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Farmers' adoption of organic agriculture—a systematic global literature review

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Abstract

Policymakers worldwide set ambitious targets to increase the share of organic farming. We conduct a global, systematic literature review to synthesise evidence on the adoption of organic farming and support policymakers and food-value chain actors in reaching policy goals. First, we map the existing research and identify substantial gaps regarding the research focus, methodology and geographical coverage. Second, using a conceptual framework of the farmers' adoption process, we provide an overview of evidence-based recommendations to scale organic adoption. Finally, using regression analysis, we show that especially the organic market maturity and the level of agricultural productivity matter for the type of recommended measures.

Keywords: organic agriculture, adoption, global, systematic review, policy

JEL classification: Q10, Q12, Q15, Q18

1. Introduction

Policy goals for increasing the share of organic farming have been set in many countries around the world (Meredith, Lampkin and Schmid, 2018;

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Hysa *et al.*, 2022).[1] The EU (by 2030) and Japan (by 2050) have for example set policy goals for a 25 per cent share of organic production in agriculture, and some EU Member States like Germany, Austria or Sweden even aim at achieving 30 per cent by 2030 (e.g. Schebesta and Candel, 2020; Fujibayashi, 2021; Lampkin and Sanders, 2022). However, progress on these targets is slow despite substantial efforts,[2] pathways to reaching those policy goals are unclear and a systematic overview of evidence-based recommendations from the scientific literature for designing supporting policies and programmes is missing. An important research question therefore is which policy measures (or policy mixes) have been identified as effective and efficient for increasing the share of organic farming in the scientific literature. Moreover, we have in the past observed large differences in the adoption rates of organic farming across countries and crops (Willer, Schlatter and Trávníček, 2023) and in the response of adoption rates to policies (Rees, Grovermann and Finger, 2023). Systematically identifying relevant institutional-, environmental- and socio-economic contexts for choosing and adapting measures to increase the share of organic farming is thus key to support policymakers and food-value chain actors' strategic decision-making in this area.

In this study, we conduct a global systematic literature review based on 183 policy recommendations from 120 studies. We (i) identify important research gaps in terms of geographic, production system and methodological scope and make recommendations for future research to fill these gaps, (ii) synthesise recommendations for policymakers and food-value chain actors from literature using a conceptual framework of the farmer adoption process and (iii) use regression analysis to assess important context specific characteristics for the choice of measures supporting the adoption of organic farming.

Different terms for increasing or broadening the adoption of innovations in agriculture have been used in literature. We here follow Wigboldus *et al.* (2016) and use the general term 'scaling' to describe an increase in the share of (organic) adoption. Further, research into organic farming is mostly divided in supply- and demand-side oriented approaches (e.g. Merel, Qin and Sexton, 2023). While the former focuses on farmer decision-making, determining the supply of organic products to markets, the latter focuses on consumers choices and preferences, determining the demand for organic products. We here specifically focus on improving our understanding of the farmer decision-making process and its implications for the design of policies and programmes to scale up organic farming. We account for integrated supply- and demand-side studies and make suggestions for future research in this direction.

1 While expanding organic farming is a widespread policy objective, other pathways could also contribute to increasing the sustainability of agricultural production, such as (labelling of) extensive, pesticide free or other biodiversity-friendly production systems (e.g. Tscharntke *et al.*, 2015; Möhring and Finger, 2022).

2 For example, support payments for conversion to and maintenance of organic farming and the adoption of National Action Plans in Europe (e.g. Rees, Grovermann and Finger, 2023; Lampkin and Sanders, 2022).

There is a broad and growing literature on the adoption and diffusion of innovative practices and technologies in agriculture (e.g. Sunding and Zilberman, 2001; Long, Blok and Coninx, 2016), with early studies originating in sociology (Rogers, 2003). The abundance of studies reflects the importance of innovations for agricultural production, agricultural stakeholders and agricultural policy (Pannell and Zilberman, 2020). Studies reviewing findings on the adoption of sustainable agricultural innovations and practices so far focused on sustainable agricultural practices more generally (Dessart, Barreiro-Hurlé and van Bavel, 2019; Swart *et al.*, 2023), or on specific practices, such as conservation agriculture (e.g. Knowler and Bradshaw, 2007; Prokopy *et al.*, 2008) or climate-smart agriculture (Long, Blok and Coninx, 2016), as well as agri-environmental schemes (e.g. Lastra-Bravo *et al.*, 2015; Schaub *et al.*, 2023; Sander *et al.*, 2024; Schulze *et al.*, 2024). Moreover, past reviews often had a specific geographic focus (e.g. on the USA or Europe; see Schaub *et al.*, 2023 for an overview). However, the global importance of organic agriculture as a policy goal, the richness and geographic distribution of organic adoption studies due to its role as a globally established strategy and label, the complex nature of adoption decisions weighing organic vs. conventional farming and the lack of systematic consideration of the potential context dependency of organic adoption in the literature, merits a review with a specific focus on the adoption of organic farming.

Importantly, literature has emphasised the importance of considering local-, regional- and innovation-specific contexts, such as opportunity costs, market and environmental conditions or institutions, when assessing adoption decisions (e.g. Knowler and Bradshaw, 2007; Lastra-Bravo *et al.*, 2015; Dessart, Barreiro-Hurlé and van Bavel, 2019; Schaub *et al.*, 2023). Moreover the extent and timing of adoption is crucial (Sunding and Zilberman, 2001). The initial adoption of an innovative technology or practice might have different determinants, impacts and requires different supporting policies than increasing or broadening the adoption of organic farming in a region (or in a later adoption stage), since the adoption process is often recognised to be non-linear over time and space (Sunding and Zilberman, 2001; Padel, 2001; Läpple and Van Rensburg, 2011; Wigboldus *et al.*, 2016). It is clearly emerging from previous literature that both the adoption context, as well as the timing and extent of adoption should therefore be differentiated when comparing adoption studies.

To address our research questions, we conduct the first systematic review of global literature into farmer decision-making and potential drivers and barriers for scaling organic farming (period from 2000 to 2021; 18,129 screened references, 120 studies and 183 recommendations identified). Based on the identified studies, we first map the the coverage of current literature and identify research gaps, i.e. which countries and production systems the current literature covers, which research questions it addresses, which methods studies employ for the analysis and where gaps are. Second, we provide an overview of and categorise the identified evidence-based recommendations for scaling the adoption of organic agriculture, using a conceptual framework on the farmer's adoption process. We differentiate findings based on categories of recommendations, but also the timing and extent of adoption in the studies. Third, to account for the potential role of heterogeneous context-specific factors on study results and recommendations, we merge our data from the literature review with external data on important environmental and socio-demographic characteristics, and check for systematic differences in recommendations across study and production contexts using regression analysis.

Following this, we first provide background on the organic production system and develop a conceptual model of farmers' organic adoption decisions. Then, we present methods and data, i.e. the detailed steps taken in the systematic literature review, the external data used and the methods used for the analysis of results. Next, we present and discuss our results along the lines of the three main research questions. Finally, we conclude and compare our results to policies and measures that are currently in place.

2. Background

Organic agriculture focuses on healthy soils, complex crop rotations, ecosystem dynamics and closed nutrient cycles (International Federation of Organic Agriculture Movements (IFOAM), 2020). It aims at reducing external inputs (e.g. via a prohibition and substitution of mineral nitrogen fertilisers and synthetic pesticides) and builds on biological plant protection (International Federation of Organic Agriculture Movements (IFOAM), 2020). 'Organic agriculture' is codified in a legal framework and many national and private label and certification organisations ensure compliance with these legal requirements (e.g. European Union (EU), 2018, International Federation of Organic Agriculture Movements (IFOAM), 2023). We focus on the adoption of 'certified' organic farming in our paper.

Farmers willing to produce organically have to follow publicly (on a national or regional level) or privately codified regulations for farm- or crop-level management practices and go through a certification process to label their products 'organic' (e.g. European Union (EU), 2018, International Federation of Organic Agriculture Movements (IFOAM), 2023). This usually entails a 2- to 3-year conversion period (depending on the organic standard and production system) in which the farmers have to follow regulations but cannot yet label products organic (e.g. European Union (EU), 2018, International Federation of Organic Agriculture Movements (IFOAM), 2023). Depending on the country, product and certification body, organically certified products obtain price premia on markets, compared to conventional produce (e.g. Crowder and Reganold, 2015). Some regions and countries (e.g. the EU) further support organic production with subsidies. Price premia and subsidies are often necessary to make organic farming economically profitable compared to conventional farming (Crowder and Reganold, 2015). This is because organic production can imply higher production costs and lower yields (Seufert and Ramankutty, 2017; Meemken and Qaim, 2018). However, increased prices for organic produce can lead to consumer welfare losses (e.g. Merel, Qin and Sexton, 2023). Furthermore, organic farming regulations restrict farmers' decisions on their farm management and organic farming is usually more knowledge intensive and requires infrastructure (such as separate logistics and certification bodies), as well as inputs (such as organic seeds and manure) that may not be available (e.g. Meemken and Qaim, 2018). Farmers' adoption decisions for organic agriculture are therefore complex and might depend on the environmental, institutional and socio-economic context. Organic agriculture shows a high sustainability performance on a per hectare basis and local level while mostly achieving lower yields—its overall welfare benefits are therefore debated and are context-dependent (Seufert and Ramankutty, 2017; Muller *et al*., 2017; Meemken and Qaim, 2018; Merel, Qin and Sexton, 2023; Aïhounton and Henningsen, 2024; Larsen, Noack and Powers, 2024).

2.1. Current state of organic production

In 2021, organic agriculture was practiced in 191 countries and covered 76.4 Mha, that is 1.6 per cent of global agricultural land (Willer, Schlatter and Trávníček, 2023). Globally, Argentina and Australia are the countries with the most organic production area, and China, France and Spain show the biggest growth rate (Willer, Schlatter and Trávníček, 2023). The biggest markets, measured in absolute sales value, lie in the USA and the EU (especially, France and Germany). The highest organic market shares are found in Denmark (13 per cent) and Austria (11.6 per cent). Together with Switzerland, Luxembourg and Sweden, they are the five countries with the highest per capita expenditure for organic food (Willer, Schlatter and Trávníček, 2023). Generally, there are large differences in the adoption rates of organic agriculture for different crops and countries, even in the same region (Figure 1). For example, in 2021, Austria had an adoption rate of 27 per cent of agricultural land, while the EU average was at 9.6 per cent (Willer, Schlatter and Trávníček, 2023). Given the gap between ambitious policy targets and current adoption rates, a systematic review of evidence-based recommendations for solutions to scale organic farming can support the decision-making of policymakers and food-value chain actors on suitable policy measures in different production contexts.

2.2. Conceptual model of farmer adoption decisions

A broad literature on the adoption and diffusion of innovations in agriculture exists (e.g. Sunding and Zilberman, 2001; Kuehne *et al*., 2017 for an overview). The focus of our study is on policy recommendations for scaling organic adoption. In building our conceptual model, we therefore especially look at previous studies that looked at policy implications for organic adoption of farmers (e.g. Padel, Lampkin and Foster, 1999; Padel, 2001; Wheeler, 2008; Stolze and Lampkin, 2009; Daugbjerg *et al*., 2011; Jaime, Coria and Liu, 2016; Rees, Grovermann and Finger, 2023) and synthesise the described adoption processes from a farmer's perspective, conceptually, into four steps.

