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Determinants of consumer and farmer acceptance of new production technologies: a systematic review

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The agricultural sector faces significant challenges in meeting rising food demands while addressing environmental sustainability and climate change. Adopting advanced technologies is crucial for transitioning to more sustainable farming practices. However, to ensure successful implementation of such technologies, consumers and other food supply chain actors should embrace them. Understanding the factors that hinder or facilitate this acceptance is therefore essential. This systematic review analyzes recent studies on the determinants of acceptance of new crop production technologies aimed at environmental sustainability. Comprehensive searches across three electronic databases were conducted in June 2023, following PRISMA guidelines. Out of 3,010 screened articles, 418 were assessed for eligibility, and 60 papers comprising 69 studies were selected. The review found that consumer acceptance is often limited by emotional barriers and perceived risks, while farmers are mainly concerned with economic factors and business-related risks. Facilitators for both groups include perceived benefits, education, and social networks. The review also highlights gaps in literature, such as the need for more studies using theoretical frameworks and a greater emphasis on social dimensions. This review provides valuable insights for enhancing the adoption of sustainable agricultural technologies and offers recommendations for policymakers, researchers, and practitioners to support the ecological transition in agriculture.

KEYWORDS

sustainability, agri-system, new technology, resistance to innovation, acceptance

1 Introduction

The agricultural sector is at a critical juncture, facing the dual challenge of meeting growing food demand and addressing climate change and environmental sustainability concerns (Agrimonti et al., 2021). The increasing negative impact of agricultural production on water, soil and the atmosphere has brought the sector to a point where an ecological transition is necessary for a sustainable future. A possible solution lies in a gradual technological transition that enables low-impact production, efficient use of resources, and better control and monitoring of agricultural processes (Tolettini and Di Maria, 2023; Zhang et al., 2022). New enabling technologies, often traced to the concept of Agriculture 4.0, have the potential to transform traditional agriculture into a more efficient and sustainable industry. Among the most widely used and efficient technologies are IoT, artificial intelligence, robotics, big data analytics, vertical farming, and drones (da Silveira et al., 2021). In particular, new innovative technologies are designed to optimize resource use, reduce environmental impact, monitor and manage field variability, and improve crop yields. For example, new tools such as precision and smart agriculture, which utilize GPS and IoT devices, or sustainable farming practices, have been developed to enhance productivity while minimizing the environmental footprint, improving yield and pest control, and showing promise in enhancing agricultural sustainability (Finger et al., 2019; Tey et al., 2017). Based on past studies, new technologies applied to the food system in agriculture, aimed at sustainability, refer to innovative approaches that enhance efficiency, minimize environmental impact, and ensure long-term food security (Da Silveira et al., 2021). These technologies include tools such as intelligent systems, including the Internet of Things (IoT), Artificial Intelligence (AI), drones, and big data, to monitor, analyze, and optimize agricultural production. Furthermore, the concept of new technologies also encompasses production methods such as precision agriculture and smart farming, which utilize these tools to manage resources like water and fertilizers more efficiently, reducing waste and improving soil quality (Khan et al., 2021a). However, the acceptance of these technologies by both consumers and farmers is essential for their successful implementation and widespread adoption, as well as by other stakeholders in the agro-food system, such as industries, traders, and institutions, all of whom play important roles in facilitating the transition toward more sustainable and efficient agricultural practices. Nevertheless, the two fundamental actors remain farmers and consumers, whose engagement and support are crucial for ensuring that these innovations meet their needs and gain traction in the market. Indeed, farmers are the primary adopters and implementers of agricultural technologies, yet the demand for the products they produce is largely shaped by consumer preferences. If consumers are not willing to embrace the changes brought about by these technologies, such as purchasing products produced with new methods or technologies, it can significantly undermine the potential for long-term adoption.

On the other hand, if farmers are hesitant to adopt technologies due to concerns about costs, effectiveness, or market reception, it can limit the availability of these innovations in the marketplace. Understanding the perspectives of both consumers and farmers allows us to identify the barriers and facilitators from both ends of the supply chain, ensuring that technological innovations are not only feasible to implement but also have a market that is willing to accept them. Considering both points of view provides a comprehensive understanding of the factors that drive or hinder the success of agricultural technologies, leading to more effective strategies for their integration and wider use within sustainable agro-food systems.

Despite their potential, acceptance and, consequently, adoption of these technologies varies significantly across regions and stakeholders, influenced by a complex interplay of factors including economic, social, and psychological determinants.

As new technologies are crucial for enhancing productivity and environmental sustainability, studies on their acceptance among different actors in the supply chain have been increased conducted in recent years. These studies come from various disciplines—such as economics, sociology, psychology, agricultural sciences, and technological engineering—and analyze a range of factors, often explicitly or implicitly referencing different theoretical approaches (Giacalone and Jaeger, 2023; Siegrist and Hartmann, 2020). There are micro-level theories, mainly from management and ICT studies, that focus on individual decision-making. The Technology Acceptance Model (Davis, 1989) explains innovation adoption based on perceived usefulness (belief that the innovation improves work) and ease of use (the simpler it seems, the higher the adoption likelihood). The Theory of Planned Behavior (Ajzen, 1991) links behavior to intentions, shaped by social influence (perceived social pressure), perceived control (confidence in adopting the behavior), and personal attitude toward innovation. Venkatesh et al. (2003) merge these theories and add contextual factors, such as existing infrastructures, which can facilitate innovation adoption.

Another set of theories, from sociology, examines innovation systems and the social processes behind innovation diffusion and emphasize non-instrumental rationality in innovation processes. In Diffusion of Innovations (1962), Rogers identifies cognitive and psychological (such as knowledge of the innovation and openness to change), economic (availability of resources), and social factors affecting adoption (degree of cosmopolitanism and participation in organizations or associations). He classifies adopters into innovators, early adopters, and late adopters, highlighting how peer influence shapes adoption. Trustworthy information, especially for risky decisions, often comes from through informal interactions with close actors who have direct experience with the innovation (Rogers, 1962; Coleman et al., 1957).

These perspectives focus on cognitive-psychological or social dimensions of innovation. The ecological model developed by Story et al. (2008) integrates both, viewing behavior as shaped by interactions across multiple levels: individual factors (personal and psychological factors), social environments (networks, interactions with family, friends, peers, and others), physical environment (settings where behavior takes place, such as home, schools, supermarkets), and macrolevel environments (societal and cultural norms, food industry, agriculture policies). This model is also related to the ecological framework developed by Bronfenbrenner (1979) which helps to understand how people behave while interacting with their environment (Sallis et al., 2008). In this review, we utilized this approach to analyze factors related to the individual, social, physical, and macrolevel environments.

This systematic review aims to analyze and synthesize the most recent studies on the determinants of consumer and farmer acceptance of new crop production technologies oriented toward environmental sustainability. By identifying key facilitators and barriers, this review seeks to provide insights that can inform policymakers, researchers, and practitioners in promoting the adoption of sustainable agricultural technologies. The review seeks to address the following research questions:

- RQ1) What are the main factors influencing consumer acceptance of new crop production technologies?
- RQ2) What are the key determinants of farmer acceptance of these technologies?

- RQ3) What are the common facilitators and barriers to the adoption of sustainable crop production technologies?
- RQ4) What are the main shortcomings in the literature on the acceptance of new technologies aimed at fostering sustainable development?

By answering these questions, this review aims to contribute to a deeper understanding of the complexities surrounding the acceptance of sustainable agricultural technologies and provide recommendations to enhance their adoption.

2 Methodology and methods

The review was conducted and reported following the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009). PRISMA provides a rigorous approach to reviewing studies. It has been widely applied in systematic reviews in health settings but is increasingly being used in other domains such as food acceptance (Baker et al., 2022).

2.1 Eligibility criteria

The PICO (Population Intervention Comparison and Outcome) acronym (Methley et al., 2014) was used to refine the eligibility criteria for the review. Table 1 outlines the eligibility criteria upon which this work was based. Our focus was on quantitative, evidence-based research aimed at understanding consumer and farmer acceptance of new technologies, oriented toward environmental sustainability, and applied to crop production (cereals, vegetables, fruits, etc.).

