, such as the 'Homo economicus', fall short in explaining their behaviour. This observation aligns with those of previous reviews (Ahnström et al. 2008; Bartkowski and Bartke 2018; Brown et al. 2021; Dessart et al. 2019; Siebert et al. 2006). While economic considerations do exert significant influence on farmers' willingness to adopt BFFM, intrinsic values and motivations, such as positive attitudes and a strong sense of responsibility towards the natural environment, can hold equal (Barghusen et al. 2021) or even greater importance for farmers (Banerjee et al. 2021; Birge and Herzon 2014; Casagrande et al. 2016; Davies and Hodge 2006; Papadopoulos et al. 2018; Rois-Díaz et al. 2018; Sattler and Nagel 2010; Sereke et al. 2016; Stobbelaar et al. 2009; Theocharopoulos et al. 2012; Toma and Mathijs 2007; van Dijk et al. 2016). From a different angle, Burton et al. argue that "if financial loss is compensated by agri-environmental payments but new land uses and activities are unable to generate symbolic capital [i.e. resources that evoke social recognition], then the net result could be that farmers lose significant amounts of capital despite apparently generous financial compensation" (2008, p. 21). Frameworks that account for the variety of factors influencing decision-making are needed to address these complexities.

In this review, we have disaggregated determinants underlying the farmers' decisions concerning BFFM adoption and structured the numerous influencing factors identified in empirical studies based on their operational levels. Organising behavioural processes in a multilevel framework is an established approach to contextualise internal and external factors along an individual–structural spectrum (Boulet et al. 2021; Kaufman et al. 2014). Within multilevel frameworks, it is implicit that levels are nested within each other and interconnected (Fischer et al. 2005; Kaufman et al. 2014; Mathieu and Chen 2011). This enables a multilevel framework to clearly display influences on decision-making and provides a better comprehension of the relationship between the meta, meso, and micro levels and individual behaviour (Boulet et al. 2021; Fischer et al. 2005; Penner et al. 2005).

External information reaches down to the internal level, at which it undergoes a cognitive process of evaluation and judgement, and influences the farmers' willingness to adopt BFFM. However, this influence is not unidirectional but reciprocal, as indicated by the arrows in Fig. 4. Farmers have an impact on external factors related to themselves, for instance, by changing their farming system or renting new fields, but to also their communities, for example, by influencing and judging neighbouring farmers. We suppose that the closer a factor is to the individual level, the greater the potential for the farmer to influence it. While our framework indicates the 'distance' of a factor based on its proximity to the individual level and the farmer's behaviour, Schoonhoven and Runhaar (2018) emphasise this aspect by describing the farmer as an acting individual within a 'direct context', which encompasses everyday interactions with family, neighbours, or peers, and a 'distal context', including actors and factors beyond the farmer's sphere of influence. Using similar wording but a different logic, Dessart et al. (2019) classify behavioural factors along a proximal–distal spectrum according to their 'distance' from the decision situations. They categorise distal factors as independent of the specific decision, such as personality, motivations, values, and beliefs, whereas proximal factors are decision-specific, such as the expected costs and risks of adopting the practice or perceived behavioural control.

In our study, we took a multilevel perspective. While there's a substantial overlap across the spectrum from large to small scale, our focus diverges from identifying factors within the farmer's reach more towards examining steering possibilities, i.e. differentiating the scales at which diverse policy strategies should be directed. Our approach shares similarities with Mills et al. (2017), who operationalised behavioural determinants encompassing willingness to adopt, farmer engagement (in terms of interaction with advice and support networks), and the ability to adopt, categorised across society, community, and farm levels. Runhaar et al. (2017) propose four conditions necessary for integrating nature conservation into farming practices: the presence of demand, farmer motivation, farmer ability concerning resources and skills, and the legitimisation of practices through governmental regulations or social norms. Merging and extending these ideas, Westerink et al. (2020) integrated the ability aspect from both selected frameworks, combining willingness (Mills et al. 2017) and motivation (Runhaar et al. 2017), and incorporating farmer engagement (Mills et al. 2017) into demand and legitimation (Runhaar et al. 2017). The authors highlight the interconnectedness of motivation and ability, noting that high motivation can enhance farmers' ability, while a lack of ability can be demotivating. In contrast, hindering factors that influence farmers' motivation form part of the thematic categories in our framework, whereas ability refers specifically to factors beyond farmers' direct and situational control, or as stated by Dessart et al. (2019), only distal factors. These factors can either facilitate or prevent the implementation of BFFM, regardless of farmers' motivations.

