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Unleashing the value of artificial intelligence in the agri-food sector: where are we?

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Abstract

Purpose – This study analyses the literature on artificial intelligence (AI) and its implications for the agri-food sector. This research aims to identify the current research streams, main methodologies used, findings and results delivered, gaps and future research directions.

Design/methodology/approach – This study relies on 69 published contributions in the field of AI in the agri-food sector. It begins with a bibliographic coupling to map and identify the current research streams and proceeds with a systematic literature review to examine the main topics and examine the main contributions.

Findings – Six clusters were identified: (1) AI adoption and benefits, (2) AI for efficiency and productivity, (3) AI for logistics and supply chain management, (4) AI for supporting decision making process for firms and consumers, (5) AI for risk mitigation and (6) AI marketing aspects. Then, the authors propose an interpretive framework composed of three main dimensions: (1) the two sides of AI: the "hard" side concerns the technology development and application while the "soft" side regards stakeholders' acceptance of the latter; (2) level of analysis: firm and inter-firm; (3) the impact of AI on value chain activities in the agri-food sector.

Originality/value – This study provides interpretive insights into the extant literature on AI in the agri-food sector, paving the way for future research and inspiring practitioners of different AI approaches in a traditionally low-tech sector.

Keywords Artificial intelligence, Bibliometric, Agri-food, Systematic literature review

Paper type Research paper

1. Introduction

Artificial intelligence (AI) is making rapid strides, playing a significant role in our civilization's growth and evolution. Having all the potential to revolutionize every aspect of the world, either in medicine, economy, leisure, communication, logistics and beyond

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(Apell and Eriksson, 2023; Bag *et al.*, 2023; Malthouse and Copulsky, 2023; Tohidi *et al.*, 2023), AI has gained more popularity along the diffusion of the fourth Industrial revolution and has become a perfect ingredient for every sector to flourish (Jan *et al.*, 2022; Mariani *et al.*, 2023).

AI is a vast field that invokes multiple facets, such as sensing, modelling, planning and action, as well as decision-support systems, natural perception, analytics and robotics (Camaréna, 2020). Its applications and its impact have been under investigation since 1950 (Nayal *et al.*, 2022, 2023; McCarthy, 2004) when Alan Turing (1950) drove the attention to the subject by questioning "machines" ability to "think" in his research paper "Computing Machinery and Intelligence". This impact of AI is also noticeable in sectors that are considered "traditional" as the agri-food one (Mônica da Silva Zanuzzi *et al.*, 2020). In the last 30 years AI significantly contributed to shift the agri-food industry (Rejeb *et al.*, 2022). AI has been used to accomplish operation efficiency (Liakos *et al.*, 2018), increased food quality and quantity, promote sustainability (Bechar and Vigneault, 2016; Wolfert *et al.*, 2017), as well as to support decisions (Deo and Şahin, 2015) and increase competitiveness and profitability (Slaughter *et al.*, 2008; Xiong *et al.*, 2017).

Currently, AI plays a key role in the success of various sectors, including more traditional ones, such as agri-food. Even if its potential is not fully understood, it is evident that AI has the capability to guide managers in adopting the best strategies and making well-informed decisions in every stage of the value chain (Soltani-Fesaghandis and Pooya, 2018; Dhamija and Bag, 2020).

The agri-food sector presents some peculiarities that make AI particularly appealing to companies along the entire supply chain. According to the United Nations' 2019 forecasts, factors such as climate change, world population (expected to reach 9.7 billion by 2050), food deterioration, and changes in consumers' food preferences have created the need for faster, more customized, and more efficient production. These reasons are the main drivers of the full integration of AI in the referred sector.

However, despite recent literature reviews on broader topics such as agri-food entrepreneurship (Petrolo *et al.*, 2022), food value chain and open innovation (Misra and Mention, 2021), business models for vertical farming (Biancone *et al.*, 2022), and the application of new technologies in consumer behavior studies (Berčík *et al.*, 2021), knowledge about AI in the agri-food context remains insufficient. While some attempts have been made in computer science, where scholars have analysed extant research on AI implications in food from a digital transformation perspective (Monteiro and Barata, 2021), to the best of our knowledge, no comprehensive studies have been conducted until now in the management area. This knowledge gap is particularly intriguing because the potential of AI in the agri-food sector is central to several EU-funded initiatives (*e.g.* the Italian PNRR Agritech), and its benefits could have significant impact companies of all sizes operating the entire agri-food value chain. Therefore, we individuated the following research questions:

RQ1. What is the state-of-the-art in management studies on AI in the agri-food sector?

RQ2. What are the dimensions of AI in the agri-food sector?

RQ3. Which are the impacts of AI on value chain activities in the agri-food sector? Are they at firm or inter-firm level?

The remainder of this paper is structured as follows. In the next section, we begin by identifying and describing the main avenues of AI and their application in the agri-food sector. Following that, we provide a detailed overview of the methods employed in this study. Based on an initial analysis of 407 papers in the management field, we highlighted an intellectual core of 69 contributions. This intellectual core was then subject to a bibliographic coupling analysis to identify the current trends of AI in the agri-food sector. Subsequently, we conducted a further systematic review of all the documents. These analyses led to the proposal of an interpretive framework that aims to guide future research and inspire practitioners regarding the potential applications of AI along the agri-food value chain. Finally, the paper concludes with limitations and future research avenues.