It is important to clarify what is meant by "new technology" applied in crop production and oriented toward environmental sustainability. Indeed, defining "new" crop production technology with an orientation toward sustainability is complex, and there are no consistent definitions in the literature. For example, some studies do not consider genome editing as a "new" technology and do not view it as always beneficial to the environment, although it has recently been introduced into agricultural systems with some environmental advantages (Mutenje et al., 2019; Thierfelder et al., 2017). Given the ambivalence of this theme, we considered as *new technologies* applied to crop production and oriented toward sustainability those mapped by a recent systematic review conducted by Khan et al. (2021b). This

TABLE 1 Eligibility criteria for systematic review.

	Inclusion criteria	Exclusion criteria
Population	• Minimum age of 18 years • Farmers (crop production) • Healthy consumers	• Children/<18 years old • Non crop farmers • "Expert" consumers (e.g., good tasters/trained panelists) or patients
Intervention type	• Interventions enabled by new technology geared toward environmental sustainability (e.g., use of drones, apps, genetic technologies, etc.) used by farmers in crop production • Interventions enabled by new technology and applied to crop food products to improve their sustainability	• Interventions involving the use of new technologies not geared toward environmental sustainability • Interventions involving the use of technologies not applied to crop production • New technological interventions on food products not grown in the field (meat, fish, insects)
Study type	• Quantitative studies exploring acceptance of technology, oriented toward environmental sustainability, used in crop production • Quantitative studies exploring acceptance of crop food products on which these technologies are applied • Quasi-experimental studies, cross sectional studies, experimental studies are considered	• Study Protocols • Opinion pieces • Review papers • Book chapters • Conference abstract • Dissertations • Letters • Qualitative studies
Outcome measures	• Acceptance of new technology oriented toward environmental sustainability, used in crop production • Acceptance of crop food products on which these new technologies are applied	• Absence of new technology • Absence of acceptance data related to these new technologies • Absence of crop food products acceptance data
Study analysis	• Quantitative data focusing on the analysis of barriers or facilitators toward the acceptance of novel technologies oriented toward environmental sustainability and applied to crop production • Quantitative data focusing on the analysis of barriers or facilitators toward the acceptance of crop food products on which these new technologies have been applied	• No analysis of data reported • Qualitative Data • Data not focused on analysis of barriers or facilitators toward acceptance of technology oriented toward environmental sustainability and applied to crop production • Data not focused on analysis of barriers or facilitators toward acceptance of crop food products on which these new technologies have been applied
Publication criteria	• Published in peer-reviewed journals • Published in the English language	• Published in a language other than English with no peer-reviewed English translation available

study identifies the main modern technologies specifically designed to promote sustainable crop food systems and organizes them into the following macro-categories: digital and cellular agriculture, gene technology, inputs intensification, replacement food and feed, resource use efficiency, health, food processing, and safety.

2.2 Search strategy

An extensive search strategy was developed to retrieve peer reviewed publications on the acceptance of new crop production technologies or crop food products to which these technologies are applied, with a focus on environmental sustainability. The strategy combined title and abstract words (keywords). Four main groups of search terms were generated to describe: (I) the phenomenon of interest, namely, technologies or innovations oriented toward environmental sustainability; (II) the specific field of interest (e.g., food, agrifood, agrisystem, etc.); (III) the evaluation of the phenomenon, namely, the acceptance of these technologies, encompassing indicators such as likelihood or intention to perform a behavior, perceived benefits/risks, willingness to pay, perception, adoption, and attitudes; (IV) the subjects of interest, namely, consumers and farmers. The search was limited to articles published from 2019 to the present, to ensure the work is up-to-date and reliable. This time restriction was introduced because a systematic and comprehensive literature review was published in early 2019 (Kamrath et al., 2019). However, that review is now outdated due to the rapid growth of heterogeneous literature on this topic in recent years and the increasingly rapid developments in agricultural technology. Therefore, a new systematic review was necessary. Compared to the previous review, our study is innovative as it includes the most recent research on a wider range of new technologies applied to crops aimed at sustainable development.

To carry out our systematic review, we developed the following string:

TITLE-ABS-KEY (tech*) OR TITLE-ABS-KEY (innovation)

AND TITLE-ABS-KEY (sustainab*) OR TITLE-ABS-KEY ("sustainable development") OR TITLE-ABS-KEY ("circular economy") OR TITLE-ABS-KEY (green)

AND TITLE-ABS-KEY (agrofood) OR TITLE-ABS-KEY (agro-food) OR TITLE-ABS-KEY (agrifood) OR TITLE-ABS-KEY (agri-food) OR TITLE-ABS-KEY (food) OR TITLE-ABS-KEY (agrisystem)

AND TITLE-ABS-KEY (acceptance*) OR TITLE-ABS-KEY (opinion*) OR TITLE-ABS-KEY (reaction*) OR TITLE-ABS-KEY (motiv*) OR TITLE-ABS-KEY (barrier*) OR TITLE-ABS-KEY (deterrent*) OR TITLE-ABS-KEY (driver*) OR TITLE-ABS-KEY (obstacle*) OR TITLE-ABS-KEY (resistance*) OR TITLE-ABS-KEY (perception*) OR TITLE-ABS-KEY (attitud*) OR TITLE-ABS-KEY (evaluation*) OR TITLE-ABS-KEY (valuation*) OR TITLE-ABS-KEY (adopt*) OR TITLE-ABS-KEY (expectation*) OR TITLE-ABS-KEY (determinant*) OR TITLE-ABS-KEY (facilitator*) OR TITLE-ABS-KEY (enabler*)

AND TITLE-ABS-KEY (consumer*) OR TITLE-ABS-KEY (citizen*) OR TITLE-ABS-KEY (shopper*) OR TITLE-ABS-KEY (user*) OR TITLE-ABS-KEY (public) OR TITLE-ABS-KEY (farmer∗) OR TITLE-ABS-KEY (stakeholder∗) OR TITLE-ABS-KEY ("supply chain∗") OR TITLE-ABS-KEY (producer*)

AND PUBYEAR >2019

This search strategy was applied to the SCOPUS, PSYCINFO and WEB OF SCIENCE databases during the third week of June 2023 and was limited to English language and peer-reviewed studies. The reference lists of eligible studies and review articles were scanned to identify any missed articles. Authors were contacted to obtain original measurement development studies when they were referenced as unpublished or unavailable.

2.3 Selection and screening of studies

Screening of relevant studies was based on well-defined criteria before data extraction was performed.

We used a three-phase screening process to select eligible studies. In the first phase, the initial screening was conducted by the first author using Zotero to eliminate duplicate articles. The second phase involved screening the titles and abstracts. Abstracts were distributed equally among six team members for independent screening. To ensure the quality and consistency of the process, the first 10% of each reviewer's titles and abstracts were screened by all team members, with a comparison of included and excluded titles; disagreements were resolved through discussion. This ensured that eligibility criteria were applied consistently to the remaining 90% of titles and abstracts.

The researchers then proceeded with the third and final screening phase, reviewing the full text to exclude articles not in line with the study's objectives, using the same selection process described above.

2.4 Data extraction

After screening and confirming the relevance of selected studies, a database was constructed. The following information was extracted from the selected studies: author(s), year of publication, countries where the study was carried out, study population, sample characteristics (including sample size), study design, target of the study (farmers or consumers), type of new technology, factors influencing technology acceptance, theoretical framework, and the relationships between identified factors and the technology acceptance. Specifically, two databases were created: the first includes all the information related to the selected papers and the investigated technologies, and the second provides a comprehensive overview of studies focusing on the independent variables that impact the acceptance of new technologies oriented to environmental sustainability and applied to crop production considering the perspective of farmers and consumers. Given the assortment of variables used to map the enablers and barriers related to the acceptance of new technologies, we organized these variables into categories to make the results easier to analyze and interpret.

2.5 Procedure of grouping independent and dependent variables

Two different types of information extracted from the studies were grouped into macro-categories, namely, *independent* variables that impact new technology acceptance, and the *dependent* variables used to measure acceptance toward technologies.

A qualitative content analysis procedure, widely used to analyze textual data (Hsieh and Shannon, 2005), was adapted to reduce the number of categories separately for dependent and independent variables. More specifically, conventional content analysis (Hsieh and Shannon, 2005; Schilling, 2006), also described as inductive category development, was applied because this procedure allows categories and their names to emerge from the data instead of using preconceived categories (Hsieh and Shannon, 2005). The procedure for developing the categories of the extracted information was carried out independently by three researchers (GC, SR, and VM).