Our multilevel framework contributes to scientific discussions by introducing a comprehensive approach to dissect the adoption of biodiversity-friendly farming practices. The expansive range of data within this framework, encompassing societal, community, farm, and individual levels, facilitates a holistic analysis of the multifaceted influences on farmers' decisions. By considering a variety of factors, the framework offers insight into the complex interaction among different elements underlying the uptake of BFFM. This inclusive perspective enables exploration of the heterogeneous conditions that influence agricultural choices and their broader implications.

## Policy implications at different levels

The purpose of this paper is to present the results of the systematic review in a structure that is linked to policy interventions from a farmers' decision perspective. While refraining from explicit policy recommendations, our study offers valuable insights for policy formulation related to BFFM. These insights can serve as reference points, for which a multilevel framework is considered a helpful tool (Fischer et al. 2005).

Earlier studies have underscored the importance of understanding external influences and internal behavioural factors in policy development (Dessart et al. 2019; Mills et al. 2017). Our aggregated findings contribute to this understanding, shedding light on themes and determinants across different scales. The results hold potential in informing biodiversity management and governance processes, acknowledging that, despite general variations in governance levels, specific interventions can exert a significant influence across diverse scales and on multiple aspects. In this way, the multilevel framework aids in depicting impact paths for individual interventions or policy mixes, while also revealing the complementarity and coherence of different governance approaches across various levels.

Policy strategies at the *societal level* encompass various approaches, such as targeting supply chains to stimulate sustainable food demand and engaging consumers in biodiversity-conscious consumption (e.g., Langen et al. 2022). Another example are public education and information campaigns that rely on narratives highlighting the contributions farmers make to biodiversity conservation. This perspective underscores the necessity for agricultural policy to extend beyond the farming sector and encompass society at large. To cascade supply chain interventions, enhancing direct marketing opportunities to foster regional demand and establishing market infrastructure for biodiversity-friendly produced commodities shifts the emphasis towards conditions at the *community level*. Correspondingly, initiatives aiming to facilitate stakeholder cooperation, promote knowledge exchange, or offer peer advice in BFFM implementation should be customised to suit the specific target community (Mills et al. 2017).

While distinct from societal and community levels, the *landscape level* is still important to consider, defining the requirements and objectives for BFFM policies in relation to environmental and geophysical conditions. Collaborative schemes, for example, can generate a sufficiently dense and connected pattern of BFFM or green infrastructure, such as landscape features. Farmers are closely connected to the landscape in which they farm, which is particularly true for traditionalists, who identify strongly with traditional rural culture and have very different motivations compared to yield optimisers (Schmitzberger et al. 2005). Traditionalists, similar to idealists, are most likely to be found in mountainous and marginalised areas (Schmitzberger et al. 2005), which our results show to have a significant influence on the adoption of BFFM. This example illustrates the importance of regional landscape conditions to be considered in policy-making.

Tailoring policy to each individual farm is neither intended nor likely, but there is a need for offering a broad portfolio of flexible measures that address heterogeneous farming styles at the *farm level* (van der Ploeg and Ventura 2014) and to target groups with shared characteristics at the *individual level* (Pedersen et al. 2020). Although separating these two levels is useful to accentuate the 'distance' to farmers in terms of external/internal decision factors, many strategies applied at a farm level, such as on-farm advice, rely on the individual level. Recognising the diversity of farm-specific and individual factors is important for the development of instruments that start from the intention to 'nudge' farmers towards voluntary BFFM and aim at long-term behaviour change by promoting the internalisation of values underlying biodiversity-friendly farm management, such as altruistic values (Mills et al. 2017). Stimulating intrinsic motivation, for example, by appealing to traditional values and moral responsibility or by instilling a sense of pride in one's biodiversity achievements, is particularly relevant for policies that require high levels of farmer commitment (e.g., schemes for creating habitats that take a long time to establish, such as wetlands), or a certain level of expertise (e.g., result-based schemes that build on farmers' skills in identifying and monitoring specific target species and relating this outcome to the management actions taken).