2. Artificial intelligence and its application in the agri-food sector

AI has caught the attention of researchers over the years, with various studies analysing its contributions and applications to multiple sectors. AI affects our lives and societies whenever a computer is used (Mhlanga, 2021) and it has been a topic of debate since the invention of the Turing test (Baryannis *et al.*, 2019; Dwivedi *et al.*, 2019).

Several literature reviews and studies relevant to AI and its applications have been published (Toorajipour *et al.*, 2021; Gao and Ding, 2022), which have shed light on various definitions of AI. McCarthy defined AI as "*the science and engineering of creating smart machines and computer software to comprehend human intelligence*" (McCarthy, 2004, p. 2). Spanaki *et al.* (2022) referred to it as a cognitive process, while according to Encyclopaedia Britannica, it is defined as the ability of computer-controlled robots and digital computers to perform tasks associated with human intelligence (Copeland, 2019).

Comprehending AI requires the proper understanding of its "soft" and "hard" sides, *i.e.* human intelligence (Camaréna, 2020) and Machine Learning (ML) respectively. ML is an Industry 4.0 (I4.0) technology (Nayal *et al.*, 2022, 2023) and is often regarded as the most straightforward way to accomplish AI (Bowling *et al.*, 2006).

One of the application sectors in which AI can be a valuable tool (Spanaki *et al.*, 2021; Yahya, 2018) is agriculture (Mhlanga, 2021). Looking at the studies analysing AI applications in Agri-food, it is possible to recognise an evolutionary path moving from specific applications to an all-encompassing approach (Rejeb *et al.*, 2022). This transformative impact has been further amplified by the emergence of I4.0, that has influenced the agricultural sector through from the integration of other enabling technologies. This has led to the emergence of agriculture 4.0 (Suma *et al.*, 2017; Patil and Kale, 2016). Agriculture 4.0 plays a key role in generating and analysing data that becomes instrumental in making accurate decisions, ultimately, leading to enhanced productivity, efficiency, and sustainability (Araújo *et al.*, 2021). While previous reviews have already highlighted the evolutionary trajectory of AI in the agri-food domain, our focus more on the underlying logic of AI in research works. Therefore, based on the literature reviewed, we can describe AI in a narrower and broader manner. "Narrow AI" regards specific intelligent technologies for a definite output, and even slight changes can generate different outcomes (Goertzel, 2014). "Broad AI" refers to advanced complex and highly adaptive intelligent systems characterized by efficiency and reasoning (Hochreiter, 2022). In the former, AI is an enabling technology linked to agriculture 4.0. In the latter, AI (particularly traditional ones such as agri-food, where it drives the change of business models, as well as business structural characteristics. The potential range of functionalities that AI could encompass within individual functions and across inter-functional levels may require changes or updates in the organizational architectures as well as in the competencies and skills required to be fully explored.

In conjunction with earlier literature reviews, we have noticed that the intersection of agri-food and innovation, including AI and smart technologies, represents a novel emerging topic since all the reviews date from 2021 or later. Table 1 provides an overview of these studies, which have all employed bibliometric and/or systematic analysis methods. Briefly, previous literature has tackled the topic from both tangible and intangible perspectives. In terms of tangible aspects, Monteiro and Barata (2021) identified the main research clusters of agri-food supply chain studies and conducted a detailed content analysis of 18 papers to ascertain the type of AI employed and its role in enhancing supply chain efficiency. They concluded that

Authors	Topic	Methodology	Sample size
Petrolo *et al.* (2022)	Agri-food entrepreneurship	Bibliometric/ systematic	220
Misra and Mention (2021)	Food value chain and innovation	Bibliometric	84
Biancone *et al.* (2022)	Innovative business models for vertical farm entrepreneurs	Bibliometric	186
Monteiro and Barata (2021)	AI for agri-food supply chain	Bibliometric/ Systematic	18
Sood *et al.* (2022)	Key determinants of AI adoption in agriculture	Systematic	N/A
Abban and Abebe (2022)	Digitalization in Building Sustainable Food Systems	Systematic	40
Camaréna (2020)	AI usage for sustainable food systems	Systematic	44
Dadi *et al.* (2021)	Technological innovation in agri-food systems	Systematic	159
Maulana *et al.* (2022)	Artificial Intelligence Research in Agriculture	Bibliometric	546

Source(s): Authors' elaboration

Table 1. Extant literature reviews

the impact of AI on food production is rapidly increasing and emphasised the importance of adapting these technologies across the entire supply chain in terms of stakeholders' engagement and exploiting multiple data sources to obtain sustainable agri-food (e.g. reducing food waste and increasing awareness) (Monteiro and Barata, 2021). Nonetheless, Biancone *et al.*'s (2022) study of 186 papers revealed what technological embracement holds, not only in terms of new agri-food market establishment in an urban context, but also in terms of entrepreneurship encouragement. Moreover, encouraging technological implementation could boost nutritional food quality and promote sustainability in the agri-food sector (Biancone *et al.*, 2022).