To handle the large amount of data, all the information related to dependent and independent variables extracted was separately transcribed into Excel. Afterward, this information was carefully re-read, and items referring to the same key concept were grouped under the same macro-category, with labels identified that were consistent with the grouped information. For example, in analyzing the independent variables considered by different studies, some investigated interest, importance, and the need to read the label, variables that we grouped under the macro-category labeled "attitude toward labels." Regarding the grouping of dependent variables used to measure acceptance toward technologies, some studies measured willingness to buy, purchase intention, predisposition to buy, and intention to consume, which we grouped under the macro-category labeled "intention to buy/consume."

Finally, the macro-categories were further validated (formative check of reliability) by the three researchers (GC, SR, and VM), who checked the level of agreement among the independently created categories and discussed cases of doubt and overlapping labels.

2.6 Data analysis and synthesis of results

The variables extracted were subjected to descriptive statistical analysis specifically frequency distributions. When a paper reported findings from different contexts (such as supply chain actors—farmers or consumers-, products, or technologies), it was counted as double or triple study based on information reported for each context. For example, the paper written by Lioutas and Charatsari, 2020 was counted as two studies since it focuses on both consumers and farmers. Therefore, bibliometric data (Table 2 and Figures 1, 2) are reported considering the total number of papers ($n = 60$), while the rest of the data are reported considering the total number of studies ($n = 69$).

Moreover, the macro-categories concerning the independent variables were classified according to the multilevel ecological model of factors influencing behavior described in the introduction (Sallis et al., 2008) that identifies the following distinct factors to understand how people behave in interaction with their environment: individual factors (personal and psychological factors), social environments (networks, interactions with family, friends, peers, and others), physical environment (settings where behavior takes place, such as home, schools, supermarkets), and macrolevel environments (societal and cultural norms, food industry, agriculture policies).

To analyze the relationships between independent variables, divided into macro categories, and the acceptance of new technology, a Correspondence Analysis (CA) was performed. This analysis allows us to explore and group the association between the two actor categories (consumer and farmers) and the different selected enablers and barriers, considering the system to which they belong (Bronfenbrenner, 1979). CA is a statistical technique used to identify patterns and associations between categorical variables and simultaneously organize them graphically within the same dimensional space along with the considered actor categories (nominal variables) (Merlino et al., 2021).

Correspondence Analysis (CA) plots the frequency points of the rows and columns of a contingency table in a shared geometric space, creating a data representation within an area structured by chi-square distance. It then represents the variables based on the identified principal components (axes) (Ayele et al., 2014; Beldona et al., 2005; Gursoy and Chen, 2000). In the resulting map, closer proximity between points indicates a higher proportion associated with different levels of rows and columns. All eigenvalues (estimated dimensions, single significant values higher than 0.20, inertia, and the proportion explained by each dimension) were reported in the results section (Hair et al., 1998).

3 Results

3.1 Search results

A total of 3,971 papers were retrieved. In the first screening round, 961 duplicate articles were eliminated. The second round of screening focused on the title and abstracts on the remaining 3,010 papers. After applying the eligibility criteria, 418 articles were judged as potentially relevant. A final screening phase based on the full-text was conducted to exclude articles not aligned with the study's objectives. Additionally, review articles identified during these screening processes were scanned to find any missed articles. Based on the eligibility criteria, 60 papers were ultimately selected, encompassing a total of 69 studies (Figure 3).

3.2 Overview of studies and technologies

Table 2 provides an overview of the included papers. As mentioned in the introduction, the distributions of the 60 papers by year of publication and country shows that in recent years there has been increasing interest in new technologies applied to crop production, with most studies conducted in China and Italy (see Figures 1, 2). Although, Figure 1 shows a decrease in studies for 2023, this is likely influenced by the fact that this review only included papers published up to June 2023 and therefore does not account all publications from that year. Most of the studies are cross-sectional ($n = 47$; 78%), nine used an experimental design (15%), and the remaining four employed mixed methods (7%). Sample sizes of the studies vary from $n = 98$ to $n = 3{,}584$.

Table 3 shows the distribution of the 69 studies by target group, revealing that 29 studies focused on consumers while 40 involved farmers. Additionally, most studies focused on gene technologies (25%) and digital technologies (25%). However, the studies involving farmers primarily focused on digital technologies (38%) and inputs (33%), while those involving consumers mainly examined the acceptance of technologies related to resource use efficiency (42%). In Supplementary Table 2A, a detailed description of the considered technologies/approaches is reported.

TABLE 2 General features of included papers (*n* = 60).

Authors/years	Country	Study design	Sample size	Age range (mean years, SD)	Gender (% female)
McCarthy et al. (2019)	Australia	Quantitative (Cross sectional)	330	18-over 60 (NR; NR)	60%
Mutenje et al. (2019)	Multicountry (Malawi, Mozambique, and Zambia)	Mixed method (Quantitative = Cross sectional and qualitative = focus group)	Quantitative = 3,584; Qualitative = 72 focus groups	NR	NR
Baiyegunhi et al. (2019)	Nigeria	Quantitative (Cross sectional)	643	NR (42.22; NR)	NR
Cattaneo et al. (2019)	Italy	Quantitative (Cross sectional)	273	18–72 (43.9; 12.7)	53.90%
**Nitzko and Spiller (2019)	Germany	Quantitative (Cross sectional)	470	NR	51.10%
Powell et al. (2019)	UK	Quantitative (experiment)	510	18–70 (34.33; 9.89)	50.00%
Wilde et al. (2019)	South Africa	Quantitative (Cross sectional)	392	NR	59.90%
Zhang et al. (2019)	China	Quantitative (Cross sectional)	490	NR (49.84; 7.08)	NR
Aryal et al. (2020)	India	mixed method (Quantitative = Cross sectional and qualitative = focus group)	Quantitative = 1,267; Qualitative = 55	NR	NR
Chuang et al. (2020)	Taiwan	Quantitative (Cross sectional)	321	>18 (42.61; 13.57)	20.90%
**Coderoni and Perito (2020)	Italy	Quantitative (Cross sectional)	477	18–90 (40.56; 13.79)	NR
Li et al. (2020)	China	Quantitative (Cross sectional)	456	27–85 (59.5; NR)	54.80%
Perito et al. (2020)	Italy	Quantitative (Cross sectional)	852	NR (37.5; NR)	65.00%
Perito et al. (2019)	Italy	Quantitative (Cross sectional)	289	NR	NR
**Lioutas and Charatsari (2020)	Greece	mixed method (Quantitative = Cross sectional and qualitative = depth interviews)	Farmers = 98; consumers = 106	NR (43.1; 10.9) NR (41.1; 11.2)	First sample = 35,70%; second sample = 56.60%
Manda et al. (2020)	Nigeria	Quantitative (Cross sectional)	1,525	NR	NR
Martey et al. (2020)	Ghana	Quantitative (Cross sectional)	200	NR	NR
McFadden et al. (2021)	USA	Quantitative (Cross sectional)	1,185	>18 (43; NR)	50%
Ali B.M. et al. (2021)	Multicountry (Germany, Italy and Netherlands)	Quantitative (Cross sectional)	291	18–75 (37.23; 13.51)	Majority are females
Ali S. et al. (2021)	Hungary	mixed method (Quantitative = Cross sectional and qualitative = depth interviews)	Quantitative = 499; qualitative = 20	18–80 (31; NR)	64%
Ares et al. (2021)	Multicountry (China, Singapore, UK, and USA)	Quantitative (Cross sectional)	UK = 637; US = 644; SG = 673; CN = 683	18-59 (NR; NR)	49% (UK) 50% (US) 48% (SG) 51% (CN)
Borrello et al. (2021)	Italy	Quantitative (experiment)	627	>18 (32.9; 11.7)	47.20%
Coderoni and Perito (2021)	Italy	Quantitative (Cross sectional)	317	19–40 (27; NR)	64%
Pruitt et al. (2021)	USA	Quantitative (experiment)	282	NR (24.14; 7.26)	59.14%
Qi et al. (2021)	China	Quantitative (experiment)	312	24–84 (54.14; 11.28)	37.20%
Ramírez-Orellana et al. (2021)	Ecuador	Quantitative (Cross sectional)	416	NR	NR

(Continued)

TABLE 2 (Continued)