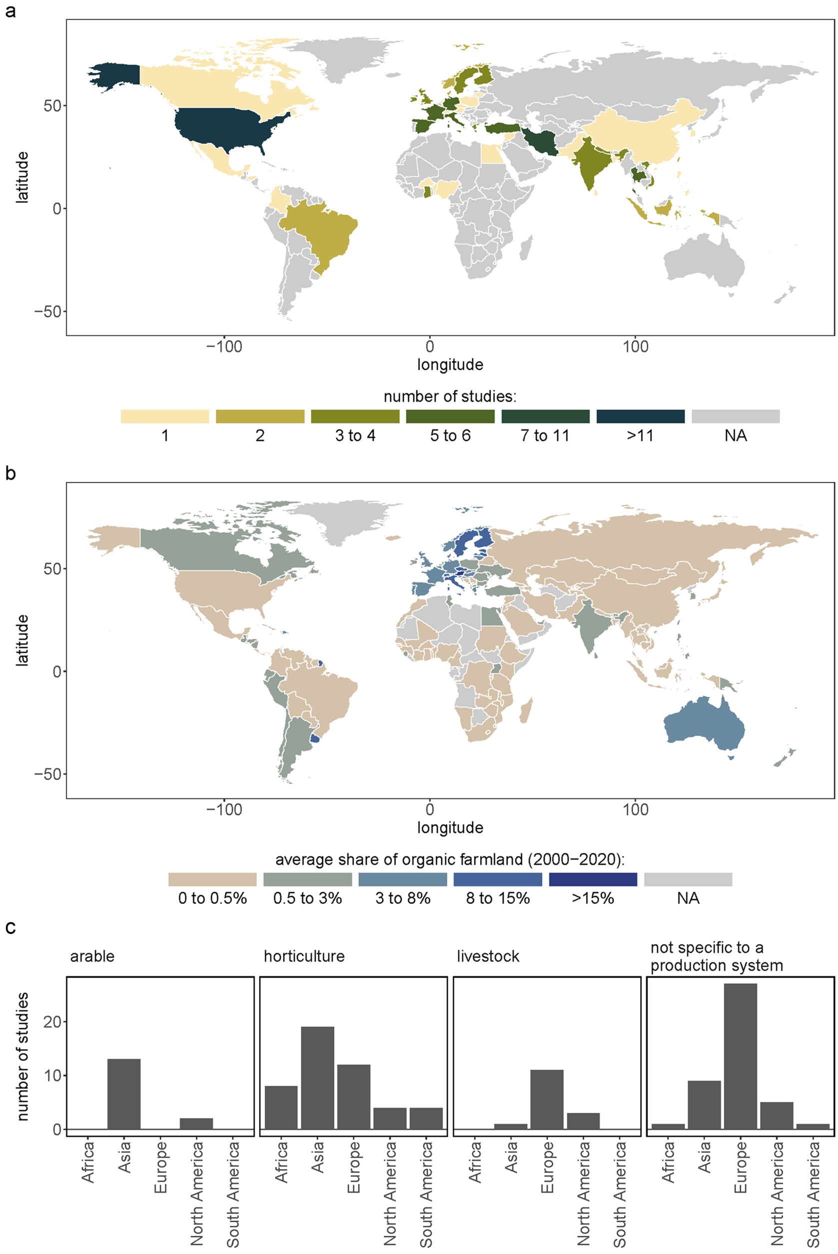

Fig. 1. Comparison of the global share of organic production and the coverage of adoption studies reveals research gaps. *Note*: Distribution of the number of identified studies on the adoption of organic farming per country (a), average share of organic farmland in overall farmland per country (in %) between 2000 and 2020 (FiBl, 2023) (b) and production system (c).

We then use the conceptual model to relate categories of policy recommendations identified in our literature review to the different steps. The four steps consist of (i) the choice of the farming system, for example, conventional or organic agriculture, (ii) the actual production process, (iii) the transport and processing of produce and (iv) the sale of the produce to consumers.

First, farmers consider which farming system (e.g. organic or conventional agriculture) to choose. Adopting organic farming first of all requires a general awareness of the organic farming system (e.g. Padel, 2001). This is especially relevant in regions with a currently very weak or inexistent organic sector. Further, it requires knowledge on the (expected) benefits and costs from adopting organic farming, i.e. the relative advantage or opportunity costs of adoption. Second, farmers must adapt and reorganise the management of their farm and the production process, which requires knowledge and experiences on organic production and farm management, as well as organic certification (e.g. Stolze and Lampkin, 2009; Daugbjerg *et al*., 2011; Jaime, Coria and Liu, 2016). Further, it requires infrastructure for the provision of organic production inputs (e.g. organic fertilisers) and entails transaction costs, such as costs for certification bodies and officers (e.g. Stolze and Lampkin, 2009). Third, the transport, storage and processing of organic products often requires separate infrastructure and supply chains to valorise the added-value (price premium) of organic products and guarantee the integrity of the supply chain (e.g. Wheeler, 2008). Fourth, to sell organic products and gain price premia, an infrastructure for marketing and sales of organic products is required. Such an infrastructure is often provided by intermediaries (trading or processing companies), as well as food service and retailers. Market demand feeds back in the production process and will affect production decisions of farmers directly through interactions with consumers and intermediaries, or indirectly through price signals (e.g. Padel, 2001; Stolze and Lampkin, 2009; Daugbjerg *et al*., 2011). Processing and sales (steps three and four) might further be integrated on the farm-level, for example through direct sales of fresh and processed products in farm shops or farmer markets. Importantly, we here take a farmer's perspective on the adoption process and focus on farmers adoption decisions as driven by farm and farmers' characteristics and behaviour (e.g. Knowler and Bradshaw, 2007; Dessart, Barreiro-Hurlé and van Bavel, 2019; Schaub *et al*., 2023). Literature on the adoption and diffusion of agricultural practices and policies has repeatedly emphasised the importance of context-specific factors, e.g. environmental-, market- and institutional conditions (Sunding and Zilberman, 2001; Knowler and Bradshaw, 2007; Kuehne *et al*., 2017). We therefore explicitly account for context-specific factors in our conceptual framework and empirical analysis. Note that these market, institutional and environmental conditions are mostly assumed to be exogenous to the farmer, at a given moment of time, in literature. Finally, the role of timing (early and late adoption), as well as the extent of adoption (first adoption vs. increasing or broadening adoption in the farming population) has been identified as crucial in adoption literature (e.g. Sunding and Zilberman, 2001; Padel, 2001; Rogers, 2003; Läpple and Van Rensburg, 2011; Wigboldus *et al*., 2016). We therefore specifically consider and discuss potential differences in identified recommendations regarding timing and extent of adoption across studies.

3. Methods and data

3.1. Systematic literature review

We conducted a systematic literature review to synthesise the existing knowledge regarding our pre-defined research question. In our systematic review, we followed the PRISMA checklist (Page *et al.*, 2021) and pre-registered the systematic review on December 14, 2021, before starting data collection (Möhring, Muller and Schaub, 2021). Using a systematic review, rather than, for example, a narrative review reduces selection and confirmation bias (e.g. Aromataris and Pearson, 2014; Pae, 2015) and helps to provide a comprehensive overview of the existing knowledge. The four steps of our systematic review were:

(1) defining the research questions,
(2) identifying relevant studies,
(3) critically assessing identified studies and
(4) synthesising recommendations for scaling organic adoption from identified studies.

3.1.1. Research questions

In our review we addressed the following three research questions:

(i) What are the scientific recommendations to scale-up adoption of (or establish) organic agriculture, based on empirical evidence?

(ii) Are the recommendations depending on the farming context (referring to our hypothesis, that reasons and thus recommendations differ across regions)?

(iii) What are the research gaps (e.g. contexts, methods and types of policy measures analysed) in the literature on the adoption of organic farming?

3.1.2. Search strategy, eligibility criteria and data extraction

We used four databases to identify relevant studies: Web of Science Core Collection (accessed via Web of Science), Scopus (accessed via Elsevier), CAB direct (accessed via Web of Science) and Google Scholar. We considered these databases, as they comprise a wide range of journals, and especially those journals that are relevant to answer our research questions (e.g. Scopus, 2022; Web of Science Group, 2022).

For identifying the relevant studies in Web of Science, Scopus and CAB direct, we used search terms related to four categories: (i) the target farming system (i.e. organic farming), (ii) the sector (agriculture), (iii) the action (adoption) and (iv) the publication year. See Supplementary Table S1 for an overview of all search terms used. We complemented the search terms that we created by using a machine learning algorithm (based on text mining and keyword co-occurrence) (Grames *et al.*, 2019) (Supplementary Table S1). This approach reduces potential biases in the search term selection introduced by researchers' knowledge and experience (Grames *et al.*, 2019). We searched in the title, abstract and keywords of studies (see Supplementary Table S1 for details). Furthermore, as our focus was on studies on the adoption of organic farming, we expected that the target system (i.e. 'organic') and a search term reflecting the production sector, i.e. 'Agriculture', is included in the papers' title or keywords. If a study does not exclusively focus on organic farming, it was not discarded, but only parts related to the findings on organic farming were considered.

This search strategy resulted in 25,101 references and after removal of duplicates in 18,129 unique references (Supplementary Figure S1). Two reviewers independently screened the title and abstract of each of those unique references and decided about inclusion or exclusion. When the decision was inconclusive, a third reviewer was consulted. For this step we used the online software Rayyan (Ouzzani *et al.*, 2016). In all, 270 references were left after this step. The full-text of all the remaining 270 references was checked independently by two reviewers. Finally, we identified 120 relevant studies, of which 96 studies included policy recommendations. Note that one reference can include more than one study, for example, when two different countries were analysed within one reference. In our review, this was the case for two references (i.e. we identified 118 relevant references). See Supplementary Table S2 for an overview of all identified studies. To provide an overview of journal types and quality, where studies were published, we further indicate if journals were classified as 'Economics' journals, as well as the quartile of their SCImago Journal & Country Rank (SJR).

Additional to identifying references in Web of Science, Scopus and CAB direct, we screened the first 100 entries on Google scholar for references from 2000 to 2021, using a simplified Boolean search string ('organic' AND 'adoption' AND 'farm' or 'agriculture') on the private browser of Firefox (which does not store cookies, etc.). This was done after we identified studies using the other databases and did not lead to the identification of any additional studies, confirming our search strategy.