Intangible aspects of agri-food and AI are represented in entrepreneurship and/or innovation-related studies. On one hand, Petrolo *et al.* (2022) through a bibliographic study and a systematic analysis, investigated the phenomenon of agri-food entrepreneurship concluding that agri-food entrepreneurs play a key role in developing ecosystems. Nonetheless, more efforts should be directed towards educating agri-food entrepreneurs on how to adapt different practices and develop their soft and hard skills to overcome sociocultural challenges (Petrolo *et al.*, 2022). On the other hand, Misra and Mention (2021), through the deployment of a bibliometric analysis of 84 publications, emphasized that open innovation concurs with a growing space in food innovation research. The effects and challenges that open innovation holds along the food value chain are summarized through a framework (Misra and Mention, 2021).

3. Methodology

This study relies on the combination of a bibliographic analysis and a systematic literature review of AI for the agri-food sector. To fulfil the objectives of this study, we passed through different steps. First, we conducted a search on the Scopus database, which relies on the identification of keywords. Scopus provides the largest number of scientific publications compared to its peers like Web of Science (WoS) (Gavel and Iselid, 2008). We used the following string TITLE-ABS-KEY ("artificial intelligence" OR "AI") AND TITLE-ABS-KEY (food* OR agri*). The query was run in February 2023. We considered only publications up to 2022. Second, the results obtained were limited to the field of "Business, Management, and Accounting", this limitation was set to only keep on journals in the field of management and business-related studies since, we seek to analyse the topic from a management perspective. Furthermore, to avoid translation overlap, we restricted the results only to English publications. The final output consisted of 407 publications, which form the initial core of this study. To focus on the most significant and representative articles related to this study topic, the authors applied a set of inclusion and exclusion criteria. They retained articles only if their title, keywords and abstract clearly provide insights about AI implications in the agri-food sector.

This screening process resulted in the identification of 129 pertinent publications related to agri-food and AI, which represent the *intellectual core* of this study, covering approximately 32% (31.9%) of the initial database. Over these 129 documents, we performed a bibliographic coupling analysis using VOSviewer software (Van Eck and Waltman, 2010). It allows grouping contributions based on the references they share; the more they overlap, the more papers are grouped in the same cluster (Casprini *et al.*, 2020; Van Eck and Waltman, 2010).

Second, we conducted a systematic review of all the articles representing the bibliometric results. This resulted in 69 documents, covering the timespan 2009–2022. Following the systematic method proposed by Toorajipour *et al.* (2021), which draws from four phases (research question formulation, data collection, data evaluation and analysis, and interpretation) method designed by Denyer and Tranfield (2009). Our data analysis provides an overview of the paper topic, methodology, and research touch points for each of the 69 publications, as illustrated in Table A1 in the Appendix.

Finally, based on both the bibliometric and systematic results, we provided an integrative and interpretive framework (reported in Section 5) linking the main streams that emerged, and providing guidance for future research and practice.

4. Results

4.1 Bibliographic coupling analysis

Reference-based analysis is the most common scrutiny method used (Gao and Ding, 2022). As shown in Figure 1, 69 publications were linked, forming 10 distinct clusters as shown in Figure 1. Based on an in-depth analysis, we grouped Cluster 2 with Cluster 4, and Cluster 5, Cluster 7 with Cluster 8 and Cluster 9 with Cluster 10, because of topic overlap. This resulted in the identification of six main clusters, as illustrated by Table 2.

Cluster A comprises 15 documents (timespan 2019–2022) which primarily focus on the adoption of AI and its benefits in the agri-food business. The papers explore how AI enhances