Authors/years	Country	Study design	Sample size	Age range (mean years, SD)	Gender (% female)
Ricart and Rico-Amorós (2021)	Spain	Quantitative (Cross sectional)	177	NR	NR
Scozzafava et al. (2021)	Italy	Quantitative (experiment)	100	18–54+ (46; NR)	60%
Serote et al. (2021)	South Africa	Quantitative (Cross sectional)	100	NR (48.76; 1.86)	55%
Shahzad et al. (2021)	Pakistan	Quantitative (Cross sectional)	540	NR (47.22; 11.26)	NR
Mwangi et al. (2021)	Kenya	Quantitative (experiment)	452	NR (45.3; NR)	18.80%
Wang et al. (2021)	China	Quantitative (Cross sectional)	261	NR	NR
**Kolady et al. (2021)	USA	Quantitative (Cross sectional)	198	NR (59.4; NR)	NR
Ahmed (2022)	Ethiopia	Quantitative (Cross sectional)	355	NR (37.67; 8.86)	NR
Araujo et al. (2022)	Canada	Quantitative (Cross sectional)	166	18–57 + (NR; NR)	NR
Baiyegunhi et al. (2022)	Nigeria	Quantitative (Cross sectional)	200	NR (55.46; 13.24)	26%
Setsoafia et al. (2022)	Ghana	Quantitative (Cross sectional)	1,284	NR (47.76; 14.49)	16%
Shahbaz et al. (2022)	Pakistan	Quantitative (Cross sectional)	384	NR (41.02; 10.76)	100%
Sheikh et al. (2022)	Pakistan	Quantitative (Cross sectional)	504	NR	NR
Motoki et al. (2022)	Japan	Quantitative (experiment)	117	NR (41.25; 9.60)	40.00%
Strong et al. (2022)	Brazil	Quantitative (Cross sectional)	344	NR	NR
Sunny et al. (2022)	Bangladesh	Quantitative (Cross sectional)	405	NR	NR
Taufik et al. (2022)	Netherlands	Quantitative (Cross sectional)	969	NR (48.9; NR)	51.30%
Vecchio et al. (2022)	Multicountry (Italy-UK-USA)	Quantitative (Cross sectional)	ITA = 752; UK = 858; USA = 856 (2,466)	NR	50.70%; 51%; 50.70%
Vindigni et al. (2022)	Italy	Quantitative (Cross sectional)	700	NR	65.00%
Xu et al. (2022)	China	Quantitative (Cross sectional)	402	25–55 (NR; NR)	NR
Guo et al. (2022)	China	Quantitative (Cross sectional)	280	NR	NR
Hashemzadeh et al. (2022)	Iran	Quantitative (experiment)	550	25–49 (31.4; NR)	68%
Hüttel et al. (2022)	Germany	Quantitative (Cross sectional)	98	21–75 (41.17; NR)	6.10%
Liu et al. (2022)	China	Quantitative (Cross sectional)	Farmers = 232; consumers = 163	NR	17%
Martínez-Filgueira et al. (2022)	Spain	Quantitative (Cross sectional)	283	NR	NR
Baum et al. (2023)	USA	Quantitative (Cross sectional)	158	18-over 55 (NR; NR)	50.60%
**Chen et al. (2023)	USA	Quantitative (Cross sectional)	132	NR	NR
Seong et al. (2023)	USA	Quantitative (Cross sectional)	2,114	18–80+ (NR; NR)	53.74%
Serote et al. (2023)	South Africa	Quantitative (Cross sectional)	100	NR	NR
Piwowar et al. (2023)	Poland	Quantitative (Cross sectional)	500	20–44 (NR; NR)	51.40%
Wu et al. (2023)	China	Quantitative (Cross sectional)	288	NR	51.70%
**Yang et al. (2023)	China	Quantitative (Cross sectional)	1,282	NR	NR
Giacalone and Jaeger (2023)	Multicountry (Australia, India, Singapore, and USA).	Quantitative (Cross sectional)	2,494	18–69 (NR; NR)	50%
Grimm and Luck (2023)	Indonesia	Quantitative (experiment)	Quantitative = 1,200; qualitative = 20	NR (53.74; 11.78)	17%

NR = Not Reported; ** these papers include multiple studies. In particular, Chen et al. (2023) five studies, Coderoni and Perito (2020) two studies, Nitzko and Spiller (2019) two studies, Yang et al. (2023) two studies, Kolady et al. (2021) two studies, Lioutas and Charatsari (2020) two studies.

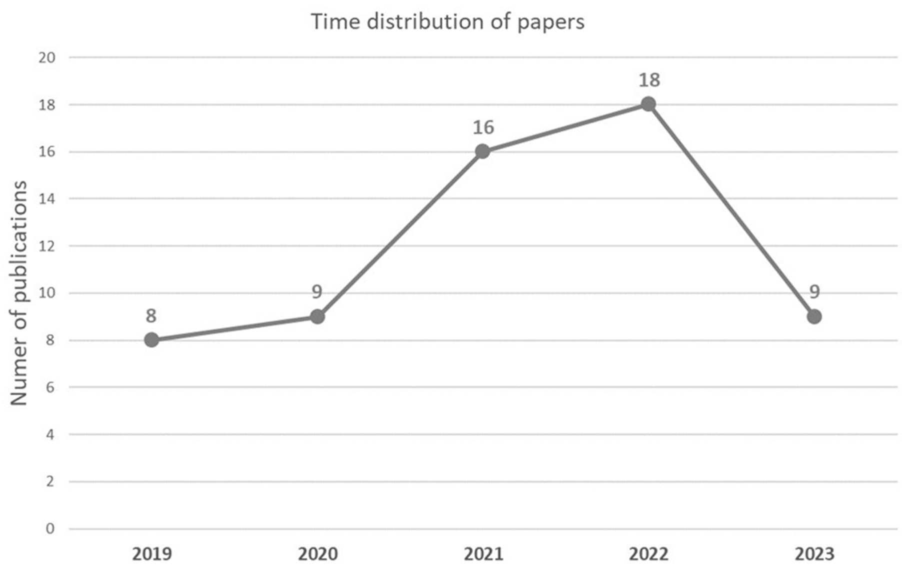

FIGURE 1
Time distribution of papers (n = 60).

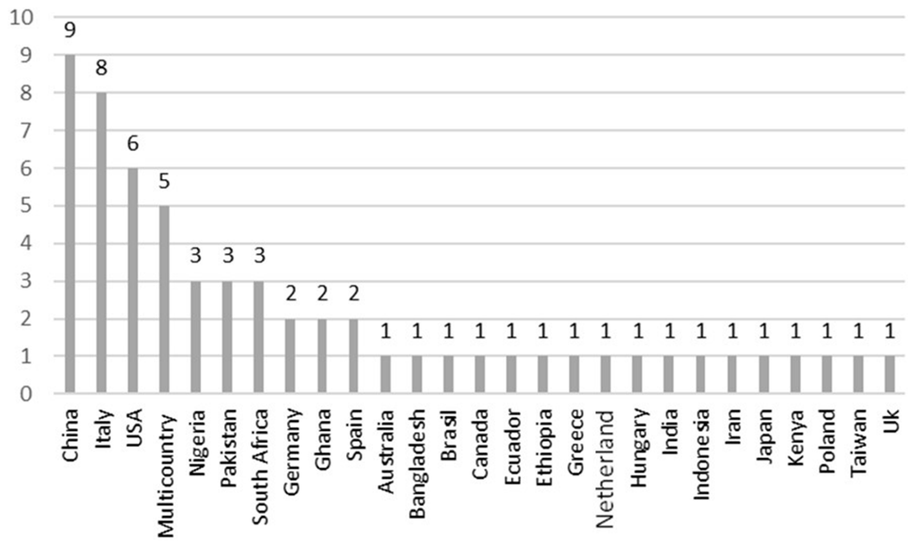

FIGURE 2
Geographical distribution of papers (n = 60).

3.3 Overview of variables and framework used by the included studies

The studies analyze 685 independent variables, which are grouped into 76 macro-categories. However, some macro-categories contained fewer than three variables, highlighting their limited presence in the literature and, consequently, their lower relevance in influencing technology acceptance. To streamline the presentation of results and focus on the most significant data, we have excluded these macro-categories from the charts and tables below. However, to ensure comprehensive documentation of all variables and macro-categories found in the literature, Supplementary Table 1A provides a complete overview, listing both the macro-categories and independent variables extracted from previous studies, as well as those considered in our analysis for consumers and farmers. Consequently, this study analyzes a total of 641 independent variables, grouped into 54 macro-categories. Table 4 presents the macro-categories highlighting their frequency. The results show that, although 13 macro-categories are studied for both farmers and consumers (italicized in Table 4), most differ by target group. When examining the distribution of macro-categories across all studies, the results indicate that socio-demographic variables, particularly education (7%) and age (7%), are the most frequently analyzed.