We considered studies to be relevant for our review based on six eligibility criteria. (i) Adoption of organic farming: We focused on the conversion of 'conventional farmers' to 'certified organic farmers'. We included both observed adoption decisions to adopt and observed preferences or intentions to adopt. Furthermore, we followed the authors' definition of 'organic' since the term is codified worldwide. (ii) Production system: We did not restrict the scope of production systems; however, we differentiated them (e.g. arable farming or livestock farming) in our analysis. (iii) Region: We did not restrict the regional scope of the studies. (iv) Method and data: Given the large body of literature (18,129 screened references), we had to make some choices to restrict the population of studies we were considering. We included studies that used quantitative statistical models to assess organic adoption, using primary and secondary data on actual observed adoption decisions or observed intentions and preferences to adopt. Thus, we excluded simulation studies and reviews, in order to arrive at the most 'conservative' selection of evidence-based recommendations, i.e. those that are only based on observed or intended decisions of farmers. Further we excluded purely qualitative studies. Restricting the body of literature to quantitative studies allowed a better comparison of findings within the population of studies due to a similarity of research approaches. Further, it allowed us to more easily differentiate if recommendations were based on the original research question and findings of the study (see Section 3.1.4). (v) Time: We included studies from 2000 to 2021 (date of data retrieval: 17 December 2021). We focused on the past 21 years of literature due to the rapid change in global agricultural systems and markets, as well as scientific literature and methods. (vi) Language and source of the study: We only included studies published in English and in peer-reviewed journals. The focus on peer-reviewed studies, i.e. studies reviewed by other independent researchers, provides an exante quality criterion, which is widely used in literature reviews (e.g. Poulsen *et al*., 2015; Gillespie, Van Den Bold and Hodge, 2019; Schaub *et al*., 2023; Wuepper, Henzmann and Finger, 2023). Note that we additionally checked for the quality of the study (see Section 3.1.3). Moreover, focusing on peer-reviewed studies ensures that usually sufficient information about the studies is available to understand the study set-up and quality, since they have to meet a set of standard criteria. Importantly, the above six eligibility criteria led to a rich and diverse set of studies on our research question.

We then extracted data of the identified studies on (i) study characteristics and quality (e.g. location, farming type, sample size, method, research design) and (ii) policy recommendations, following our pre-registration plan (see deviations from the plan in Supplementary Table S3). The data were extracted by one reviewer and checked by a second reviewer.

3.1.3. Critical appraisal

We critically appraised each of the 120 studies that were identified as relevant for our review. The critical appraisal was based on the Critical Appraisal Skills Programme Checklists for qualitative research and randomised controlled trials (Critical Appraisal Skills Programme, 2018, 2020) and Bird *et al*. (2019). Specifically, each study was critically appraised for its quality based on seven criteria: (1) a clear description of study design, (2) a clear description of methods for data analysis, (3) a clear description of methods measuring outcome, (4) research design appropriate to address research aims, (5) valid justification for choice of study area and participating farmers, (6) whether the results were described in detail and (7) whether potential biases during selection, measurement and analysis of presented data were examined. For each of the seven criteria that was met, a point was given to the study. The studies' scores ranged from 2 to 7, with a mean of 5.625 (Supplementary Figure S2). We excluded no study based on the critical appraisal, but checked the sensitivity of our results to study quality (see the data analysis section below).

3.1.4. Synthesising results

After collecting the data, we screened the policy recommendations and grouped them into categories that provide different actionable leverage points for food-value chain actors and policymakers. Our goal was to assign all distinct types of recommendations emerging from the literature to separate categories and align them with our conceptual model of the farmers' organic adoption process (Figure 2). This resulted in the five categories 'awareness and knowledge', 'infrastructure and transaction', 'supply chain and markets', 'cooperation' and 'public policies'. Next, we constructed five binary variables indicating whether a study included a recommendation in the respective category. Importantly, to ensure quality of recommendations we checked if (i) recommendations were related to the research question stated in the paper in the first place, and (ii) if they were based on the empirical findings of the study. We then excluded all recommendations that did not meet both criteria. In all, 20.4 per cent of the initial recommendations were excluded. Further, we check heterogeneity of responses not only with regard to type of recommendation but also study design. Specifically, we differentiate studies that focus on adoption in a given region and point in time vs. studies that focus on increasing or broadening adoption over time and space. The latter specifically include studies that follow up on adoption over time using panel data, studies conducting duration analysis and studies conducting spatial analyses. The full dataset resulting from the systematic review is openly available (Möhring, Muller and Schaub, 2024.

3.2. Data preparation and overview

We then merged the variables from the systematic literature review with external data on the production context of the studies. External data was merged based on the country and year of the study. The year was defined as the last year of the data included in the studies (relevant for studies with explanatory variables over several years). When authors did not indicate the time when their data were collected, we assumed that the data collection ended 2 years prior to publication. Further, for some time-variant variables single years were missing. To address this issue, we used linear interpolation to fill these gaps. Additionally, we used the information from the earliest available year when the sample of a study began before the first available year of the time-variant explanatory variable. For some countries some explanatory variables are missing. We supplemented the information about Taiwan for GDP per capita and share of rural population using information from the CIA (2023) and Worldmeter (2023), respectively. We provide a detailed overview of all data used for the analysis in Table 1.

3.3. Data analysis

We first conduct descriptive analyses on the number of recommendations in each of the five categories and then synthesise results, i.e. main findings of studies in each category. We further differentiate findings between studies that assess adoption for a specific time and locations vs. studies that assess scaling of adoption across time or space.

We then assess how far recommendations are context-specific (see background section above and 'heterogeneity hypothesis' in pre-registration

Table 1. Descriptive statistics of explanatory variables in the regression analysis

Variable	Description	Source	Mean	Standard deviation
Organic share	Share of organic farmland in total farmland (in %).	FiBl, 2023	3.05	4.65
GDP per capita	GDP per capita in constant 2010 US dollar.	World Bank Group, 2023a	19,808.28	22,091.48
Share of food exports in total exports	Food exports share of merchandise exports (in %).	World Bank Group, 2023a‡	14.22	12.32
Production value per area	Gross production value of all crops in constant 2014–2016 thousand international dollars divided by total crop area.	FAOSTAT, 2023	1951.59	1264.66
Potential pest damages	Potential maximal damages of pests and pathogens to major crops in the region in percentage (time-invariant).	Oerke, 2006	70.90	7.74
Rural population share	Rural population share of total population (in %).	World Bank Group, 2023a‡	39.75	21.41
Education	Predicted share of the population (age 25–29 years) in 2018 with 12 or more years of completed schooling (time-invariant) (in %).	Friedman *et al.*, 2020	64	26
Broadband subscriptions	Fixed broadband subscriptions per 100 people. This is a commonly used infrastructure proxy (e.g. World Bank Group, 2023b)	World Bank Group, 2023a[a]	1.73	2.14

Note: The table shows mean and standard deviation of explanatory variables used in the regression analysis. All explanatory variables described in this Table were collected from external sources to have standardised measures. The statistics are computed over data for all studies (countries) included in the regression analysis for the period from 2000 to 2020 (for time-variant variables). [a]The data from the data source World Development Indicators (World Bank Group, 2023a) were derived using the R package WDI (Arel-Bundock, 2019).

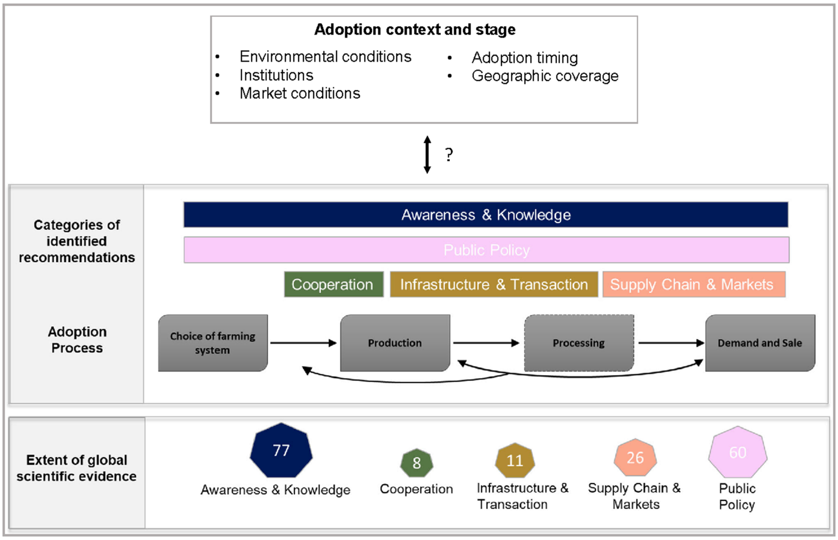

Fig. 2. The organic adoption process and global recommendations for the adoption of organic farming. *Note*: We present the adoption of organic agriculture from a farmer's perspective starting from (i) the choice of the farming system, to (ii) the production process, (iii) the transport and processing and (iv) the sale of organic produce (in grey). We summarise the global scientific evidence on recommendations for scaling organic farming in five distinct categories and match them with the different steps of the process: The category 'awareness and knowledge' (blue, 77 identified recommendations) includes measures to raise the general awareness of the existence of organic agriculture and improve the knowledge of practices and (expected) costs and benefits; the category 'cooperation' (green, 8 identified recommendations) includes recommendations for farmer-to-farmer co-operations, mostly for production; the category 'infrastructure and transaction' (yellow, 11 identified recommendations) includes recommendations to improve agricultural or general infrastructure for production, transport or processing and reduce transaction costs; the category 'supply chain and markets' (red, 26 identified recommendations) includes recommendations for supply chain and market-level measures important for farmer's adoption decisions; and the category 'public policies' (rose, 60 identified recommendations) includes all recommendations that specifically address public policies (command and control, cross compliance, market- and information-based) to scale up organic farming. Note that some recommendations may fall into two categories. Recommendations depend on the production context, such as environmental and growing conditions, institutions and market conditions, as well as the stage of adoption, e.g. timing and geographic coverage.

plan (Möhring, Muller and Schaub, 2021)). Previous literature in the field, for example, on determinants of the adoption of conservation agriculture and participation in agri-environmental schemes, found no consistent links between contextual variables and adoption decisions (e.g. Knowler and Bradshaw, 2007; Lastra-Bravo *et al.*, 2015; Tyllianakis and Martin-Ortega, 2021; Swart *et al.*, 2023)—but it also did not empirically check for such differences.[3] We

3 Note that contrary to our review, previous reviews in the field of sustainable agriculture (not focussing on organic farming) (e.g. Knowler and Bradshaw, 2007; Lastra-Bravo *et al.*, 2015; Dessart, Barreiro-Hurlé and van Bavel, 2019; Tyllianakis and Martin-Ortega, 2021; Schaub *et al.*,

therefore follow an explorative approach in our analysis and do not impose specific restrictions on variable choice before the analysis.

We use multiple linear regression models to analyse the context-dependence of recommendations for organic adoption:

$$y_{iz} = \beta_0 + \beta_1 X_i + e_i, \quad (1)$$

where y is a binary variable indicating whether a recommendation in category *z* was given in study *i*, X is a vector of explanatory variables (presented in Table 1) and *e* is the error term. For each of the five categories of recommendations identified in the literature review, we run a separate regression model. Moreover, in our main regression analysis we only include studies with at least one recommendation. We focus on those studies in the main regression analysis, as studies without any recommendation (i) might overlook specifying policy conclusions at all or (ii) are studies that focused on a methodological contribution and, therefore, did not focus on providing policy recommendations.