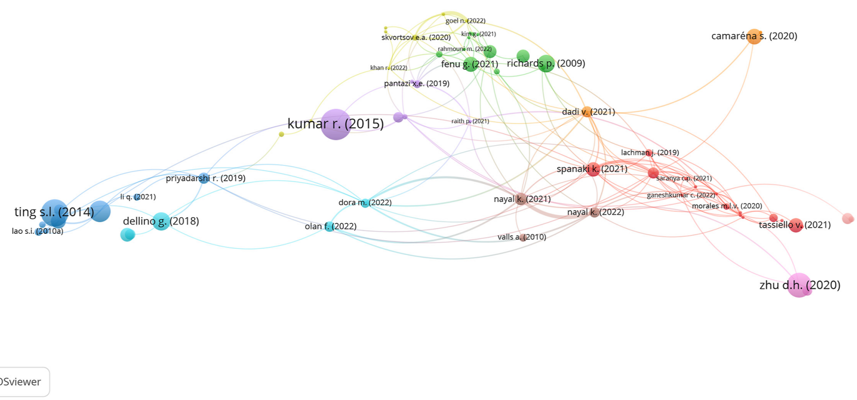


Figure 1.
Bibliographic coupling clusters

Source(s): VOSviewer

New cluster	Main articles	Cluster (colour)	Number of documents	Timespan	Main topics
A (AI adoption and benefits)	Spanaki *et al.* (2021) Tassiello *et al.* (2021)	1 (red)	15	2019–2022	Customer engagement (Alfalih, 2022), boosting entrepreneurship and innovation (Secinaro *et al.*, 2022; Lachman and Ló pez, 2019); sustainable practices in agriculture (Abban and Abebe, 2022; Morales and Elkader, 2020)
B (AI for efficiency and productivity)	Richards *et al.* (2009) Skvortsov (2020) Kumar *et al.* (2015)	2 (green) 4 (yellow) 5 (purple)	12 8 6	2009–2022 2020–2022 2015–2022	Crop yield (Fenu and Malloci, 2021; Jain and Choudhary, 2022); Boosting farming practices (Alam *et al.*, 2020); Support sustainable digital transformation (Lugonja *et al.*, 2022); Crop disease prediction (Anand *et al.*, 2022; Khan *et al.*, 2022)
C (AI for Logistics and Supply Chain Management)	Ting *et al.* (2014) Priyadarshi *et al.* (2019)	3 (blue)	10	2010–2021	Food delivery (Bocewicz *et al.*, 2017); supply chain management (Sitek *et al.*, 2017); inventory management (Basljan *et al.*, 2021; Lao *et al.*, 2010b)
D (AI for supporting decision making process for firms and consumers)	Olan *et al.*, 2022 Dora *et al.* (2022)	6 (light blue)	5	2017–2022	Healthy food choices (Kim *et al.*, 2021; Fiore *et al.*, 2017); Sales forecasting (Dellino *et al.*, 2018)
E (AI for risk mitigation)	Camaréna (2020) Nayal *et al.* (2022)	7 (light orange) 8 (brown)	4 4	2020–2022 2010–2022	Supply chain risk management (Nayal *et al.*, 2022); Agriculture risk management (Vuppalapati, 2022); Addressing agricultural and food industry challenges (Camaréna, 2020; Dadi *et al.*, 2021)
F (AI Marketing aspects)	Zhu and Chang (2020) Chu *et al.* (2019)	9 (pink) 10 (light pink)	3 2	2020–2022 2019–2021	consumer perception of food quality (Zhu and Chang, 2020); price forecasting (Chu *et al.*, 2019); enhancing sales and promoting sustainability (Yang *et al.*, 2022

Source(s): Authors' elaboration

Table 2. Bibliographic coupling clusters

customer engagement (Alfalih, 2022) and shapes their decision-making process (Tassiello *et al.*, 2021). Additionally, they explore the role of AI in boosting entrepreneurship and innovation (Secinaro *et al.*, 2022; Lachman and Lopez, 2019). Moreover, AI plays a key role in enhancing the adoption of sustainable practices in agriculture practices to meet sustainable development goals (SDGs) (Abban and Abebe, 2022; Morales and Elkader, 2020).

Cluster B, comprising 26 documents from cluster 2, 4 and 5 (timespan 2009–2022) and focuses on AI applications for efficiency and productivity enhancement. These AI-based technologies help predicting and monitoring crop diseases (Anand *et al.*, 2022; Khan *et al.*, 2022), livestock (Goel *et al.*, 2022a), also they aid to forecast production such as in the case of Pakistani wheat (Ahmed and Hussain, 2022), to solve crop selection problems (Kumar *et al.*, 2015) and to boost crop yield (Fenu and Malloci, 2021; Jain and Choudhary, 2022). However, sustainability and agriculture production efficiency are intertwined, as AI could enhance sustainable digital transformation (Lugonja *et al.*, 2022) and farming practices (Alam *et al.*, 2020).

Cluster C is composed of 10 documents (timespan 2010–2021) and centred on mapping supply and demand in terms of food logistics (Basljan *et al.*, 2021), delivery management (Bocewicz *et al.*, 2017), supply chain management (Sitek *et al.*, 2017) and inventory management both at retail (Basljan *et al.*, 2021) and warehouse (Lao *et al.*, 2010b) levels. Nonetheless, AI-based technologies enhance sustainable food supply chains (Ting *et al.*, 2014) and systems (Lao *et al.*, 2010a).

Cluster D contains 5 items (timespan 2017–2022) represented by cluster 6 and focuses on decision support systems that assist consumers in making healthy food choices (Kim *et al.*, 2021; Fiore *et al.*, 2017), help firms to forecast sales (Dellino *et al.*, 2018) and monitor their networks (Olan *et al.*, 2022) to achieve sustainable supply chain management.

Cluster E, comprising 8 documents, is composed of cluster 7 and cluster 8 (timespan 2010–2022); it explores AI role in mitigating risks in the context of supply chain (Nayal *et al.*, 2022), sewage sludge management (Valls *et al.*, 2010) as well as managing these risks (Vuppalapati, 2022). This cluster also emphasises the significance of AI in addressing challenges faced by the agri-food industry such as climate change, resource scarcity, growing population (Camaréna, 2020); food safety and security, food demand and supply gap management, and food product quality (Dadi *et al.*, 2021). It further supports the transition towards sustainable food systems (Brunori *et al.*, 2022; Agyemang *et al.*, 2022).