One strategy for 'nudging' farmers and communicating values is personal advice. Our review results indicate that farmers' knowledge of both the measures and of nature and biodiversity is positively correlated with their motivation for BFFM adoption. Therefore, advice on measures should offer practical guidance on implementation and information on their contribution to biodiversity. This guidance should be tailored to the farming system, encompassing farmers' knowledge, skills, attitudes, motivations, and abilities. It should also draw upon knowledge of regional species, structures, geophysical conditions, and landscape dynamics. Additionally, direct collaboration between farmers and biodiversity advisors holds great potential for integrating local knowledge systems through knowledge co-creation, aiming to develop regionally adapted policies to address system challenges (Utter et al. 2021).

In a practical application, the framework could support policy makers in formulating regional biodiversity management strategies. Through direct engagement with farmers, they could apply the framework to explore case-specific potential influences that affect farmers' decision-making. Policy actors could, for instance, assess farmers' awareness of biodiversity-friendly practices, their attitudes towards such practices, and the motivations guiding their decisions. Furthermore, an examination of farmers' perceptions of external factors, including social norms and market structures, could provide valuable insights. Employing such a strategy would allow farmers' perspectives to be captured, enabling policy actors to identify the most salient and influential factors operating in the specific regional context. By using the framework in this way, they would be better equipped to refine their strategies in line with practical considerations. This targeted approach would recognise the different challenges faced by farmers and help to tailor proposed biodiversity management strategies to the unique circumstances of the region. Such localised adaptation processes could improve the prospects of successfully promoting the adoption of BFFM.

## Scope and limitations of the review

Many of this study's findings confirm or complement those of previous reviews, most of which cover a wider range of sustainable agricultural practices (Table 6). However, certain unique features stand out. We identified a comprehensive set of determinants of BFFM in European agricultural landscapes by concentrating exclusively on studies related to the provision or preservation of biodiversity by European farmers. This entailed an extensive survey of literature across multiple scientific disciplines, including agronomy, agricultural and behavioural economics, behavioural and social psychology, human geography, political science, and sociology. While several other investigations centre on system understanding of conditions (Runhaar et al. 2017) or behavioural determinants (Dessart et al. 2019; Mills et al. 2017; Schoonhoven and Runhaar 2018; Westerink et al. 2020), we contribute to the existing literature by extensively gathering and synthesising available evidence to delineate a comprehensive overview and underscore the diverse range of factors that can influence a single decision. Additionally, we integrated a methodological component by incorporating an assessment of spatial distribution on NUTS-2 level regions into the systematic review.

The multilevel framework approach implies the need to consider regional disparities beyond factors assigned to the 'nature and region' category. The prevalence of factors at the societal, community, or landscape scale suggests that

**Table 6** Overview of selected literature reviews on farmers' decisions for environmentally sustainable farming practices (2010-present) compared to the current study. *Source* Authors' compilation