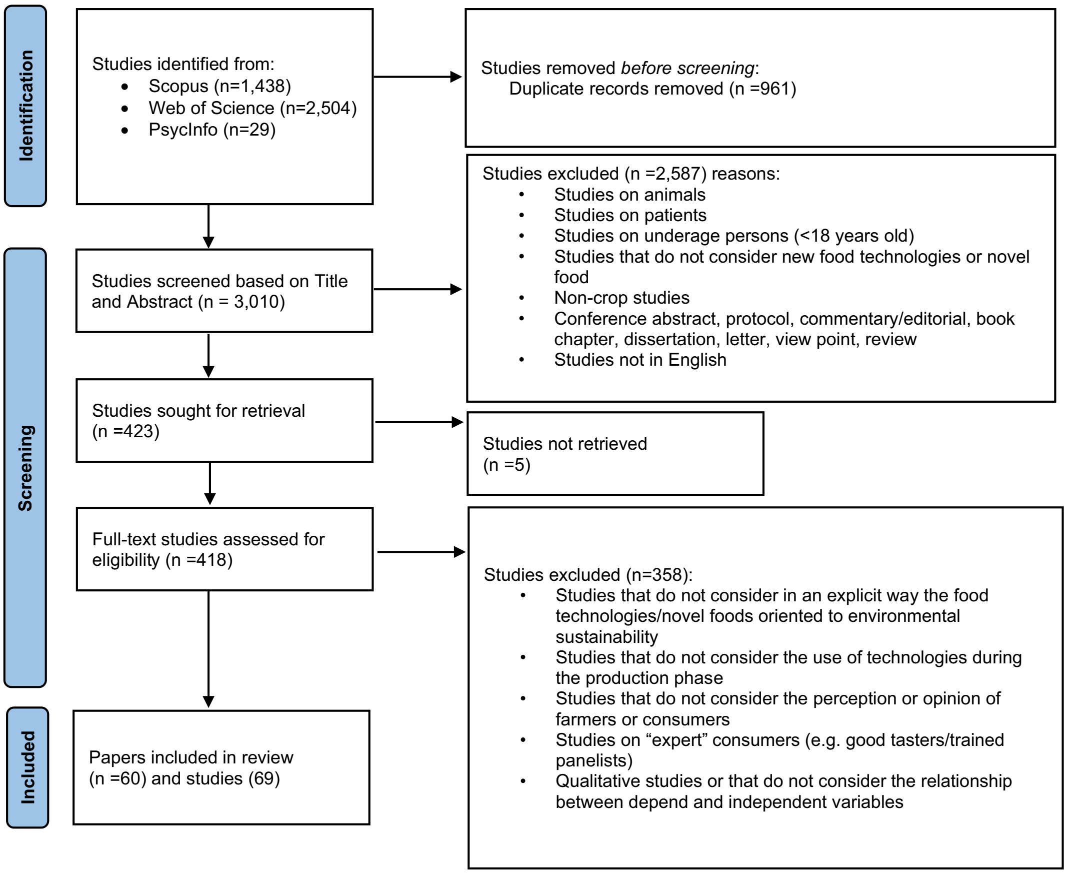

FIGURE 3
PRISMA flow diagram of study selection.

Table 5 shows the distribution of dependent variables and frameworks investigated by the studies. Most research on new technologies consider the intention to use a technology as the dependent variable (55%), followed by the intention to buy or consume the food products associated with the technology (35%). For consumer studies, the majority focus on acceptance in terms of purchase or consumption intention (80%). In contrast, the intention to use or adopt a technology (95%) is the most frequently used dependent variable in studies involving farmers.

Regarding reference frameworks, it is notable that most studies did not employ theoretical models or frameworks when analyzing the acceptance of new technologies (94%), with this percentage increasing for studies focused on consumers (97%).

3.4 Classification of macro-categories related to independent variables used by the included studies

Table 6 shows that most macro-categories of independent variables analyzed in the studies fall under the *individual environment* (50%). These include socio-demographic variables (e.g., age, gender) and characteristics related to farm attributes (e.g., total workers, size or type of land). Additionally, 28% of the macro-categories pertain to the *physical environment*, focusing on participants' perceptions and opinions about the new technology or the foods on which these technologies were applied. Lastly, 18% of the macro-categories relate to the macro-level *environment*, examining aspects such as government policies, the economic system, and macro-structures. Only 4% of the macro-categories are concerned with the *social environment*, including factors like association membership and relationships with others.

This distribution is similar for both farmers and consumers. However, studies on farmers investigate macro-level factors more frequently compared to those involving consumers (20% vs. 15%), while physical characteristics related to technology are more frequently studied in consumer research (31% vs. 27%).

3.5 The impact of independent variables on technology and novel foods acceptance: a comparison between farmers and consumers

The results of the Correspondence Analysis on the association between actor categories (consumer and farmers) and the selected barriers belonging to different systems identified by Bronfenbrenner are illustrated in Figure 4. The eigenvalues (including estimated dimensions, singular values, inertia, and the proportion of variance explained by each dimension) are detailed in Table 7. The

TABLE 3 Participants involved and type of technologies considered by the studies (n = 69).

	Consumers (*N*; %)	Farmers (*N*; %)	Total (*N*; %)
*Studies**	(29; 42%)	(40; 58%)	(69; 100%)
Cluster of technology in the studies			
Resource use efficiency (e.g., circular economy, upcycling technology)	(12; 42%)	(1; 2%)	(13; 18%)
Gene technology (e.g., gene editing, genome-wide selection)	(8; 28%)	(9; 23%)	(17; 25%)
Inputs (e.g., eco-friendly fertilizer, micro-irrigation)	(1; 3%)	(13; 33%)	(14; 20%)
Intensification (e.g., vertical agriculture, indoor agriculture)	(3; 10%)	(1; 2%)	(4; 6%)
Digital agriculture (e.g., sensing and monitoring, robotic, AI)	(2; 7%)	(15; 38%)	(17; 25%)
Replacement food and feed (e.g., livestock substitutes, seaweed for food)	(3; 10%)	(1; 2%)	(4; 6%)

Percentages are calculated for each column (farmers, consumers, and total studies).

Correspondence Analysis revealed two significant principal dimensions (axes), accounting for 75% of the total variance (Hair et al., 1998). The first dimension (38% of the explained proportion) was called (*Economic and practical considerations vs. psychological and perceptual factors*): this dimension primarily differentiates farmers and consumers based on the nature of their concerns regarding technology adoption. Farmers' acceptance was more strongly associated with economic and operational factors, such as cost, farm size, financial risk, and access to government support. In contrast, consumer acceptance was more influenced by psychological factors, including perceived health benefits, environmental sustainability, and food neophobia. The second dimension (37%, *External structural influences vs. individual attitudes and experience*) captured the extent to which external structural factors (e.g., government policies, market trends, access to technology) influence adoption, as opposed to individual-level attitudes and experience with technology. Farmers were more likely to be affected by structural aspects such as farm regulations and incentives, while consumers' attitudes were shaped by factors like prior exposure to novel food products, sustainable consumption habits, and trust in institutions.

A comparison of the main barriers to technology acceptance among farmers and consumers shows notable differences (Figure 4). For consumers, individual variables and physical factors related to the product or technology are the strongest barriers. Specifically, emotional variables such as food technology neophobia, food neophobia, and generally negative emotions toward technology are significant obstacles. Additionally, the cost of the products and health risk associated with consumption are also important barriers.

In contrast, farmers face a broader range of barriers. These include individual environment factors related to farm characteristics (e.g., distance from the market, soil fertility), macro-system factors, and physical environment factors related to the characteristics of the technologies. Economic factors, particularly the risk associated with purchasing technologies and the cost of investment/raw material, emerge as the most significant barriers. Socio-demographic variables such as gender (female) age (older individuals) and household size are also relevant but play lesser role compared to other variables.

Regarding the facilitators of technology acceptance, the results indicate that, similar to barriers, variables related to technological characteristics (physical environment) and individual factors are the most impactful for consumer. Perceived benefits—such as health improvements, environmental sustainability, and product quality—play a critical positive role. Positive emotions toward the technology also significantly enhance acceptance. Psychographic variables, including interest in health, sustainability, personal values, inclination toward innovation, and urban living, are key individual facilitators.