Finally, Cluster F has 5 contributions (2019–2022) resulting from cluster 9 and cluster 10, and it discusses AI marketing-related aspects from multiple perspectives. From a consumer viewpoint, it focuses on consumer perception of food quality as in the case of robotic chefs (Zhu and Chang, 2020) as well as understanding their preferences and attitudes towards organic food products (Taghikhah *et al.*, 2021). From a firm's perspective, it examines price forecasting (Chu *et al.*, 2019), and from retailers' perspective, it concentrates on enhancing sales and promoting sustainability (Yang *et al.*, 2022).

4.2 Systematic analysis

This analysis provides some general considerations. First, regarding methodologies, we remark that among the 69 analysed documents, most of them (37) are quantitative studies, while only around 20% of the total sample concerns qualitative ones (14) and only few works are literature reviews (7), conceptual papers (6) or have a mixed method analysis (5). These results explain that the implications of AI in the agri-food sector are an emerging topic currently under investigation. Second, multiple papers have highlighted the importance of driving attention to human-related aspects of AI.

In line with the objectives of this study, the systematic review identifies four primary research orientations as illustrated in Table A1. Firstly, most of the analysed documents investigate the application of AI technologies to improve efficiency, productivity, and ultimately, profitability. Previous research has explored the use of AI within the agri-food sector across various contexts, including smart farming, where it is employed to boost effective agricultural practices (Moreira *et al.*, 2022), address challenges in suburban and rural areas (Doshi and Varghese, 2022), and bolster sustainable digital transformation (Lugonja *et al.*, 2022). Additionally, AI has been used for predicting crop yields (Jain and Choudhary, 2022; Saranya *et al.*, 2021), optimizing crop selection to improve agricultural planning (Kumar *et al.*, 2015). Moreover, AI-based technologies and systems have proven effective in diagnosing and detecting plant and crop diseases, which can contribute to higher production levels (Moreira *et al.*, 2022; Fenu and Malloci, 2021).

Secondly, the analysis of the available literature reveals a research trend centred on AI applications for external relations and stakeholders within the agri-food sector. This domain encompasses:

(1) AI integration in agri-food supply chains, for its potential in enhancing sustainability (Ting *et al.*, 2014), addressing perishable goods delivery challenges (Basljan *et al.*, 2021), constructing resilient food networks (Bocewicz *et al.*, 2017), and optimizing supply chain management (Sitek *et al.*, 2017) and expenses (Nakandala *et al.*, 2016).

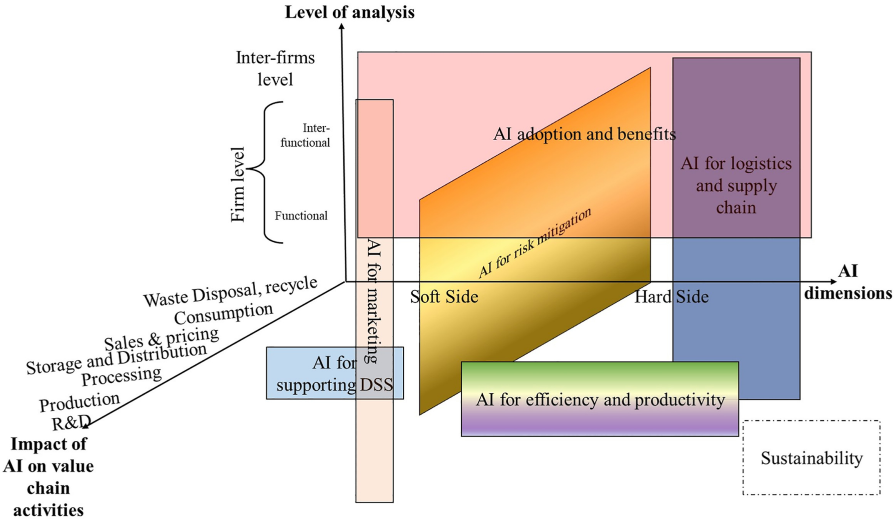
(2) AI solutions for marketing and communication, as they can improve agricultural e-commerce efficiency and competitiveness (Li and Xiao, 2021), identify attitude behaviour gap towards organic food product (Taghikhah *et al.*, 2021), provide accurate price predictions (Chu *et al.*, 2019), and optimize demand forecasting in retail (Priyadarshi *et al.*, 2019). In this context, Lee *et al.* (2021) explore consumer intentions to use AI-powered food service stores, while Zhu and Chang (2020) examine the impact of robotic chefs on consumer expectations and perceptions of food quality. Hence, in the context of agricultural entrepreneurship, emerging technologies like AI hold potential to foster and promote agri-businesses (Secinaro *et al.*, 2022).

(3) AI tools to support decision making in agri-food, as they can assess future food systems (Agyemang *et al.*, 2022), enhance fresh and perishable food supply chains management (Dellino *et al.*, 2018) and support healthy nutrition decisions as it has the potential to deliver personalized nutrition management and dietary guidance (Kim and Chung, 2020).