| | Topic | Focus | t | n | Region | Scientific databases | R |
|---|---|---|---|---|---|---|---|
| Bartkowski and Bartke (2018) | Soil governance instruments | Decision-making | –2017 | 87 | Europe (w/o RU) | WoS | x |
| Brown et al. (2021) | Environ. payments | Decision-making | 2007–2019 | 241 | EU, CH, NO | WoS Core Collection | x |
| Burton (2014) | Environ. behaviour | Farmer demographics | n.s | 53 | countries with "advanced economies" | JSTOR, Scopus, WoS | |
| Dessart et al. (2019) | Environ. sustain. practices | Decision-making | 1999–2019 | n.s | "relatively developed" countries | n.s | |
| Foguesatto et al. (2020) | Environ. sustain. practices | Decision-making | 2007–2018 | 63 | worldwide | AgEcon Search, Scopus, WoS, *(Google Scholar)* | x |
| Lastra-Bravo et al. (2015) | AES (EU) | Decision-making | 2000–2013 | 10 | EU | Scopus, WoS | x |
| Mozzato et al. (2018) | Environ. sustain. practices | Decision-making | 1995–2018 | 108 | worldwide | Scopus, WoS, *(Google Scholar)* | |
| Tyllianakis and Martin-Ortega (2021) | AES (EU) | WTA compensation | n.s | 20 | EU | WoS, *(Google Scholar)* | x |
| Klebl et al. (2023) (current study) | Biodiversity-friendly practices | Decision-making | 2000–2022 | 150 | Europe (w/o RU) | Scopus, WoS Core Collection | x |

*t* time range of publication years covered by the studies reviewed, *n* number of studies included in the review analysis, *R* replicability of literature search and selection methods in the sense of a systematic literature review, *n.s.* not specified, *WTA* willingness to accept many of these determinants rely on the corresponding society, landscape, or community for their existence. This has to be taken into account when interpreting the results, given that the underlying data do not cover the whole of Europe, which could bias the results.

Although the methods were carried out cautiously, the approach applied still involves risks of bias, primarily stemming from the limitation to two databases, an incomplete search string, language constraints, and the exclusion of grey literature. The first two concerns have been addressed earlier, the third is due to language barriers, albeit constituting a minor bias as English and German articles accounted for 98% of the publications available in European languages. The fourth bias emerged from a decision to prioritise the scientific soundness of the results included. Under such circumstances, there is a possibility that studies oriented towards regional and non-academic audiences, yet relevant to our subject, had been neglected.

Similar to many preceding reviews, we have refrained from weighting the factors due to the wide methodical spectrum of the reviewed studies, including both quantitative and qualitative approaches. This diversity, combined with the predominant focus of most studies on either specific measures or environmentally sustainable practices in general, complicates the comparison of motivations for measures targeting biodiversity with those aimed at other environmental aspects or ecosystem services. Thus, our review could neither provide evidence on the relative weight of factors nor on disparities in attitudes and perceptions towards measures targeting different environmental outcomes. We therefore encourage future research into potential asymmetries in farmers' attitudes, motivations, and perceptions regarding different pro-environmental measures. Emphasis should also be placed on empirical studies in regions under-represented in research on BFFM adoption decisions, in order to rectify the uneven regional coverage of study areas across Europe and to draw a more balanced picture.

## Conclusions

The objectives of this review paper were to present a structured set of decision factors underlying the farmers' on-farm biodiversity management and to identify potential spatial imbalances in scientific evidence on BFFM adoption. Previous literature reviews have provided valuable insights into farmers' decisions to adopt environmentally sustainable practices. We add to the scientific literature with a consolidated and comprehensive set of drivers specific to biodiversity-friendly farm management in European agricultural landscapes, an aspect not systematically reviewed before.

Our results show that the farmers' decisions regarding BFFM adoption are the outcome of complex and interrelated decision-making processes. Factors influencing these decisions range from global societal scales to the intrinsic values, beliefs, and motives of individuals. Building on the findings of the literature review, we have synthesised the behavioural factors identified into a structured framework along five distinct levels in order to disentangle complexity and to provide a systematic access to the existing scientific knowledge of the last two decades in Europe.

The framework contributes to existing research by linking the fragmented evidence on BFFM adoption, while revealing interfaces with other concepts. Furthermore, it delineates thematic intervention objectives at various levels, providing guidance for deriving potential policy interventions aimed at promoting BFFM. As the success of landscape-integrated incentives for biodiversity management through policy and regional strategies depends strongly on a deeper and more systematic understanding of farmers' implementation decisions, the framework proves its strengths in offering an integrated systems perspective and navigating existing evidence. It can therefore serve as a reference for informing biodiversity management and governance processes.