For farmers, facilitators are primarily related to farm characteristics (individual environment), mirroring the barriers identified. However, education opportunities for using the technologies, financial support, and government incentives also play a crucial role. Additionally, experience and knowledge about new technologies are significant facilitators. Social environment variables, while less studied in the literature, are also important. The results suggest that subjective norms and membership groups have a substantial impact on farmers compared to consumers: the flow of information and trust within peer networks, supported by peer-monitoring mechanisms, can decisively influence decisions in high-uncertainty situations.

4 Discussion

The systematic review identified 60 articles comprising a total of 69 studies. This selection provides a detailed overview of recent research—since 2019 up to today—on new technologies applied to agricultural production, highlighting some interesting trends and significant differences between consumer-focused and farmer-focused studies.

The distribution of articles by year and country shows a growing interest in new technologies in agriculture, with a significant concentration of studies in China and Italy. This is in line with the reports of Zhang et al., 2019, who point to an acceleration in agricultural research and development in these countries. The predominance of cross-sectional studies reflects a common and persistent approach in the social and agricultural sciences to assess attitudes and perceptions at a particular point in time, as also indicated by recent literature Narwane et al., (2019). However, cross-sectional studies have several limitations. They cannot establish causality or the direction of relationships between variables, leading to temporal ambiguity. These studies are prone to selection and recall bias, limiting the generalizability and accuracy of findings. Additionally, they only provide prevalence data at a single point in time, making it difficult to assess changes or development over time. Consequently, there is a need to conduct more experimental or longitudinal studies to overcome these limitations.

TABLE 4 Distribution of independent variables (*n* = 641) by macro-categories (*n* = 54).

Consumer		Farmer		Total	
Independent variable (*n* = 222)	%	Independent variable (*n* = 419)	%	Independent variable (*n* = 641)	%
Attitude toward technology/foods	8	*Education*	7	Education	7
Education	7	*Age*	6	Age	7
Age	7	Farm size	6	Knowledge about technology/ food	6
Gender	7	Membership group	5	Gender	6
Sustainable consumption	7	*Income*	5	Income	5
Quality perception of product	6	*Knowledge about technology/food*	5	Farm size	4
Knowledge about technology/food	6	*Gender*	5	Membership group	4
Perceived health benefits	6	Educational opportunity	5	Attitude toward technology/ foods	4
Attitude toward environment	5	Farm Level of technological integration in the farm	4	Educational opportunity	3
Perceived environmental benefits	5	Ease of use	4	Perceived economic benefits	3
Food Technology neophobia	5	Credit availability	3	Level of technological integration in the farm	2
Place of consumption	4	Workforce	3	Ease of use	2
Income	4	Government support	3	Sustainable consumption	2
Living area	4	*Perceived economic benefits*	3	Perceived environmental benefits	2
Innovativeness	3	Water availability	3	Attitude toward environment	2
Attitude toward labels	3	Negative emotions toward technology	2	Quality perception of product	2
Perceived economic benefits	2	*Trust in institutions*	2	Credit availability	2
Food Neophobia	2	Position of farm	2	Perceived health benefits	2
Price/cost of food	2	Distance from market	2	Workforce	2
Trust in institutions	1	*Subjective norms*	2	Government support	2
Subjective norms	1	Personal experience of farming	2	Trust in institutions	2
Knowledge about environmental thematic	1	*Knowledge about environmental thematic*	1	Water availability	2
Household size	1	*Household size*	1	Negative emotions toward technology	2
Personal value	1	Trust in Technology	1	Subjective norms	2
Perceived health risk	1	Perceived economic risks	1	Food Technology neophobia	2
Attitude toward health	1	Land typology	1	….	1
		Attitude toward technology/foods	1		
		Positive emotions toward technology	1		
		Perceived usefulness of technology	1		
		Occupation	1		
		Fertile soil	1		
		Trust in data privacy	1		
		Land ownership	1		
		Cost of investment	1		
		Perceived social benefits	1		

(Continued)

TABLE 4 (Continued)

Consumer		Farmer		Total	
Independent variable (*n* = 222)	%	Independent variable (*n* = 419)	%	Independent variable (*n* = 641)	%
		Management decisions	1		
		Experience about environmental thematic	1		
		Price/cost of raw materials	1		
		Innovativeness	1		
		Perceived environmental benefits	1		
		Social status	1		

Percentages are calculated for each column (Farmers, consumers, and total studies); macro-categories written in italics identify those in common between farmers and consumers.

TABLE 5 Independent variables and theoretical framework on total studies (*n* = 69).

Factor analyzed	Consumer studies (*n* = 29) (*n*; %)	Farmer studies (*n* = 40) (*n*; %)	Total studies (*n* = 69) (*n*; %)
Dependent variable			
Intention to buy/consume novel food	(23; 80%)	(1; 3%)	(24; 35%)
Perceived safety of novel food	(1; 3%)	–	(1; 1%)
Intention to use/adopt new technology	–	(38; 95%)	(38; 55%)
Willingness to pay novel food	(4; 14%)	(1; 3%)	(5; 7%)
Attitude toward new technology	(1; 3%)	–	(1; 1%)
Type of framework			
Model of risk perception	(1; 3%)	–	(1; 1%)
Theory of acceptance and use of technology	–	(2; 5%)	(2; 3%)
Theory of reasoned action	–	(1; 3%)	(1; 1%)
Technology-organization-environment conceptual framework	–	(1; 3%)	(1; 1%)
None	(28; 97%)	(36; 89%)	(64; 94%)

Percentages are calculated for each column (consumers, farmers, and total studies).

Considering the clusters of technologies examined by various studies, most focus on gene technologies and digital agriculture. However, there are few studies investigating consumer acceptance of input-related technologies and digital agriculture, which are well-studied from the farmers' perspective. Conversely, technologies related to resource use efficiency are well-studied among consumers but less represented among farmers. This imbalance has already been highlighted by other previous studies (e.g., Kamrath et al., 2019), emphasizing the need to address this gap through further research to enable comparisons of the different factors influencing acceptance among various stakeholders.

When examining how different studies have approached the concept of acceptance of new technologies, it becomes evident that consumer and farmers acceptance has mostly been studied in terms of the intention to adopt rather than actual behavior. For consumers, the dependent variables refer to purchase intention and consumption of novel foods to which these technologies are applied. These results are in line with previous studies (Thomas et al., 2023). On the other hand, studies on farmers consider the acceptance of new agricultural technologies in terms of farmers' intention to adopt or use these technologies.

Moreover, as highlighted in other studies examining technologies applied to food, most of the research in this area does not employ established theoretical frameworks to analyze the connections between independent and dependent variables (Aschemann-Witzel and Stangherlin, 2021). This absence of theoretical grounding is a major drawback because theoretical models provide a structured approach to understanding and predicting how and why certain factors influence technology acceptance.

The analysis of independent variables, grouped according to Bronfenbrenner's model, reveals that individual variables related to the socio-demographic characteristics of consumers and farmers, as well as their farms, continue to be the most studied (Afful-Dadzie et al., 2022). However, macro-system variables are primarily studied in the farmer population, while variables related to perceptions and attitudes toward technology or novel food are predominantly explored in consumer research. These differences stem from the fact that overarching social, economic, and cultural structures of a country

TABLE 6 Classification of macro-categories (n = 54) using Bronfenbrenner's systems.

Systems of Bronfenbrenner	Macro-categories about consumers (N = 26)		Macro-categories about farmers (N = 41)		Total (N = 54)
Macrolevel environment	*Knowledge about environmental thematic*	15%	Educational opportunity	20%	18%
	Attitude toward environment		Government support		
	Attitude toward labels		*Trust in institutions*		
	Trust in institutions		*Knowledge about environmental thematic*		
			Trust in data privacy		
			Cost of investment		
			Price/cost of raw materials		
			Experience about environmental thematic		
Physical environment	*Perceived environmental benefits*	31%	*Knowledge about technology/food*	27%	28%
	Perceived economic benefits		Ease of use		
	Perceived health benefits		*Perceived economic benefits*		
	Knowledge about technology/food		Negative emotions toward technology		
	Attitude toward technology/foods		Trust in technology		
	Perceived health risk		Perceived economic risks		
	Price/cost of food		*Attitude toward technology/foods*		
	Quality perception of product		Positive emotions toward technology		
			Perceived usefulness of technology		
			Perceived social benefits		
			Perceived environmental benefits		
Social environment	*Subjective norms*	4%	Membership group	5%	4%
			Subjective norms		
Individual environment	*Age*	50%	*Education*	49%	50%
	Education		*Age*		
	Gender		Farm size		
	Income		*Income*		
	Personal value		*Gender*		
	Living area		Level of technological integration in the farm		
	Sustainable consumption		Credit availability		
	Attitude toward health		Workforce		
	Household size		Water availability		
	Place of consumption (outside)		Position of farm		
	Food technology neophobia		Distance from market		
	Food neophobia		Personal experience of farming		
	Innovativeness		*Household size*		
			Land typology		
			Fertile soil		
			Land ownership		
			Occupation (mainly farmer)		
			Management decisions (woman)		
			Innovativeness		
			Social status (high)		

Percentages are calculated for column considering the total number of macro-categories for consumers (26) and farmers (41) in Bronfenbrenner's different systems; macro-categories written in italics identify those in common between farmers and consumers.