Furthermore, the third pillar of the literature synthesises AI adoption in the agri-food business. Issa *et al.* (2022) offer a comprehensive explanation of AI readiness and identify strategic elements for agritech companies to ameliorate their technology adoption process. Ganeshkumar *et al.* (2022) explore the agritech industry digital transformation, highlighting the potential benefits and challenges of AI-based products in agriculture. Furthermore, Sood *et al.* (2022) identify the main drivers and barriers to AI adoption in agriculture.

Finally, a review of existing AI literature reveals a rising emphasis on various dimensions of sustainability, including environmental, social, and economic aspects. Sustainability is strongly intertwined with AI based technologies adoption to the agri-food industry. These technologies have been found to facilitate and to support sustainable digital transformation (Yang *et al.*, 2020; Lugonja *et al.*, 2022), promoting responsible and sustainable practices in the agri-food sector (Yang *et al.*, 2022). In terms of social sustainability, AI can foster equitable growth in developing nations (Morales and Elkader, 2020) and enhance societal well-being (Ali and Xia, 2022). Within the realm of food security, which is a crucial component of both environmental and social sustainability, researchers contend that AI can ameliorate food security by addressing related challenges (Camaréna, 2020; Spanaki *et al.*, 2022; Richards *et al.*, 2009), optimizing agricultural practices and reducing waste. Furthermore, AI can optimize agricultural practices by integrating with renewable energy sources leading to increased efficiency (Doshi and Varghese, 2022).

In conclusion, AI adoption in the agri-food industry presents numerous opportunities and challenges. By understanding and addressing these challenges, the sector can harness the full potential of AI technologies to improve efficiency and productivity, to support agricultural sustainable practices and food security, to improve decision making processes, to promote entrepreneurship and to assure trust with various stakeholders.



Source(s): Authors' elaboration

Figure 2. Interpretive framework

5. Discussion: an interpretive framework

This study serves as a comprehensive overview of the key international scientific contributions to AI and its applications within the agri-food sector, examined from a management perspective. Drawing from bibliographic coupling analysis and systematic literature review, this paper builds on recent contributions to the subject (e.g. Misra and Mention, 2021), and proposes an interpretive framework (Figure 2). The framework distinguishes three primary dimensions across which AI can be explored, as explained below.

5.1 AI "hard" and "soft" sides

We identified two sides of AI, entailing its technological aspects, which can be examined from two angles: the "hard" and the "soft". The "hard" facet of AI focuses on technological development, adoption, and utilization. Research in this area aims at enhancing productivity and performance through AI technologies, thereby improving efficiency and effectiveness (Yang *et al.*, 2020). A variety of AI implementations in the agri-food industry, ranging from crop disease detection (Anand *et al.*, 2022; Darapaneni *et al.*, 2022), to crop monitoring (Goel *et al.*, 2022a), and crop productivity yield (El Hachimi *et al.*, 2021; Kumar *et al.*, 2015) and accuracy (Saranya *et al.*, 2021) illustrate the potential of AI. Notably, the employment of robotic chefs to predict and ameliorate food quality as showcased by Zhu and Chang (2020) testify that AI holds a transformative power. Future studies could focus on deepening the knowledge of AI-driven technologies' role in business ecosystems (Yang *et al.*, 2020), and understanding how machine learning could improve yield prediction (Murugesan *et al.*, 2019).

On the other hand, the "soft" facet concerns stakeholders related sides of AI, emphasizing on the significance of the technology acceptance and embracement by consumers (Lee *et al.*, 2021) and firms (Issa *et al.*, 2022), an aspect that requires further understanding as highlighted by Zhu and Chang (2020). Nonetheless, voice-assistant interactions like "Alexa" are an intriguing domain to be deepened, shedding light on the effects of these interactions on the consumer experience and decision-making process (Tassiello *et al.*, 2021).

An example of AI "soft" side is illustrated by the case of firms opting for recent AI-based technologies and exploiting their value to the fullest, assuring a high acceptance level by its individual and employees to adopt an adequate knowledge-transfer strategy should be incorporated. In this respect, the core analysis may be due to all human-related factors that facilitate or hinder AI endorsement. The literature on technology acceptance and diffusion (e.g. Rogers, 1962) could be helpful in guiding future research. Increasing the spread of innovative technologies and ideas in societies might change their food diets (Kim and Chung, 2020), as higher diffusion of innovation could shrink certain food product consumption and favour others and thus change the purchasing behaviour towards more sustainable consumption patterns (Fiore *et al.*, 2017).

5.2 AI: Bridging firm's functions and networks

Secondly, we recognize two primary levels of analysis: (a) the firm and (b) inter-firm networks. Within the firm, the impact of AI can be categorised into two branches: (a1) the individual function, where AI is applied to a specific value chain activity (e.g. research and development (R&D)), and (a2) the inter-functional level, where AI impacts various organizational functions (necessitating top management to reevaluate the entire network of relationships and activities, both internally and with external partners).

For instance, in the context of the individual functions, Nayal *et al.* (2022, 2023) suggest that AI has a positive and significant role in managing agricultural supply chain risk. In contrast, at the inter-functional level, digital technologies such as AI and ML prove to be effective in executing various strategies and thus efforts that span multiple value chain activities (Ali and Xia, 2022).