Many behavioural factors influencing farmers, including societal norms and pressures, culture, social environment, opportunity costs, natural conditions, and farm characteristics, vary across regional contexts. European policies face these heterogeneous conditions, as do regional or local implementation strategies for biodiversity-friendly agriculture. Yet, the disparity in the spatial distribution of research studies across different regions, particularly if not balanced by other ways of gathering data, such as monitoring for policy evaluation, raises the question of whether the specific challenges related to biodiversity management in agricultural landscapes are being adequately addressed in scientific and political debates, and ultimately, in policy-making.

A suitable means of adapting policies to local circumstances is to identify links between regional landscape elements or traditional features of high biodiversity value (e.g., stone walls, wood pastures, hedgerows), farmers' motivations and skills, local knowledge, and modern management opportunities. Relating to people's connections to their land, thereby reinforcing positive attitudes towards biodiversity and a sense of moral obligation to conserve the natural environment, could become part of such place-based and context-sensitive strategies, and would offer a promising field for integrated action research.

## Appendix

See Fig. 5.

**TITLE**((*farm* OR *peasant* OR *rancher* OR (land AND owner*) OR ((agricultur* OR farm*) AND (owner* OR producer* OR manager*))) **AND** (attitude* OR aware* OR belie* OR concept* OR conscious* OR favo* OR feeling* OR identit* OR imag* OR intent* OR judg* OR knowledge OR *like* OR mindset* OR motiv* OR notion* OR opinion* OR perceive* OR percept* OR position* OR prefer* OR recogni* OR sensibilit* OR thought* OR understand* OR view* OR willing* **OR** accept* OR adapt* OR adopt* OR agree* OR behav* OR choice OR choose*S OR chose* OR compromi* OR cooperat* OR decide* OR decision* OR engage* OR participat* OR refus* OR resist* OR reject* OR commit* OR select* OR uptake OR "take* up") **AND** (((*environment* OR *ecolog*) AND (scheme* OR measure* OR program* OR polic* OR management* OR *practice* OR intervention* OR payment*)) OR biodivers* OR ((conservation OR ecol* OR bio* OR organic) AND (measure* OR agriculture* OR farm* OR cultivat*)) OR "ecological focus area*" OR (*flower* AND (strip* OR meadow*)) OR hedgerow* OR "field margin*" OR non-harvest* OR "dry stone wall*" OR (landscape AND element*) OR (field AND tree*) OR ((reduc* OR low* OR less OR no OR restrict*) AND (pesticide* OR herbicide* OR fungicide* OR fertili* OR *chemic*)) OR no-till* OR "no till*" OR "conservat* till*" OR "direct sow*" OR "cover crop*" OR "crop diversification" OR fallow OR ((buffer OR grass) AND (zone* OR strip*)) OR "crop rotation*" OR intercrop* OR agroforest* OR silvopastor* OR extensiv* OR ((permanent OR herb* OR *flower*) AND (grass* OR pastur*)) OR ((less OR reduc* OR low*) AND (stock* OR dens*)) OR ((delay* OR late*) AND mow*) OR (wetland* AND (*creat* OR rewet* OR restor*)) OR "water log*" OR (reduc* AND field* AND size*) OR (small* AND field*) OR ((nest* OR breed* OR insect* OR pollinator* OR bee* OR bat* OR bird* OR skylark* OR *beetle* OR animal* OR wildlife) AND (box* OR hotel* OR shelter* OR refuge* OR plot* OR window* OR bank* OR habitat* OR protect* OR conserv*))) AND NOT aquacultur* AND NOT fish*) OR