Further, we conduct a set of robustness checks. First, we check the sensitivity of our results to model choice. To this end, we use a non-linear (i.e. a logistic model) instead of a linear model.[4] Second, we consider alternative classifications of our recommendation categories. Specifically, we divided the category 'awareness and knowledge' into the two categories 'awareness' and 'knowledge'. We only perform this sensitivity analysis for the 'awareness and knowledge' category, as such a split would have led to very small samples for the other sub-categories (Supplementary Table S4). Third, we check robustness with regard to quality of the studies: (i) we only consider studies with a quality score of six or higher out of seven possible points (Supplementary Figure S2) and (ii) we only consider studies that rank in the top first quartile within their respective discipline, using the SJR (Supplementary Table S2).[5] Fourth, we also include studies in our analysis that formulated no policy recommendation. Fifth, we additionally check if the context-dependence of recommendations differs for studies that focus on adoption in a given region and point in time vs. studies that focus on increasing or broadening adoption over time and space. Finally, our descriptive analysis highlights the importance of understanding smart mixes of policy measures. To identify which types of policy mixes were recommended by studies, we conduct a hierarchical agglomerative cluster analysis based on a Gower distance measure, which accounts for the binary nature of our data (i.e. 1/0 if recommendation was given) (Gower, 1971). Running the cluster analysis, we find that

2023; Swart *et al.*, 2023; Sander *et al.*, 2024; Schulze *et al.*, 2024) did not empirically assess the differences in the production context across studies.

4 We only run these models for the categories 'awareness and knowledge', 'public policies' and 'supply chain and markets' as other categories of recommendations were only relevant for few studies, leading to incidental parameter problems in the non-linear estimations.

5 Note that (i) one journal can belong to several disciplines, we used the highest-ranking quantile, and (ii) we used the median quantile between 2000 and 2021.

a cluster number above three yields clusters with fewer than ten observations; to ensure interpretability of results, we therefore opt for three clusters.[6] After identification of the clusters, we again assess context-dependent variables related to the clusters of recommendations, using regression analysis.

4. Results and discussion

4.1. Mapping global research on the adoption of organic farming

We identify 120 peer-reviewed studies on farmer adoption decisions of organic agriculture in our systematic literature review. The number of identified studies increased over time (i.e. with the year of publication, period 2000–2021 covered, Supplementary Figure S3), highlighting the growing policy relevance of organic production. Most of the studies were published in journals that did not cover explicitly economic topics ($N = 73$) (Supplementary Table S2) and most studies were published in journals that were ranked in the first ($N = 48$) or second quartile ($N = 34$; Supplementary Table S2) within their (best) discipline, following SJR.

To compare the global distribution of organic farming and research on its adoption, we map the number of studies per country and production system and compare it with the global distribution of organic production measured as the average share of total agricultural land per country between 2000 and 2020 (Figure 1). We also provide a comparison with an alternative measure of organic market maturity, i.e. total organic farmland in hectares, in the Appendix (Supplementary Figure S4). The comparison shows important research gaps, in terms of geographic and production system scope. The USA, parts of South-East Asia and Europe (a very important region in terms of policy goals and adoption rates) have received considerable attention in the literature. However, we find important literature gaps in the geographic coverage of studies. Canada, South America and Oceania have received very little attention, despite their relatively large share of organic production. Notably, these regions comprise important exporting countries (Willer, Schlatter and Trávníček, 2023). Furthermore, studies in regions with very low adoption, such as Africa and central Asia (only Turkey is covered well and has a high organic share for some products) are missing. When we zoom in on Europe, with its ambitious policy targets to increase organic farming, we find a higher number of studies in Northern, Central and Southern Europe than in Eastern Europe, matching the higher current adoption rates of the former regions (Supplementary Figures S5 and S6). Adoption rates in Eastern Europe are low, but also studies on the adoption of organic agriculture are missing. Generally, in terms of production systems, existing studies have a focus on horticulture and agriculture in general (studies that do not differentiate between production

6 For example, a cluster size of four would yield cluster sizes of 44, 38, 10 and 3, whereas a cluster size of three yields cluster sizes of 47, 38 and 10.

systems). In contrast, specific studies on arable (except for Asia) and livestock production systems (except for Europe) are underrepresented.

A variety of methodological approaches to assess farmers' adoption decisions of organic agriculture are being used in the identified studies (Supplementary Figure S7). They range from binary choice models to duration analysis, structural equation models and spatial regression analysis, as well as different methods for causal inference. Importantly, methods and data used are key to the study design, and are thus indicative of which type of research questions studies may (or may not) respond to. Linear regression and binary choice models with cross-sectional data based on agricultural census or surveys are the most common approaches ($N = 75$), allowing a 'snapshot in time' on adoption decisions and potential drivers. While most studies work with data on observed decisions of farmers, organic farming might not have been adopted in some regions and for some production systems yet. For these cases, we find studies using survey data on hypothetical choices of farmers (intentions to adopt), which are analysed with linear regression analyses or using constructs like the Theory of Planned Behavior (Ajzen, 1991) in combination with structural equation modelling ($N = 7$). Further, it is of interest how farmers' adoption decisions change over time and space. We find that studies approach the question of change over time by focusing on entry vs. exit decisions of farmers. This is most often done with duration analysis based on single surveys of farmers' decisions ($N = 6$). Changes over space were approached using spatial regression models, mostly based on aggregate spatial data, for example adoption rates per year and country ($N = 14$). Finally, we explicitly differentiate studies that aim to identify causal effects, exploiting, for example, changes in policies or (other) exogenous variations over time and space ($N = 10$). We identify three important methodological and data gaps in the existing literature: a lack of (i) studies that assess changes in adoption over time, (ii) approaches that allow a causal interpretation of results and (iii) considerations of changes in prices and demand affecting farmer decision-making.

First, only a few studies analyse changes in adoption over time. However, literature on the adoption and diffusion of innovations has clearly established that adoption decisions change over time, i.e. the state of diffusion of an innovation (e.g. Sunding and Zilberman, 2001; Rogers, 2003), for example between early and late adopters. Studying adoption decisions and their drivers in a given region and production system over time therefore seems essential to give reliable recommendations on establishing and adapting appropriate policies. It therefore constitutes an important literature gap. Establishing such studies and data is often conflicting with incentives and financing of research opportunities, but should be a priority given the ambitious policy goals.

Second, only very few studies claimed to, for example, account for endogeneity and selection bias to analyse causal mechanisms, sometimes exploiting natural experiments in the form of policy changes over time, but sometimes only using variation over time in panel data or instrumental variables for identification (Kumbhakar, Tsionas and Sipiläinen, 2009; Kirchweger and

Kantelhardt, 2015; Jaime, Coria and Liu, 2016; Ma *et al*., 2017). Implementing causal assessments of drivers of organic adoption is not always possible, due to the lack of data quality and quantity (e.g. El Benni, Grovermann and Finger, 2023). However, studies using 'in-field' experimental approaches, such as randomised control trials, have widely gained traction in the field of economics in the past years, also in complex systems (such as agriculture) (e.g. Ferraro, Sanchirico and Smith, 2019), and it seems surprising that no study on the adoption of organic agriculture using these methods so far exists. Given the ambitious policy targets, there is a need for more causal approaches on organic adoption to supply evidence-based recommendations to policymakers and food-value chain actors. Moreover, most of the identified adoption studies were very broad and explorative in terms of the scope of their research question. We find a lack of studies that explore and quantify specific adoption mechanisms or combinations in-depth, which is important to improve and target policy advice. Additional to the creative use and combination of different data sources, this can be done using appropriate statistical approaches. Potential tools for this are available and readily implemented in software: for example, controlling for quality and sensitivity of results due to omitted variable or sampling bias (e.g. Oster, 2019, Diegert, Masten and Poirier, 2022, Broderick, Giordano and Meager, 2020 and Dakpo, Desjeux and Latruffe, 2022).

Third, almost no study considers how changes in prices and demand affect farmer decision-making. We find that this is not due to a lack of findings, but already extends to the general scope or design of studies, which mostly do not cover such effects. However, developments of organic markets and consumer demand (e.g. Katt and Meixner, 2020) may become particularly relevant in the long-term and for 'entries and exits' from organic farming (if demand and price premia decrease or vary). The relevance of such considerations is highlighted in the recent context of a boost of organic consumption in some places during the global pandemic (e.g. Willer, Schlatter and Trávníček, 2023)—as well as recently rising food prices and inflation and stalling or decreasing sales of organic products in some countries (European Commission (EC), 2023). Lindström, Lundberg and Marklund (2020) for example show how demand-side (public procurement) policies can increase farmers' organic adoption.

4.2. A synthesis of evidence-based recommendations for scaling organic farming

We identified 120 studies with 183 recommendations in our systematic review. We grouped those 183 recommendations based on the similarity of suggested measures into five distinct groups of actionable leverage points for food-value chain actors and policymakers to support the adoption of organic agriculture. We then aligned these five categories with our conceptual model of the adoption process to show at which point of the adoption process they intervene typically (Figure 2). Most recommendations fall in the categories of 'awareness and knowledge' (77) and 'public policies' (60), whereas a considerably smaller number of recommendations was identified in the categories 'supply chain and markets' (26), 'infrastructure and transaction' (11) and 'cooperation' (8). Further, most of the identified recommendations focused on the first two steps of the adoption process, i.e. the choice of the farming system and the reorganisation of farm management and production. Following this, we synthesise recommendations for each of the categories.[7] See Supplementary Table S4 for a complete overview of all identified recommendations per category and subcategory.

First, we identify recommendations to improve (i) the general awareness and attitude towards organic farming, (ii) the knowledge of the costs and benefits of organic farming and (iii) the capacity to implement organic farming practices. We summarise them in the category 'awareness and knowledge'. The identified studies find that awareness and capacity-building measures, for example information about the potential costs and benefits of organic vis-a-vis conventional farming, can improve the willingness to adopt organic production (e.g. Hattam, Lacombe and Holloway, 2012; Torres and Marshall, 2018; Yazdanpanah *et al*., 2022), especially in regions with low adoption rates. Further, there is a broad range of studies showing that providing (more) information and extension service for organic production can reduce barriers for adoption (e.g. Kleemann, Abdulai and Buss, 2014; Lampach, Nguyen-Van and To-The, 2020; Sharma and Pudasaini, 2021). This is related to the higher complexity of organic management practices and the need to adapt these to the local context and production system (requiring new extension services).

The second category of identified recommendations focuses on improving farmer–farmer 'cooperation', for example through membership in networks, co-operatives or producer groups. Studies show that farmer–farmer cooperation can improve the awareness and perception of organic agriculture, as well as the availability of organic inputs, and can support farmers in learning and improving organic practices in context-specific settings (e.g. Wollni and Andersson, 2014; Lampach, Nguyen-Van and To-The, 2020).

Third, we identify recommendations for the provision and improvement of general and organic farming-specific infrastructure and the reduction of transaction costs. Studies show that access to labor markets, the availability of organic inputs, a basic agricultural infrastructure and access to internet and mobile phones are necessary conditions for the development of an organic sector (Bravo-Monroy, Potts and Tzanopoulos, 2016; Badu-Gyan *et al*., 2019). Further, access to contract farming, as well as processing and marketing infrastructure can help to increase organic adoption (e.g. Khaledi *et al*., 2010, To The and Nguyen Tuan, 2019).