At the inter-firm level, we have identified two types of AI-influenced networks. Firstly, the backward network which encompasses connections with suppliers. In essence, AI-based technologies can boost performance and co-create value among various parties, including suppliers and distributors of AI (technology providers) that either directly or indirectly contribute to the development and delivery of products and services (Yang *et al.*, 2020). Secondly, the forward network pertains to a firm's relationships with customers and consumers, such as in the case of consumer voice-assistant interactions (e.g. "Alexa"), which prove advantageous (Tassiello *et al.*, 2021).

5.3 AI benefits for the value chain

We aimed to identify the potential impact of AI on all agri-food value chain activities. For simplicity, we relied on extant frameworks of the agri-food value chain, distinguishing among R&D, production, processing, storage and distribution, sales and pricing, consumption, waste disposal, and recycling (van der Vorst *et al.*, 2001). For example, Kumar *et al.* (2015) introduced a crop selection method and proved that it could ameliorate the net yield rate of crops over seasons. Another example may relate to the adoption of new technologies to reinforce the user experience. Zhu and Chang's (2020) study of the anthropomorphism effect of robotic chefs on quality prediction highlights that real consumption experiences involving diverse cultures should be studied, and robots with higher levels of anthropomorphism should be examined to deepen our understanding of its impact on food quality.

Moreover, AI can make significant contributions to sustainability in the agri-food sector. It can be effective in addressing both environmental and social challenges at a niche level of agri-food businesses as well as to the broader ecosystem, shaping the future of the agri-food sector. The environmental aspect of AI revolves around resources management (Alam *et al.*, 2020; Camaréna, 2020) and optimizing their utilization processes (Rahutomo *et al.*, 2019), waste management (Yang *et al.*, 2022) and employing renewable energy to enhance sustainable practices in the sector (Doshi and Varghese, 2022). These elements are interconnected with AI potential to enhance productivity and efficiency in the sector.

Simultaneously, AI can contribute to social welfare (Ali and Xia, 2022), ensure food security (Camaréna, 2020; Richards *et al.*, 2009) and foster sustainable development goals like zero hunger and sanitation (Morales and Elkader, 2020).

6. Conclusion

This study reviews the literature on AI in the agri-food sector from a management perspective. We have identified six clusters to provide insight into the current research focus: (1) AI adoption and benefits, (2) AI for productivity and efficiency, (3) AI for logistics and supply chain management, (4) AI for supporting decision making process for firms and consumers, (5) AI for risk mitigation and (6) AI marketing aspects. This study adds to previous studies that have recently investigated multiple phenomena in the agri-food sector (Misra and Mention, 2021; Petrolo *et al.*, 2022). Furthermore, we performed a systematic literature review in which we analysed 69 publications. In conclusion, we present an integrative framework aimed at providing better comprehension of AI integration in the agri-food industry and guiding future research to better analyse and develop topic-related contributions.

We argue that AI involvement in the agri-food sector drives value through three main dimensions. The first dimension entails two sides: the "hard" and the "soft". The "hard" side focuses on technology development, adaptation, and usage, while the "soft" side emphasizes stakeholders' embracement and acceptance of these technologies. The second dimension covers the firm and inter-firm sides; the former reflects AI's impact on specific activities of the value chain (individual function), the latter refers to its influence on multiple value chain activities (inter-functions). The inter-firm level pertains to AI-influenced networks, which can be backward (with suppliers) or forward (with consumers). The third dimension is conclusive and concerns the role, applications, and effects of AI on the value chain process. We conclude that sustainability is a transversal out of AI integration in the agri-food sector, which links all the mentioned dimensions.

Based on the in-depth systematic literature, we believe that future research should focus on defining the theoretical underpinnings of AI in the agri-food sector. For example, we recommend that scholars consider theories related to ethics (as one of the key challenging and interdisciplinary areas of inquiry), consumer experience (as one of the main marketing aspects that could be affected by AI), and quality and sustainability (as core to production-related studies).

There are three primary challenges that must be addressed. The first is *communicating the concept of AI and its full benefits to agri-food sector participants*, including farmers, entrepreneurs, and stakeholders. A gap exists between the analysed literature and practitioners' needs, while academics and experts exploring cutting-edge applications of AI, farmers first require basic knowledge and understanding of AI's real advantages and benefits. Future research should ensure the creation of a common reference, based either on explicit knowledge (knowing-that, embedded through a series of trainings), to facilitate AI integration, or on tacit knowledge (knowing-how, gained with experience) to construct an intuitive wisdom-based model (Nonaka and Takeuchi, 1995). This model has the potential to strengthen AI implementation in the agri-food sector, overcoming challenges related to both the 'hard' and 'soft' side of AI identified by this paper. Future research should also aim to develop a frame model to facilitate technology integration and understanding for stakeholders who may struggle with complex academic studies or scientific models. For example, future research could focus on AI utility to minimize human intervention from crop production processes (Charania and Li, 2020) to the evaluation of food quality prepared by smart robotic chefs (Zhu and Chang, 2020), also considering cultural differences (Tassiello *et al.*, 2021).