**ABS**((*farmer* OR *peasant* OR *rancher*) **W/8** (attitude* OR aware* OR belie* OR conscious* OR favo* OR feeling* OR judg* OR motiv* OR perceive* OR percept* OR prefer* **OR** behav* OR ((why OR reason* OR willing* OR like* OR decision* OR decide* OR choose* OR chose* OR choice* OR intend* OR intention OR rational* OR position* OR refuse* OR dislike* OR reject* OR commit* OR deny) W/8 (adopt* OR participat* OR engage* OR cooperat* OR transform* OR agree* OR accept* OR uptake OR "take* up" OR adapt* OR adopt* OR apply))) **AND** (((*environment* OR *ecolog*) PRE/3 (scheme* OR measure* OR program* OR *practice* OR intervention* OR payment*)) OR biodivers* OR ((conservation OR ecol* OR bio* OR organic OR extensive*) PRE/3 (measure* OR agriculture* OR farm* OR cultivat*)) OR "ecological focus area*" OR ((flower* OR wildflower*) W/2 (strip* OR meadow*)) OR hedgerow* OR ((field) W/3 (margin*)) OR non-harvest* OR "dry stone wall*" OR "landscape element*" OR ((field) W/3 (tree*)) OR ((reduc* OR low* OR less OR no OR restrict*) W/6 (pesticide* OR herbicide* OR fungicide* OR fertili* OR *chemic*)) OR no-till* OR "no till*" OR "conservat* till*" OR ((direct*) W/2 (sow*)) OR "cover crop*" OR "crop diversification" OR fallow OR ((buffer OR grass) PRE/0 (zone* OR strip*)) OR "crop rotation*" OR intercrop* OR agroforest* OR silvopastor* OR ((permanent OR herb* OR flower* OR wildflower*) W/8 (grass* OR pastur*)) OR ((less OR reduc* OR low*) W/3 (stock* OR dens*)) OR ((delay* OR late*) W/2 (mow*)) OR ((wetland*) W/3 (*creat* OR rewet* OR restor*)) OR "water log*" OR ((reduc*) W/3 (field*) W/3 (size*)) OR ((small*) W/3 (field*)) OR ((nest* OR breed* OR insect* OR pollinator* OR bee* OR bat* OR bird* OR skylark* OR *beetle* OR animal* OR wildlife) W/2 (box* OR hotel* OR shelter* OR refuge* OR plot* OR window* OR bank* OR habitat* OR protect* OR conserv*))) AND NOT aquacultur* AND NOT fish*) OR

**KEY**((*farmer* OR *peasant* OR *rancher*) **AND** (attitude* OR awareness OR belief* OR motivation OR perception* **OR** acceptance OR behav* OR willingness OR reject* OR commit*) **AND** (((*environment* OR *ecolog*) PRE/0 (scheme* OR measure* OR program* OR *practice* OR intervention* OR payment*)) OR biodivers* OR ((conservation OR ecol* OR bio* OR organic) PRE/0 (measure* OR agriculture* OR farm* OR cultivat*)) OR "ecological focus area*" OR ((*flower*) PRE/0 (strip* OR meadow*)) OR hedgerow* OR ((field) W PRE/0 (margin*)) OR non-harvest* OR "dry stone wall*" OR "landscape element*" OR ((field) PRE/0 (tree*)) OR ((reduc* OR low* OR less OR no OR restrict*) W/0 (pesticide* OR herbicide* OR fungicide* OR fertili* OR *chemic*)) OR no-till* OR "no till*" OR "conservat* till*" OR "direct sow*" OR "cover crop*" OR "crop diversification" OR fallow OR ((buffer OR grass) PRE/0 (zone* OR strip*)) OR "crop rotation*" OR intercrop* OR agroforest* OR silvopastor* OR extensive* OR ((permanent OR herb* OR *flower*) PRE/0 (grass* OR pastur*)) OR ((delay* OR late*) PRE/0 (mow*)) OR "wetland creation" OR rewet* OR "water log*" OR (reduc* AND field* AND size*) OR ((small*) W/0 (field*)) OR ((nest* OR breed* OR insect* OR pollinator* OR bee* OR bat* OR bird* OR skylark* OR *beetle* OR animal* OR wildlife) PRE/0 (box* OR hotel* OR shelter* OR refuge* OR plot* OR window* OR bank* OR habitat* OR protect* OR conserv*))) AND NOT aquacultur* AND NOT fish*) AND

PUBYEAR > 1999 AND (LIMIT-TO (LANGUAGE, "English") OR LIMIT-TO (LANGUAGE, "German"))

**Fig. 5** Full search string for Scopus

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