Fourth, we identify recommendations at the 'supply chain and market' level to improve farmer uptake of organic agriculture. They include the establishment of new, and the improvement of (and access to) existing organic markets,

7 Note that in our synthesis we reflect all recommendations but for examples mainly focus on publications from Q1 and Q2 journals (according to SJR). See Figure 2, Supplementary Figure S8 and Supplementary Table S4 for a complete overview of all identified recommendations.

as well as establishing organic price premia, for example, through improving consumer awareness and export markets (e.g. Digal and Placencia, 2019; Allaire *et al*., 2015). Furthermore, recommendations in this group include (improving) the access to organic certification and the reduction of transaction costs of organic certification, for example, through the increased availability of certification bodies, or farmer support and education (Veldstra, Alexander and Marshall, 2014; Badu-Gyan *et al*., 2019). Moreover, some studies recommend the development of integrated supply chains and marketing channels, as well as the provision of on- and off-farm risk management instruments to increase organic adoption (e.g. Serra, Zilberman and Gil, 2008; Sauer and Park, 2009; Heinze and Vogel, 2017). Given its potential importance for farmer decisions to scale up organic agriculture (see section above), we generally identify few studies on the effect of demand-side effects and resulting changes on farmer decision-making, for example through price changes (price premia).

Fifth, we identify studies that provide recommendations on public policies that can improve organic adoption. The identified public policy measures have a broad scope, spanning along the entire adoption process (Figure 2). They include the introduction and improvement of farm-level economic incentives, such as area-based subsidies for conversion to and maintenance of organic agriculture, tax subsidies for conversion periods, subsidies for organic inputs and agri-environmental schemes (e.g. Kumbhakar, Tsionas and Sipiläinen, 2009; Skolrud, 2019; Lampach, Nguyen-Van and To-The, 2020), access to credits and investment support (e.g. Djokoto, Owusu and Awunyo-Vitor, 2016; Kirchweger and Kantelhardt, 2015)—but also the abolishment and re-alignment of the existing economic disincentives (e.g. Jaime, Coria and Liu, 2016; Chen, Saghaian and Tyler, 2020). Disincentives comprise tax advantages for conventional inputs, general production subsidies or trade-offs between existing policy schemes. Further, studies find that demand-side policies, such as public procurement of organic produce have positive effects on the adoption of organic production (Lindström, Lundberg and Marklund, 2020). Other recommended policy measures include broader measures, such as the support of structural change and R&D, as well as landscape-level approaches for organic policies (e.g. organic production landscapes, Parker and Munroe, 2007; Mayen, Balagtas and Alexander, 2010). Moreover, identified studies not only recommended the introduction of novel policy measures but also to differentiate existing policies along spatial or farm and farmers characteristics, in order to make them more effective and efficient (e.g. Schmidtner *et al*., 2012; Bui and Nguyen, 2021). The latter is especially relevant in more established organic markets with a tradition of policy support, such as the EU. Relevant characteristics for differentiation included spatial clusters of adoption rates, production potential or environmental conditions, as well as farm size, education, gender, opportunity costs or openness to innovation. Further, the importance of stable and reliable policies combined with continuous support through education and knowledge transfer is emphasised to prevent farmers from exiting the sector (e.g. Sauer and Park, 2009; Kuminoff and Wossink, 2010).

Importantly, some studies highlight the importance of 'smart mixes' of measures to increase adoption of organic farming. For example, Chatzimichael, Genius and Tzouvelekas (2014) recommend, for organic farming in Germany and Greece, combining subsidies (relevant for late adopters) with information provision (e.g. extension creating information cascades—for early adopters), as they would not be efficient alone. Lampach, Nguyen-Van and To-The (2020) show for organic tea production in Vietnam that organic subsidies should be combined with the provision of extension services and the support of (existing) farmer associations. Bravo-Monroy, Potts and Tzanopoulos (2016) find for coffee in Colombia that the farm and business management skills of farmers should be supported together with social programmes and extension services that strengthen farmers' negotiation power and access to technologies.

Finally, we specifically look at recommendations of studies that assess changes in adoption over time and space. These included 22 out of the 120 studies, with 28 recommendations. Most of the studies that look at changes in adoption over time fall in the category of duration analysis, i.e. looking at determinants of entry and exit decisions of organic farming. Interestingly, these studies especially emphasise the important role of targeted education and information and market conditions. They highlight the importance of organic extension and information (networks) targeted at potential adopters for entry decisions, but also in the transition phase from conventional to organic farming to prevent 'early exits' (Burton, Rigby and Young, 2003; Läpple, 2010; Allaire *et al*., 2015, Dapaah Opoku *et al*., 2020). They further emphasise the need for stable market conditions, access to certification and export markets in combination with specialisation and targeting of extension services to specific farmer groups, crops, or environmental contexts, using tailored information channels, to prevent exits from the sector (Läpple, 2010; Pornpratansombat, Bauer and Boland, 2011; Heinze and Vogel, 2017). Studies focusing on changes over space mostly look at changes in the aggregate share of organic adoption in geographic areas (such as counties or regions). They emphasise the importance of neighbourhood effects and increasing these farmer–farmer interactions for adoption, for example through regional organic clusters or organic landscapes—but also find that such conclusions are region-specific (Parker and Munroe, 2007; Schmidtner *et al*., 2012; Wollni and Andersson, 2014; Läpple and Kelley, 2015; Boncinelli, Riccioli and Casini, 2017). This is in line with recent research in Ecology, confirming that a higher concentration of organic farming in the landscape can support pest management of organic farms (Larsen, Noack and Powers, 2024). Further, they highlight the importance of policies that differentiate for the heterogeneous opportunity costs of farmers across different geographic regions in a country (Taus, Ogneva-Himmelberger and Rogan, 2013; Bonfiglio and Arzeni, 2019).

The analysis in this section is descriptive and provides an overview over recommendations, but does not assess how the varying study contexts or the stage of adoption relate to the type of recommendation given. In the next step, we account for important contextual factors and analyse how they relate to the type of recommendation given, using regression analysis.

4.3. Context-dependence of recommendations for scaling organic farming

The identified recommendations for scaling organic farming vary over the production context in which studies are conducted. We use regression analysis to study systematic differences in recommendations across the different production contexts (Figure 3). To this end, we combine information from the literature review with external, country-level data on the maturity of the organic sector, and on important agricultural, environmental-, institutional- and socio-economic characteristics. In the regression analysis, we selected explanatory variables that cover important factors for organic adoption related to agricultural and environmental conditions (i.e. including organic share, production value per area and potential pest damages), and the institutional and socio-economic development (GDP per capita, share of food exports, rural population share, education and broadband subscriptions; with the latter being a commonly used infrastructure proxy (e.g. World Bank Group, 2023b) of study regions. See methods and data for a detailed description of data sources, matching procedures and estimation methods. The descriptive analysis revealed the importance of policy mixes. We therefore not only assess contextual factors relevant for distinct groups of recommended measures but also for relevant mixes of measures, using cluster analysis. Following this, we synthesise results from the regression analysis, focusing on the contextual factors most consistently linked to policy recommendations.

First, we find that the maturity of the organic sector in a country is associated with the recommended category of measure to scale up organic adoption. More specifically, we find that when the share of organic agriculture is low, increasing 'awareness and knowledge' is recommended (regression coefficient [95 per cent confidence interval] = −0.15 [−0.26, −0.04]). Indeed, when the organic sector is not yet or newly established, farmers might simply not be aware (enough) of organic farming and its potential costs and benefits—or general information is lacking about how to adopt organic farming. This can, for example, in less mature organic markets, make information campaigns by extension services about the benefits of organic farming and advice on how to adapt it more important (see the previous section). Furthermore, we find that when the organic sector is already more mature, studies more often recommend 'public policies' to increase the adoption of organic farming (regression coefficient [95 per cent confidence interval] = 0.18 [0.04, 0.31]). This might relate to a need for subsidies to offset higher opportunity costs of late adopters, or to the necessary adaptation of (long-) existing policy measures in more mature markets (see the previous section).

Second, we find that the type of recommendation given is related to agricultural productivity (production value per area). When productivity is higher, studies rather recommend increasing organic adoption via farmer–farmer 'cooperation' (regression coefficient [95 per cent confidence interval] = 0.07 [0.01, 0.13]). A possible explanation for this is that when productivity is high, the opportunity costs of changing agricultural practices are also higher (ceteris

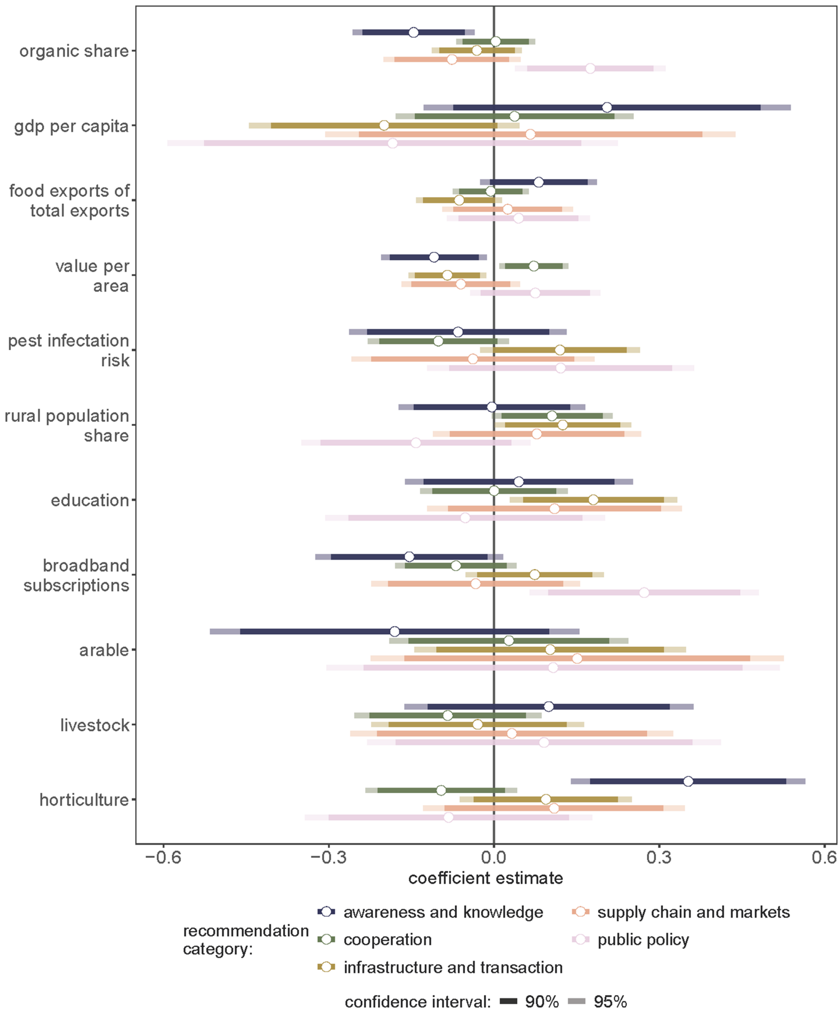

Fig. 3. Relation between context specific characteristics and the type of recommendation given for the adoption of organic production—across all studies worldwide. *Note*: We here report results from multiple linear regression analysis. We run separate analyses for each of the five categories of recommendations. Colours indicate the different categories: 'awareness and knowledge' (blue), 'cooperation' (green), 'infrastructure and transaction' (yellow), 'supply chain and markets' (orange) and 'public policies' (mauve). We include all studies with at least one recommendation (only recommendations linked to the research question of the study considered): $N = 95$. White cycles represent point estimates of regression coefficients. Light and dark coloured bars show the 90 per cent and 95 per cent confidence intervals from two-sided t-tests against the null hypothesis of zero regression coefficients, respectively. The y-axis indicates the independent variable and the x-axis the magnitude of the estimated regression coefficient. For the analysis, we scaled all continuous variables, so that they have a mean of zero and standard deviation of one.