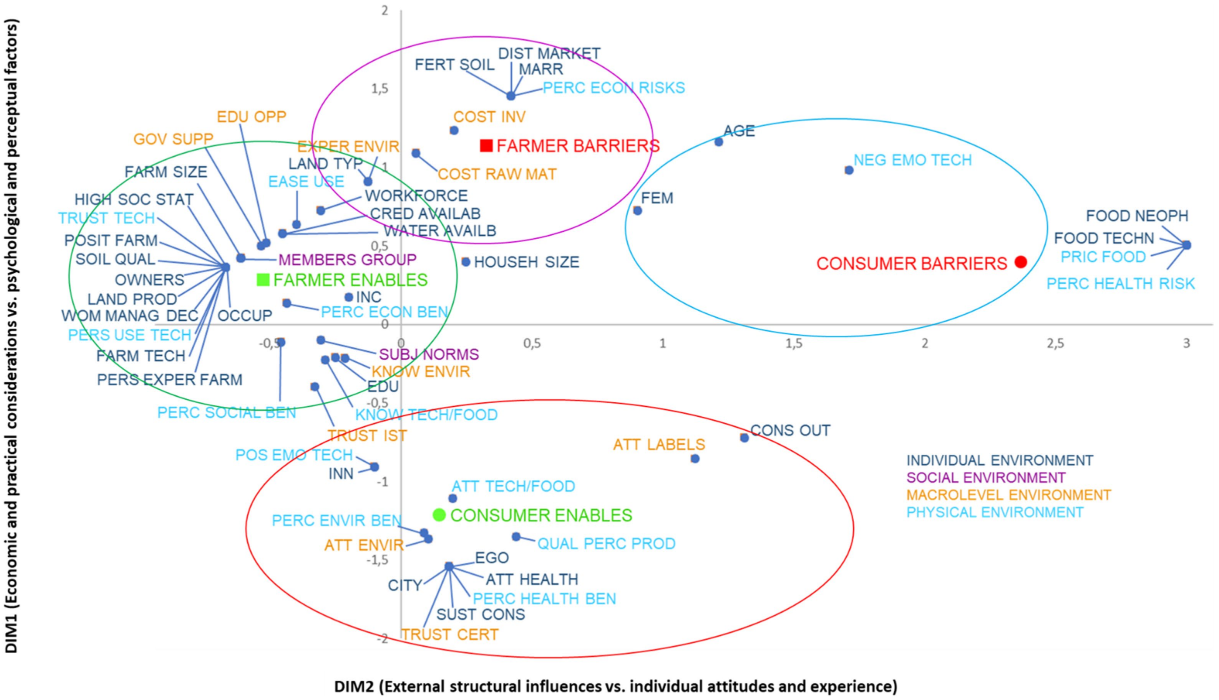

FIGURE 4
Correspondence analysis (actor categories × enables and barriers). The variable "trust in data privacy" is not included in this figure because it was found to have an insignificant impact on the acceptance of new technologies. ATT BRAND = Attitude toward brand; ATT ENVIR = Attitude toward environment; ATT HEALTH = Attitude toward health; ATT LABELS = Attitude toward labels; ATT TECH/FOOD = Attitude toward technology/foods; CITY = Living area; CONS OUT = Place of consumption (outside); COST INV = Cost of investment; COST RAW MAT = Price/cost of raw materials; CRED AVAILAB = Credit availability; DEC.MAK style = Decision-making style (cognitive); DIST MARKET = Distance from market; EASE USE = Ease of use; EDU = Education; EDU OPP = educational opportunity; EGO = Personal value (egoistic); EXPER ENVIR = Experience about environmental thematic; FARM SIZE = farm size; FARM TECH = Farm technology; FEM = Gender (female); FERT SOIL = Fertile soil; FOOD NEOPH = Food Neophobia; FOOD TECHN = Food Technology neophobia; GOV SUPP = Government support; HIGH FARM REG = high farm regulations; HIGH SOC STAT = Social status (high); HIGH TEMP = High temperature; HOUSEH SIZE = Household size; INC = Income; INN = innovativeness; INV = Involvement in food; KNOW ENVIR = Knowledge about environmental thematic; KNOW TECH/FOOD = Knowledge about technology/food; LAND PROD = Land productivity; LAND TYP = Land typology; MARK TREND = Market trend (Unpredictability); MARR = Marital status (married); MEMBERS GROUP = Membership group; NEG EMO TECH = Negative emotions toward technology; NO EUR = nationality (not European); OCCUP = Occupation (mainly farmer); OWNERS = Ownership; PERC ECON BEN = Perceived economic benefits; PERC ECON RISKS = Perceived economic risks; PERC ENVIR BEN = Perceived environmental benefits; PERC HEALTH BEN = Perceived health benefits; PERC HEALTH RISK = Perceived health risk; PERC SOCIAL BEN = Perceived social benefits; PERS EXPER FARM = Personal experience of farming; PERS USE TECH = Perceived usefulness of technology; POS EMO TECH = Positive emotions toward technology; POSIT FARM = Position of farm; PRIC FOOD = Price/cost of food; PROD SPEC = Production specialization; QUAL INFO = Quality of information; QUAL PERC PROD = Quality perception of product; RESP WORKER = respect of worker; RIGHT = Political orientation (right); SELF EFF = Self efficacy; SOCIAL RESP = Social Responsibility; SOIL EROS = Soil erosion; SOIL QUAL = Soil quality; SUBJ NORMS = Subjective norms; SUST CONS = Sustainable consumption; TRUST CERT = trust in certification/labels; TRUST IST = Trust in institutions; TRUST TECH = Trust in Technology; WATER AVAILB = water availability; WATER SOIL RETE = Water soil retention; WOM MANAG DEC = Management decisions (woman); WORKFORCE = Workforce.

TABLE 7 Correspondence analysis (actor categories x enables and barriers).

Dimensions	Singular value	Inertia	Proportion explained %	Cumulative proportion %	Chi square	Sign.
1	**0.548**	**0.301**	**0.3799**	**0.379**	751.988	***
2	**0.432**	**0.210**	**0.3708**	**0.7508**		
3			0.2492	1.000		

The chi-square of independence between the two variables (columns and rows) and the *p*-value are also reported. The accepted dimensions are highlighted in bold. The *p*-value refers to the statistical significance level: *** < 0.001.

have a greater impact on businesses and their decisions to adopt changes (Samuel et al., 2024). Conversely, consumers are more influenced by beliefs, perceptions of risk, and perceived benefits when making food choices (Siegrist and Hartmann, 2020).

The social dimension, including the presence or opinions of others, is a crucial determinant that is significantly underrepresented in the studies examined for both consumers and farmers. We hypothesize that this underrepresentation is due to the specific difficulties in collecting comprehensive network data, such as the need for longer and more detailed questionnaires and the challenges in recreating networks in experimental research.

The correspondence analysis shows significant differences between farmers and consumers with respect to barriers and facilitators associated with technology acceptance. For consumers, individual and physical barriers predominate, whereas for farmers, economic and business barriers are more relevant. In particular, results indicate that the main barriers for consumers include emotional variables such as food neophobia and perceived health risks, in line with the findings of Siegrist (2018), who highlights the impact of negative emotions on the acceptance of new food technologies. For farmers, barriers are more related to economic risks and farm characteristics, corroborating the findings of Baumüller (2018) who highlights cost and economic uncertainty as significant barriers to the adoption of new technologies.