paribus; see, e.g. Schaub *et al*., 2023 for an extensive discussion on farmers' opportunity costs). Farmer–farmer cooperation may then become an effective lever to reduce opportunity costs. In contrast, when productivity is lower, increasing (i) 'awareness and knowledge' (regression coefficient [95 per cent confidence interval] = −0.11 [−0.21, 0.01]) and (ii) 'infrastructure and transaction' (regression coefficient [95 per cent confidence interval] = −0.08 [−0.16, −0.01]) is more often recommended.[8] We interpret these findings as an indication that the (agricultural) training of farmers and (agricultural) infrastructure (such as the availability of trained labour or organic seeds and manure) constitute two of the main barriers for scaling organic farming in production contexts with an overall low productivity. We conduct several robustness checks for our main analysis on the global data (Figure 3). We find that the main results described above are robust to excluding studies with 'low' quality (based on the quality scores and SJR journal ranking), different model specification (i.e. linear vs. non-linear models) and inclusion of studies with zero policy recommendations (Supplementary Figures S10, S11, S12 and S13, respectively; see Material and Methods for details). An exception are awareness and knowledge-related recommendations not being related to agricultural productivity anymore, when only considering journals in the first- and second-ranking quantile with their respective field.[9] Moreover, when using two separate categories for 'awareness' and 'knowledge', instead of one, we observe similar results for the maturity of the organic sector and agricultural productivity (Supplementary Figure S14). Further, we find that studies which assess changes in adoption over time and space (looking at scaling) do not differ from the other studies regarding most aspects. Interestingly, they are though more likely to recommend supply chain and market-based measures, which confirms evidence from the descriptive analysis (Supplementary Figure S15).

We conduct a second analysis that specifically focuses on Europe, as a study region with a high organic share and important organic adoption targets and policies, and compare results with our global analysis. Note that the sample size is considerably smaller ($N = 38$) than in our main analysis ($N = 95$), and we thus have less statistical power. Further, we find that no farmer–farmer cooperation-related recommendations are given in Europe. When we look at results, the changes for infrastructure and transaction-related recommendation, as well as public policy-related recommendations are most notable (Supplementary Figure S16). For example, we find that when only considering European studies, lower wealth (i.e. GDP per capita) is more clearly linked to suggesting infrastructure and transaction-related recommendations (regression coefficient [95 per cent confidence interval] = −0.33 [−0.57, −0.09]), while for education (regression coefficient [95 per cent confidence interval] = 0.05 [−0.11, 0.21]) and pest pressure (regression coefficient [95 per cent confidence

8 Note that in general only a limited number of studies recommended measures related to infrastructure and transaction, as well as cooperation (Supplementary Figure S9), which suggests that the results for those categories should be interpreted with caution.

9 Using the quality scores robustness check, the agricultural productivity also seems to matter for when public policy-related recommendations are given.

interval] = –0.07 [–0.21, 0.06]), the associations become less clear. For public policy-related recommendations, we find a clearer negative association with rural population shares (regression coefficient [95 per cent confidence interval] = –0.42 [–0.77, –0.07]) and a less clear positive association with maturity of the organic sector (regression coefficient [95 per cent confidence interval] = 0.08 [–0.05, 0.21]) and infrastructure (i.e. broadband subscriptions; regression coefficient [95 per cent confidence interval] = 0.21 [–0.05, 0.47]) compared to the main analysis. Thus, our analyses suggest that many findings from the global analysis also hold for the European subsample. However, relevant indicators for choosing suitable policy measures might differ between European- and non-European studies. For example, as European agricultural infrastructure is comparably good on global levels, the share of rural population might be a more relevant indicator for choosing policy measures.

Finally, we assess important characteristics for choosing policy mixes. We identified three relevant policy mixes in our cluster analysis: (i) 'policy mixes with a focus on awareness and knowledge', (ii) 'policy mixes with a focus on public policies' and (iii) 'policy mixes with a focus on supply chains, markets and public policies' (Supplementary Table S5). We again find that maturity of the organic sector in a country and agricultural productivity (production value per area) are important indicators for the type of policy mix recommended (Supplementary Figure S17). Specifically, a policy mix with a focus on awareness and knowledge is especially recommended when organic maturity and agricultural productivity are low (regression coefficient [95 per cent confidence interval] = –0.15 [–0.28, –0.02] and regression coefficient [95 per cent confidence interval] = –0.12 [–0.23, –0.01], respectively). In contrast, a policy mix with a focus on public policies is especially recommended when organic maturity and agricultural productivity are high (regression coefficient [95 per cent confidence interval] = 0.17 [0.04, 0.] and regression coefficient [95 per cent confidence interval] = 0.13 [0.02, 0.25], respectively).

5. Conclusion

Increasing the share of organic agriculture is a major policy goal in several countries worldwide. Evidence-based information is crucial in supporting policymakers, and supply chain actors to choose effective and efficient support measures and guide future research for achieving these goals. However, an overview of the literature and a synthesis of recommendations for scaling the adoption of organic agriculture is currently lacking. In this paper, we present the first global, systematic review of literature on the adoption of organic agriculture. We (i) map research gaps in terms of geographic, production system and methodological scope, (ii) provide a systematic and detailed overview of recommendations for scaling the adoption of organic farming, and (iii) assess which context-specific characteristics of the production system matter for the choice of support measures. Our analysis provides a basis for a better understanding of farmer's adoption processes of organic agriculture, supports policymakers and food-value chain actors in selecting effective and efficient measures for scaling organic farming and provides entry points for future research.

Our recommendations for future research can be summarised as follows. First, despite the large body of literature, there are substantial research gaps on organic adoption, in terms of geographic and methodological scope, as well as a restricted focus on certain parts of the farmer adoption process and its potential drivers. On a global level, future research should take a concerted effort to close current gaps in the geographic coverage of adoption studies, especially in areas that are currently understudied given their importance, such as Eastern Europe, but also Africa, as well as North and South America. Second, studies that account for the influence of changing price or demand levels on decision-making of farmers are lacking. Future studies could, for example, systematically exploit changes in demand-side policies, such as public spending on organic products (e.g. Lindström, Lundberg and Marklund, 2020), to consolidate evidence on supply-side effects of such measures. Our findings support that supply chain and market measures are especially relevant for scaling up the adoption of organic agriculture by farmers. More generally, studies on farmer decision-making (supply side) and the demand side are currently often disjointed in literature. Combining theory and data on farmer decision-making with insights on organic markets (e.g. Li *et al*., 2024) could deliver important insights (e.g. Bellemare, Bloem and Lim, 2022), for example on combined supply- and demand-side policies and resulting welfare effects (Merel, Qin and Sexton, 2023). Third, we find that only a handful of studies chose a research design that can account, for example, for endogeneity and selection bias, and thus make causal claims about identified adoption mechanisms. Research design of future studies should allow for causal inference and a detailed investigation of underlying adoption mechanisms, which is key for robust policy advice. Several methodological tools and a broad literature discussing the set-up of such studies exist (e.g. Ferraro, Sanchirico and Smith, 2019 for an overview). Fourth, changes in adoption decisions over time have been identified as critical in the literature on the adoption and diffusion of innovations but we find that they are scarcely considered in organic adoption literature so far. A better understanding of how to scale organic farming would require more studies that assess changes in adoption over time and space. Fifth, we find that the great majority of the studies were very broad and explorative in their scope i.e. focusing on general determinants of organic adoption. Advancing research on scaling organic adoption would require more studies that explore and quantify specific adoption mechanisms or combinations in-depth, which is important to improve and target policy advice (e.g. Schaub *et al*., 2023). With regard to points three to five, the lack of studies could be related to the fact that they require more costly and long-term structures that are not in line with the current funding and incentive structures for research. In order to close research gaps, such types of studies must be financed, feasible and rewarded and should be a priority for funding bodies investing in assessing challenges for scaling organic farming.

We further identify several recommendations for policy. First, we provide the first synthesis of evidence-based recommendations for supporting the adoption of organic farming. Our results provide policymakers and food-value chain actors with a detailed overview of all identified recommendations in literature and categorise them into different, actionable types of interventions. We then discuss which types of policy measures can target different stages of the adoption process and how they can be combined to provide 'smart-mixes' of measures. Our results thus support policymakers and food-value chain actors in choosing and adapting (bundles of) suitable support measures to scale up organic farming. Second, our analysis suggests that the production context matters for the choice of measures supporting the uptake of organic production. We especially identified that the maturity of the organic sector and the agricultural productivity are key characteristics along which support strategies should be adapted. This is currently often not the case. We further find that, although specific indicator variables might differ, results on important context-specific factors for our global analysis also hold when we restrict it to the subsample of studies with a focus on Europe. Third, when we compare the recommended measures identified here from literature to the types of policies that are currently in place (e.g. Lampkin and Sanders, 2022; Rees, Grovermann and Finger, 2023 for an overview), it is most striking that current policies often strongly focus on payments for conversion to and maintenance of organic farming (e.g. Lampkin and Sanders, 2022), while findings from literature suggest a number of other measures besides those, to be—of at least equal importance. These include tailored extension and information, as well as regionally specific measures and market-based measures, but also the dismantling of disincentives from other policies. The Organic Action Plans that many countries and regions have formulated and partly adopted provide the opportunity to diversify and contextualise these measures. The nature of such action plans varies widely, but they are usually seen as important guidelines for the development of the organic sector (Meredith, Lampkin and Schmid, 2018). Recent findings that such plans have only partly been successful (Rees, Grovermann and Finger, 2023) could point out that not all of these plans have sufficiently led to the enactment of smart mixes of context-specific policies. Our results highlight the need for more contextualised policymaking, for example for different regions globally but also for different Member States of the EU. More specifically, we find in our regression results that information provision may be particularly important in contexts with low organic shares, and public policies of importance in contexts of mature organic markets. Further, our results show that in contexts with low productivity, support for training and infrastructure investments are central.

There are limitations to our analysis. First, our focus here was on quantitative studies working with primary and secondary farm-level data. Qualitative studies were out of the scope of our analysis, but can give valuable in-depth insights into ideas for scaling organic farming—and could be highly complementary to our analysis. Second, most of the identified studies look at correlations but not causal drivers of adoption and their results should therefore be carefully interpreted. Nevertheless, given the current lack of causal studies, our analysis provides an important first step in guiding policymakers and food-value chain actors in choosing measures for supporting the adoption of organic agriculture.

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Supplementary data

Supplementary data are available at *ERAE* online.

Data availability

Data are available at: https://doi.org/10.60507/FK2/KI9WGA/UY6TMJ (Möhring, Muller and Schaub, 2024). Code is published with the paper.

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Author contributions

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References

Aïhounton, G. B. and Henningsen, A. (2024). Does organic farming jeopardize food security of farm households in Benin? *Food Policy* 124: 102622.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes* 50: 179–211.

Allaire, G., Poméon, T., Maigné, E., Cahuzac, E., Simioni, M. and Desjeux, Y. (2015). Territorial analysis of the diffusion of organic farming in France: between heterogeneity and spatial dependence. *Ecological Indicators* 59: 70–81.

Arel-Bundock, V. (2019). WDI: World Development Indicators (World Bank). R package version 2.6.0. https://CRAN.R-project.org/package=WDI. Accessed 8 August 2023.

Aromataris, E. and Pearson, A. (2014). The systematic review: an overview. *AJN the American Journal of Nursing* 114: 53–58.

Badu-Gyan, F., Henning, J. I., Grové, B. and Owusu-Sekyere, E. (2019). Examining the social, physical and institutional determinants of pineapple farmers' choice of production systems in Central Ghana. *Organic Agriculture* 9: 315–329.

Bellemare, M. F., Bloem, J. R. and Lim, S. (2022). Producers, consumers, and value chains in low-and middle-income countries. *Handbook of Agricultural Economics* 6: 4933–4996.

Bird, F. A., Pradhan, A., Bhavani, R. V. and Dangour, A. D. (2019). Interventions in agriculture for nutrition outcomes: a systematic review focused on South Asia. *Food Policy* 82: 39–49.

Boncinelli, F., Riccioli, F. and Casini, L. (2017). Spatial structure of organic viticulture: evidence from Chianti (Italy). *New Medit* 16: 55–63.

Bonfiglio, A. and Arzeni, A. (2019). Spatial distribution of organic farms and territorial context: an application to an Italian rural region. *Bio-based and Applied Economics* 8: 297.

Bravo-Monroy, L., Potts, S. G. and Tzanopoulos, J. (2016). Drivers influencing farmer decisions for adopting organic or conventional coffee management practices. *Food Policy* 58: 49–61.

Broderick, T., Giordano, R. and Meager, R. (2020). An automatic finite-sample robustness metric: when can dropping a little data make a big difference? arXiv preprint arXiv:2011.14999.

Bui, H. T. M. and Nguyen, H. T. T. (2021). Factors influencing farmers' decision to convert to organic tea cultivation in the mountainous areas of northern Vietnam. *Organic Agriculture* 11: 51–61.

Burton, M., Rigby, D. and Young, T. (2003). Modelling the adoption of organic horticultural technology in the UK using duration analysis. *Australian Journal of Agricultural and Resource Economics* 47: 29–54.

Chatzimichael, K., Genius, M. and Tzouvelekas, V. (2014). Informational cascades and technology adoption: evidence from Greek and German organic growers. *Food Policy* 49: 186–195.

Chen, B., Saghaian, S. and Tyler, M. (2020). Substitute or complementary: relationship between US farmers' adoption of organic farming and direct marketing. *British Food Journal* 122: 531–546.

CIA. (2023). The world factbook. https://www.cia.gov/the-world-factbook/countries/taiwan/. Accessed 8 August 2023.

Critical Appraisal Skills Programme. (2018). CASP qualitative checklist. https://casp-uk.b-cdn.net/wp-content/uploads/2018/03/CASP-Qualitative-Checklist-2018_fillable_form.pdf. Accessed 28 October 2021.

Critical Appraisal Skills Programme (2020). CASP randomised controlled trial checklist. https://casp-uk.b-cdn.net/wp-content/uploads/2020/10/CASP_RCT_Checklist_PDF_Fillable_Form.pdf. Accessed 28 October 2021.

Crowder, D. W. and Reganold, J. P. (2015). Financial competitiveness of organic agriculture on a global scale. *Proceedings of the National Academy of Sciences* 112: 7611–7616.

Dakpo, K. H., Desjeux, Y. and Latruffe, L. (2022). sfaR: stochastic frontier analysis using R.

Dapaah Opoku, P., Bannor, R. K. and Oppong-Kyeremeh, H. (2020). Examining the willingness to produce organic vegetables in the Bono and Ahafo regions of Ghana. *International Journal of Social Economics* 47: 619–641.

Daugbjerg, C., Tranter, R., Hattam, C. and Holloway, G. (2011). Modelling the impacts of policy on entry into organic farming: evidence from Danish–UK comparisons, 1989–2007. *Land Use Policy* 28: 413–422.

Dessart, F. J., Barreiro-Hurlé, J. and van Bavel, R. (2019). Behavioural factors affecting the adoption of sustainable farming practices: a policy-oriented review. *European Review of Agricultural Economics* 46: 417–471.

Diegert, P., Masten, M. A. and Poirier, A. (2022). Assessing omitted variable bias when the controls are endogenous. arXiv preprint arXiv:2206.02303.

Digal, L. N. and Placencia, S. G. P. (2019). Factors affecting the adoption of organic rice farming: the case of farmers in M'lang, North Cotabato, Philippines. *Organic Agriculture* 9: 199–210.

Djokoto, J. G., Owusu, V. and Awunyo-Vitor, D. (2016). Adoption of organic agriculture: evidence from cocoa farming in Ghana. *Cogent Food & Agriculture* 2: 1242181.

El Benni, N., Grovermann, C. and Finger, R. (2023). Towards more evidence-based agricultural and food policies. Q Open.

European Commission (EC). (2023). *EU Imports of Organic Agri-Food Products, Key Developments in 2022, July 2023*. Brussels: European Commission, DG Agriculture and Rural Development.

European Union (EU). (2018). Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) No. 834/2007. Official Journal of the Euopean Union 14.06.2018.

FAOSTAT. (2023). FAO data on agricultural production. https://www.fao.org/faostat/en/#data/QV. Accessed 14 April 2023.

Ferraro, P. J., Sanchirico, J. N. and Smith, M. D. (2019). Causal inference in coupled human and natural systems. *Proceedings of the National Academy of Sciences* 116: 5311–5318.

FiBl. (2023). FiBL Statistics - European and global organic farming statistics. https://statistics.fibl.org/data.html. Accessed 8 August 2023.

Friedman, J., York, H., Graetz, N., Woyczynski, L., Whisnant, J., Hay, S. I. and Gakidou, E. (2020). Measuring and forecasting progress towards the education-related SDG targets. *Nature* 580: 636–639.

Fujibayashi, K. (2021). MAFF releases interim report on green food system strategy. United States Department of Agriculture (USDA), Foreign Agricultural Service, Report Number: JA2021-0048.

Gillespie, S., Van Den Bold, M. and Hodge, J. (2019). Nutrition and the governance of agri-food systems in South Asia: a systematic review. *Food Policy* 82: 13–27.

Gower, J. C. (1971). A general coefficient of similarity and some of its properties. *Biometrics* 27: 857–871.

Grames, E. M., Stillman, A. N., Tingley, M. W. and Elphick, C. S. (2019). An automated approach to identifying search terms for systematic reviews using keyword co-occurrence networks. *Methods in Ecology and Evolution* 10: 1645–1654.

Hattam, C. E., Lacombe, D. J. and Holloway, G. J. (2012). Organic certification, export market access and the impacts of policy: Bayesian estimation of avocado smallholder "times-to-organic certification" in Michoacán Mexico. *Agricultural Economics* 43: 441–457.

Heinze, S. and Vogel, A. (2017). Reversion from organic to conventional agriculture in Germany: an event history analysis. *German Journal of Agricultural Economics* 66: 13–25.

Hysa, X., Anselmi, S., Zhmailo, V., Figeczky, G., Moura E Castro, F. and Meinshausen, F. (2022). Worldwide overview of policies and regulations on agroecological approaches, including organic. In: *FiBL & IFOAM – Organics International (2022): The World of Organic Agriculture*. Frick and Bonn, 158–169.

International Federation of Organic Agriculture Movements (IFOAM). (2020). *Principles of Organic Agriculture*. Bonn, Germany.

International Federation of Organic Agriculture Movements (IFOAM) (2023). "The Organic Guarantee System" of IFOAM - Organics International. https://www.ifoam.bio/our-work/how/standards-certification/organic-guarantee-system. Accessed 5 September 2023.

Jaime, M. M., Coria, J. and Liu, X. (2016). Interactions between CAP agricultural and agri-environmental subsidies and their effects on the uptake of organic farming. *American Journal of Agricultural Economics* 98: 1114–1145.

Katt, F. and Meixner, O. (2020). A systematic review of drivers influencing consumer willingness to pay for organic food. *Trends in Food Science and Technology* 100: 374–388.

Khaledi, M., Weseen, S., Sawyer, E., Ferguson, S. and Gray, R. (2010). Factors influencing partial and complete adoption of organic farming practices in Saskatchewan, Canada. *Canadian Journal of Agricultural Economics/Revue Canadienne D'agroeconomie* 58: 37–56.

Kirchweger, S. and Kantelhardt, J. (2015). The dynamic effects of government-supported farm-investment activities on structural change in Austrian agriculture. *Land Use Policy* 48: 73–93.

Kleemann, L., Abdulai, A. and Buss, M. (2014). Certification and access to export markets: adoption and return on investment of organic-certified pineapple farming in Ghana. *World Development* 64: 79–92.

Knowler, D. and Bradshaw, B. (2007). Farmers' adoption of conservation agriculture: a review and synthesis of recent research. *Food Policy* 32: 25–48.

Kuehne, G., Llewellyn, R., Pannell, D. J., Wilkinson, R., Dolling, P., Ouzman, J. and Ewing, M. (2017). Predicting farmer uptake of new agricultural practices: a tool for research, extension and policy. *Agricultural Systems* 156: 115–125.

Kumbhakar, S. C., Tsionas, E. G. and Sipiläinen, T. (2009). Joint estimation of technology choice and technical efficiency: an application to organic and conventional dairy farming. *Journal of Productivity Analysis* 31: 151–161.

Kuminoff, N. V. and Wossink, A. (2010). Why isn't more US farmland organic? *Journal of Agricultural Economics* 61: 240–258.

Lampach, N., Nguyen-Van, P. and To-The, N. (2020). Robustness analysis of organic technology adoption: evidence from Northern Vietnamese tea production. *European Review of Agricultural Economics* 47: 529–557.

Lampkin, N. and Sanders, J. (2022). Policy support for organic farming in the European Union 2010–2020 (No. 200). Thünen Working Paper.

Läpple, D. (2010). Adoption and abandonment of organic farming: an empirical investigation of the Irish drystock sector. *Journal of Agricultural Economics* 61: 697–714.