Consumer facilitators include perceived benefits such as improvements in health and environmental sustainability, as well as positive emotions toward technologies. This is consistent with the study of Taufik et al. (2022) which shows perceived benefits can mitigate emotional resistance. For farmers, facilitators include economic factors, farm characteristics and, significantly, education and training on new technologies, highlighting the importance of educational programs and government incentives as suggested by Xu et al. (2022) and Zhang et al. (2019). Moreover, despite the limited number of studies that have considered social dimensions, it is important to emphasize that belonging to farmers' associations (membership groups), where farmers can exchange information and opinions, and learn from others' experiences, is a crucial factor in facilitating technology acceptance. Indeed, participation in these groups provides a platform for farmers to share experiences, seek advice, and gain insights from peers who face similar challenges. This social support network fosters trust in new technologies since farmers are more likely to adopt innovations that have been successfully implemented by their peers (Ricart and Rico-Amorós, 2021). Moreover, these groups often serve as conduits for disseminating information about new technologies, practices, and market trends. Through meetings, workshops, and communications, farmers can stay informed about the latest advancements and their potential benefits. Research has consistently supported the importance of these social networks in technology adoption over time. Guo et al. (2022) underlined that social networks help reduce uncertainty about the benefits of new technologies through peer learning and support. Consequently, the more connections there are within membership groups, the quicker they tend to adopt new techniques, as they can observe and learn from the experiences of others (Coleman, 1990; Rogers, 2003). In summary, we can observe that farmers' adoption of new technologies is primarily driven by economic and structural constraints, while consumers' acceptance is more influenced by psychological factors and individual perceptions. Moreover, peer influence and institutional support play a much more significant role for farmers, whereas consumers tend to rely more on personal attitudes and product-related attributes when assessing new technologies.

Despite the important results of the study, it has limitations. In particular, cross-sectional cannot establish causality or the direction of relationships between variables, leading to temporal ambiguity. Furthermore, these studies are susceptible to selection and recall biases, which may affect the generalizability and accuracy of findings. To address these limitations, future research should prioritize longitudinal and experimental studies to track changes in technology acceptance over time and provide stronger causal inferences. It is essential to recognize that the outcomes of reviews are shaped by the selection criteria for the papers. However, other factors not discussed here may influence consumer acceptance of new technologies. While a rigorous methodology was followed, the inclusion of only peer-reviewed studies published in English may have excluded relevant insights available in other languages or unpublished reports. This could have led to an incomplete representation of consumer and farmer perspectives on new agricultural technologies. Moreover, factors influencing consumer acceptance, particularly sociocultural and psychological aspects, may have been overlooked if discussed primarily in non-scientific reports or older publications not captured in our search. To mitigate this issue, we employed three different databases to ensure comprehensive coverage of the topic. The research has exclusively examined agricultural technologies related to sustainability and novel food crops. This focus has limited the consideration of a broader range of emerging technologies and innovative practices that could impact sustainability and food security. For instance, advanced technologies such as the use of artificial intelligence or biotechnological techniques like genetic modification of non-plant organisms have not been explored. In addition, the research has concentrated primarily on consumers and farmers, excluding other key players in the food supply chain, such as distributors, retailers, and non-governmental organizations. Moreover, this work is not a meta-analysis, and therefore it does not provide results that clarify causal relationships regarding technology acceptance. The studies reviewed mainly highlight relationships between variables rather than establishing cause-and-effect connections.

In addition, the review also highlights a lack of deep critical analysis in existing studies. Although numerous studies explore consumer and farmer acceptance of agricultural technologies, many do not engage with established theoretical frameworks. This absence of theoretical grounding weakens the ability to synthesize findings across studies and limits the depth of interpretation regarding behavioral determinants. For example, most studies rely on self-reported intentions rather than actual behavior, which may not always translate into real-world adoption patterns. Additionally, while some studies address economic and technological factors, fewer investigate the social and cultural dynamics that influence adoption, such as trust in institutions, peer influence, and ethical considerations. Future research should broaden its scope to encompass a wider array of technological innovations and stakeholder perspectives such as distributors, retailers, and non-governmental organizations. Additionally, given the significant lack of studies investigating the acceptance of new technologies through a theoretical framework, there is a need for research that investigates these aspects. Utilizing theories from general consumer behavior or technology adoption research could offer a more comprehensive and nuanced understanding. Moreover, none of the studies in the review incorporated real field studies; most relied on product concepts such as textual descriptions or online visualizations. Conducting studies in actual sales environments or simulating real consumer choice contexts could yield more realistic insights into consumer responses and reduce the likelihood of social desirability bias (Fisher and Katz, 2000). Furthermore, increased attention should be given to social dimensions, including the influence of social networks and peer interactions on technology acceptance. Longitudinal studies are necessary to monitor changes in technology acceptance over time, and meta-analyses could synthesize findings to clarify causal relationships, providing a deeper understanding of the mechanisms driving technology adoption. Finally, although our analysis has focused primarily on the acceptability of agricultural innovation from the perspective of consumers and farmers, it is important to recognize that some individuals may play both roles simultaneously. Farmers who also consume agricultural products are in a unique position to influence the acceptance of innovation, as they experience both the practical and consumer-facing aspects of agricultural innovations. This dual perspective can shape their attitudes toward new technologies and practices, as they not only evaluate innovations for their economic feasibility and usefulness in production, but also for their appeal, safety, and quality as consumers. Failure to consider this situation in this review could be a limitation of the research. However, understanding this overlap could be explored in the future to offer deeper insights into how innovation can be embraced by all types of stakeholders.

5 Insights for practical applications

The results of the review suggest that strategies to improve the acceptance of new technologies must be targeted and specific to the intended group. For farmers, membership groups, such as farmers' associations, are crucial in this context. Although innovation is often perceived as the result of the heroic actions of special individuals, it is actually the outcome of building and combining networks of relationships that involve processes of learning and negotiation among actors. These groups provide farmers with a platform to exchange information, share experiences, and gain insights from peers. Moreover, repeated interactions and the opportunity to monitor each other allow trust to emerge. Under these conditions, information and knowledge about new technology can be trusted, significantly enhancing acceptance. Therefore, supporting associational networks and, more generally, fostering collaborative learning environments can be highly beneficial for spreading new technologies. In addition, economic incentives and access to information are vital for farmers. Economic barriers, such as excessive costs and financial risks, are significant impediments to technology adoption. Policymakers should focus on providing targeted financial support and incentives to mitigate these economic risks. Moreover, ensuring that farmers have access to comprehensive and up-to-date information about new technologies is essential. Educational programs, training sessions, and government incentives can help farmers better understand and utilize these technologies, ultimately facilitating their adoption. In this regard, it is equally important that research findings do not remain exclusively within academia but are disseminated more broadly to the relevant stakeholders through an appropriate dissemination strategy that is systematic rather than sporadic.

For consumers, effective communication strategies are also essential, particularly concerning emotional dimensions. The review highlights that emotional factors, such as food neophobia and perceived health risks, can significantly impact consumer acceptance of novel foods and technologies. To address these concerns, communication strategies should focus on highlighting the positive aspects of new technologies and their benefits, such as improved health outcomes and environmental sustainability. By framing the technology in a way that resonates with consumers' values and addressing their emotional concerns, stakeholders can reduce resistance and promote a more positive reception of new food technologies. Tailored messaging that alleviates fears and emphasizes benefits can be instrumental in shifting consumer attitudes and fostering acceptance.

6 Conclusion

This systematic review contributes to a deeper understanding of the dynamics influencing the consumers' and farmers' acceptance of new technologies in agriculture, offering practical insights for researchers and policy makers. Key findings reveal a growing focus on gene technologies and digital agriculture, particularly in China and Italy. The analysis reveals notable differences in technology acceptance barriers between farmers and consumers. Consumers face individual and emotional barriers, such as food neophobia and health risks, while farmers encounter economic and business-related obstacles. Facilitators for consumers include perceived health benefits and positive emotions, whereas for farmers, economic factors, education, membership groups and training play crucial roles. Strategies to improve the acceptance of new technologies must be targeted and specific to the target group. For farmers, strengthening membership groups and providing economic incentives and education are crucial. For consumers, addressing emotional barriers through positive communication and highlighting benefits is key to improving acceptance.

Author contributions

GC: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. SR: Conceptualization, Data curation, Formal analysis, Investigation, Validation, Visualization, Writing – original draft, Writing – review & editing. VM: Conceptualization, Data curation, Formal analysis, Investigation, Validation, Visualization, Writing – original draft, Writing – review & editing. FB: Conceptualization, Funding acquisition, Project administration, Writing – review & editing. CC: Formal analysis, Investigation, Validation, Writing – review & editing. FB: Funding acquisition, Project administration, Validation, Writing – review & editing. GG: Conceptualization, Funding acquisition, Project administration, Supervision, Writing – review & editing.

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Supplementary material

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