Läpple, D. and Kelley, H. (2015). Spatial dependence in the adoption of organic drystock farming in Ireland. *European Review of Agricultural Economics* 42: 315–337.

Läpple, D. and Van Rensburg, T. (2011). Adoption of organic farming: are there differences between early and late adoption? *Ecological Economics* 70: 1406–1414.

Larsen, A. E., Noack, F. and Powers, L. C. (2024). Spillover effects of organic agriculture on pesticide use on nearby fields. *Science* 383: eadf2572.

Lastra-Bravo, X. B., Hubbard, C., Garrod, G. and Tolón-Becerra, A. (2015). What drives farmers' participation in EU agri-environmental schemes?: results from a qualitative meta-analysis. *Environmental Science & Policy* 54: 1–9.

Li, Q., Çakır, M., Beatty, T. K. and Park, T. A. (2024). Differential price pass-through in organic and conventional fresh fruit and vegetable markets. *American Journal of Agricultural Economics*.

Lindström, H., Lundberg, S. and Marklund, P. O. (2020). How green public procurement can drive conversion of farmland: an empirical analysis of an organic food policy. *Ecological Economics* 172: 106622.

Long, T. B., Blok, V. and Coninx, I. (2016). Barriers to the adoption and diffusion of technological innovations for climate-smart agriculture in Europe: evidence from the Netherlands, France, Switzerland and Italy. *Journal of Cleaner Production* 112: 9–21.

Ma, W., Ma, C., Su, Y. and Nie, Z. (2017). Organic farming: does acquisition of the farming information influence Chinese apple farmers' willingness to adopt? *China Agricultural Economic Review* 9: 211–224.

Mayen, C. D., Balagtas, J. V. and Alexander, C. E. (2010). Technology adoption and technical efficiency: organic and conventional dairy farms in the United States. *American Journal of Agricultural Economics* 92: 181–195.

Meemken, E. M. and Qaim, M. (2018). Organic agriculture, food security, and the environment. *Annual Review of Resource Economics* 10: 39–63.

Meredith, S., Lampkin, N. and Schmid, O. (2018). *Organic Action Plans: Development, Implementation and Evaluation*, 2nd edn. Brussels: IFOAM EU.

Merel, P., Qin, Z. and Sexton, R. J. (2023). Policy-induced expansion of organic farmland: implications for food prices and welfare. *European Review of Agricultural Economics* 50: 1583–631.

Möhring, N. and Finger, R. (2022). Pesticide-free but not organic: adoption of a large-scale wheat production standard in Switzerland. *Food Policy* 106: 102188.

Möhring, N., Muller, A. and Schaub, S. (2021). Pre-registration plan for: "Scaling-up the adoption of organic farming: a systematic scoping review of policy recommendations". https://osf.io/7k9yr

Möhring, N., Muller, A. and Schaub, S. (2024). Dataset on the adoption of organic agriculture.

Muller, A., Schader, C., El-Hage Scialabba, N., Brüggemann, J., Isensee, A., Erb, K. H. Niggli, U. (2017). Strategies for feeding the world more sustainably with organic agriculture. *Nature Communications* 8: 1–13.

Oerke, E. C. (2006). Crop losses to pests. *The Journal of Agricultural Science* 144: 31–43.

Oster, E. (2019). Unobservable selection and coefficient stability: theory and evidence. *Journal of Business & Economic Statistics* 37: 187–204.

Ouzzani, M., Hammady, H., Fedorowicz, Z. and Elmagarmid, A. (2016). Rayyan—a web and mobile app for systematic reviews. *Systematic Reviews* 5: 1–10.

Padel, S. (2001). Conversion to organic farming: a typical example of the diffusion of an innovation? *Sociologia Ruralis* 41: 40–61.

Padel, S., Lampkin, N. and Foster, C. (1999). Influence of policy support on the development of organic farming in the European Union. *International Planning Studies* 4: 303–315.

Pae, C. U. (2015). Why systematic review rather than narrative review? *Psychiatry Investigation* 12: 417.

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D. … Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Systematic Reviews* 10: 1–11.

Pannell, D. and Zilberman, D. (2020). Understanding adoption of innovations and behavior change to improve agricultural policy. *Applied Economic Perspectives and Policy* 42: 3–7.

Parker, D. C. and Munroe, D. K. (2007). The geography of market failure: edge-effect externalities and the location and production patterns of organic farming. *Ecological Economics* 60: 821–833.

Pornpratansombat, P., Bauer, B. and Boland, H. (2011). The adoption of organic rice farming in Northeastern Thailand. *Journal of Organic Systems* 6: 4–12.

Poulsen, M. N., McNab, P. R., Clayton, M. L. and Neff, R. A. (2015). A systematic review of urban agriculture and food security impacts in low-income countries. *Food Policy* 55: 131–146.

Prokopy, L. S., Floress, K., Klotthor-Weinkauf, D. and Baumgart-Getz, A. (2008). Determinants of agricultural best management practice adoption: evidence from the literature. *Journal of Soil and Water Conservation* 63: 300–311.

Rees, C., Grovermann, C. and Finger, R. (2023). National organic action plans and organic farmland area growth in Europe. *Food Policy* 121: 102531.

Rogers, E. M. (2003). *Diffusion of Innovations*. New York: Free Press.

Sander, A., Ghazoul, J., Finger, R. and Schaub, S. (2024). Participation in individual and collective agri-environmental schemes: a synthesis using the theory of planned behaviour. *Journal of Rural Studies* 107: 103255.

Sauer, J. and Park, T. (2009). Organic farming in Scandinavia—productivity and market exit. *Ecological Economics* 68: 2243–2254.

Schaub, S., Ghazoul, J., Huber, R., Zhang, W., Sander, A., Rees, C. Finger, R. (2023). The role of behavioural factors and opportunity costs in farmers' participation in voluntary agri-environmental schemes: a systematic review. *Journal of Agricultural Economics* 74: 617–60.

Schebesta, H. and Candel, J. J. (2020). Game-changing potential of the EU's farm to fork strategy. *Nature Food* 1: 586–588.

Schmidtner, E., Lippert, C., Engler, B., Häring, A. M., Aurbacher, J. and Dabbert, S. (2012). Spatial distribution of organic farming in Germany: does neighbourhood matter? *European Review of Agricultural Economics* 39: 661–683.

Schulze, C., Zagórska, K., Häfner, K., Markiewicz, O., Czajkowski, M. and Matzdorf, B. (2024). Using farmers' ex ante preferences to design agri-environmental contracts: a systematic review. *Journal of Agricultural Economics* 75: 44–83.

Serra, T., Zilberman, D. and Gil, J. M. (2008). Differential uncertainties and risk attitudes between conventional and organic producers: the case of Spanish arable crop farmers. *Agricultural Economics* 39: 219–229.

Seufert, V. and Ramankutty, N. (2017). Many shades of gray—the context-dependent performance of organic agriculture. *Science Advances* 3: e1602638.

Sharma, M. and Pudasaini, A. (2021). What motivates producers and consumers towards organic vegetables? A case of Nepal. *Organic Agriculture* 11: 477–488.

Skolrud, T. (2019). Farm-level determinants of product conversion: organic milk production. *Canadian Journal of Agricultural Economics/Revue Canadienne D'agroeconomie* 67: 261–281.

Scopus. (2022). Sources. https://www2.scopus.com. Accessed 15 December 2022.

Stolze, M. and Lampkin, N. (2009). Policy for organic farming: rationale and concepts. *Food Policy* 34: 237–244.

Sunding, D. and Zilberman, D. (2001). The agricultural innovation process: research and technology adoption in a changing agricultural sector. *Handbook of Agricultural Economics* 1: 207–261.

Swart, R., Levers, C., Davis, J. T. and Verburg, P. H. (2023). Meta-analyses reveal the importance of socio-psychological factors for farmers' adoption of sustainable agricultural practices. *One Earth* 6: 1771–1783.

Taus, A., Ogneva-Himmelberger, Y. and Rogan, J. (2013). Conversion to organic farming in the continental United States: a geographically weighted regression analysis. *The Professional Geographer* 65: 87–102.

Torres, A. P. and Marshall, M. I. (2018). Identifying drivers of organic decertification: an analysis of fruit and vegetable farmers. *HortScience* 53: 504–510.

To The, N. and Nguyen Tuan, A. (2019). Efficiency and adoption of organic tea production: evidence from Vi Xuyen district, Ha Giang province, Vietnam. *Asia-Pacific Journal of Regional Science* 3: 201–217.

Tscharntke, T., Milder, J. C., Schroth, G., Clough, Y., DeClerck, F., Waldron, A. Ghazoul, J. (2015). Conserving biodiversity through certification of tropical agroforestry crops at local and landscape scales. *Conservation Letters* 8: 14–23.

Tyllianakis, E. and Martin-Ortega, J. (2021). Agri-environmental schemes for biodiversity and environmental protection: how we are not yet “hitting the right keys”. *Land Use Policy* 109: 105620.

Veldstra, M. D., Alexander, C. E. and Marshall, M. I. (2014). To certify or not to certify? Separating the organic production and certification decisions. *Food Policy* 49: 429–436.

Web of Science Group. (2022) Master Journal List. https://mjl.clarivate.com/search-results. Accessed 15 December 2022.

Wheeler, S. A. (2008). The barriers to further adoption of organic farming and genetic engineering in Australia: views of agricultural professionals and their information sources. *Renewable Agriculture and Food Systems* 23: 161–170.

Wigboldus, S., Klerkx, L., Leeuwis, C., Schut, M., Muilerman, S. and Jochemsen, H. (2016). Systemic perspectives on scaling agricultural innovations. A review. *Agronomy for Sustainable Development* 36: 1–20.

Willer, H., Schlatter, B. and Trávníček, J. (eds), (2023). Statistics and emerging trends 2023. In: *The World of Organic Agriculture*. Bonn: Research Institute of Organic Agriculture FiBL, Frick, and IFOAM – Organics International, 1–360.

Wollni, M. and Andersson, C. (2014). Spatial patterns of organic agriculture adoption: evidence from Honduras. *Ecological Economics* 97: 120–128.

World Bank Group. (2023a). World development indicators. World Bank. https://datatopics.worldbank.org/world-development-indicators/. Accessed 8 August 2023.

World Bank Group. (2023b). Metadata glossary. https://databank.worldbank.org/metadataglossary/world-development-indicators/series/IT.NET.BBND.P2. Accessed 8 August 2023.

Worldmeter. (2023). Taiwan Population. https://www.worldometers.info/world-population/taiwan-population/. Accessed 8 August 2023.

Wuepper, D., Henzmann, S. and Finger, R. (2023). Measuring farmer time preferences: a systematic literature review for Europe and North America. *Journal of the Agricultural and Applied Economics Association* 2: 823–837.

Yazdanpanah, M., Moghadam, M. T., Zobeidi, T., Turetta, A. P. D., Eufemia, L. and Sieber, S. (2022). What factors contribute to conversion to organic farming? Consideration of the Health Belief Model in relation to the uptake of organic farming by Iranian farmers. *Journal of Environmental Planning and Management* 65: 907–929.