The second challenge is about *adapting and combining AI strategies in a more complex and dynamic environment*, where traditional solutions and innovative strategies must find a new equilibrium by incorporating new knowledge. Within agri-food firms, AI can impact specific activities or multiple functions, necessitating updates that invokes various parties; thus, the establishment of a routine that structures new AI-based knowledge and guarantees its intertwinement with the existing structures and processes is deemed crucial (Filippini *et al.*, 2012). Consequently, new research should not only identify novel solutions needed, but also outline new managerial profiles that can enhance knowledge absorption capacity by setting a common 'frame of reference' at the inter-firms' level, between technology providers (suppliers) and technology receivers (buyers) (Filippini *et al.*, 2012).

The third one refers to *ethical concerns surrounding AI,* a domain that requires additional research (Camaréna, 2020; Maulana *et al.*, 2022), also with a multidisciplinary approach (e.g. law). For example, future studies could focus on developing business models that ensure proper privacy settings, data control, and confidentiality in the agri-food industry, particularly within the farming sector (Spanaki *et al.*, 2022). Moreover, the supply chain and AI should be given more space in research, considering supplier behaviour towards innovative technologies (Olan *et al.*, 2022).

This study has some limitations. First, we focused on a specific technology in a restricted sector, hence selecting a small core of documents. This could be subject to criticism. Second, we did not provide a large variety of future research avenues. Of course, there could be several other potential future research streams, but we want to enlighten the two main (and holistic) pathways for which we hope for a prompt and significant effort from scholars and experts in this field. Thus, after academics will cover the proposed challenges, further research can be made with a higher focus on more punctual problems and issues.

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Further reading

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Appendix

Table A1. Systematic analysis of the main contributions

Authors	Topic	Methodology: *Mixed Method*	*Qualitative*	*Literature Review*	*Conceptual*	*Quantitative*	Touchpoints: *AI technologies for external stakeholders*	AI technologies for sustainability	AI for decision support systems and entrepreneurship	AI technologies for efficiency, productivity and profitability	Cluster
Abban and Abebe (2022)	The literature review investigates the importance of digitalization and sustainability in African agribusinesses and food supply chains and highlight their potential to overcome challenges in the sector. The authors point out the main technologies employed in agriculture and supply chain management and highlight several sustainable practices			X			X	X			A
Agyemang *et al.* (2022)	This study examines food system frameworks in relation to sustainability aspects, constructs future scenarios, and develops a decision support system that helps stakeholders make strategic decisions and take pre-emptive actions to address potential challenges and uncertainties in the food system	X						X	X		E
Ahmed and Hussain (2022)	The authors suggest a forecasting model to predict wheat production using machine learning. After analysis, the model proposed is proven to be effective and thus could be replicable on other crops and regions		X							X	B
Alam *et al.* (2020)	The authors discuss the integration of emerging technologies like artificial intelligence (AI) and blockchain in the development of an innovative, smart and sustainable farming environment. They focus on addressing the challenges faced by the agriculture industry and provide solutions through the use of these advanced technologies							*X*			B
Alfalih (2022)	This article aims to examine the impact of intelligent automation on customer engagement and retention in the food and restaurant industry, particularly in the context of the COVID-19 pandemic					X	X				A

(*continued*)

Table A1.

Authors	Topic	Methodology: *Mixed Method*	*Qualitative*	*Literature Review*	*Conceptual*	*Quantitative*	Touchpoints: *AI technologies for external stakeholders*	AI technologies for sustainability	AI for decision support systems and entrepreneurship	AI technologies for efficiency, productivity and profitability	Cluster
Ali and Xia (2022)	This paper discusses the role of the digital agricultural market (DAM) in developing countries to mitigate uncertainty faced by stakeholders and to contribute to sustainability and social welfare, especially in the context of the COVID-19 pandemic				X			X			A
Anand *et al.* (2022)	The authors, based on a literature review, confer the use of artificial intelligence based technologies such as machine learning and Image processing in plant diseases detection and discuss their potential benefits			X						X	B
Basljan *et al.* (2021)	The authors discuss the challenges associated with delivering perishable goods and propose an approach for reliable planning and scheduling of perishable goods orders implementing artificial intelligence. This approach relies on gated recurrent unit neural networks to predict delivery routes and address the identified challenges					X	X				C
Bocewicz *et al.* (2017)	The authors examine the optimization of transportation logistics within the food supply chain, with a focus on developing a comprehensive model for efficient traffic flow management and planning. The purpose of this study is to provide valuable insights and actionable solutions to food supply chain management decision makers to build resilient food supply networks					X	X				C
Brunori *et al.* (2022)	This book chapter addresses the challenges of transitioning to sustainable food systems and explores the role of digital technologies, in this process. It identifies key digital technologies with disruptive potential, discusses the risks associated with their adoption, and provides recommendations for embedding socio-economic principles in the digitalization process		X					X			E

(continued)

Authors	Topic	Methodology: *Mixed Method*	*Qualitative*	*Literature Review*	*Conceptual*	*Quantitative*	Touchpoints: *AI technologies for external stakeholders*	AI technologies for sustainability	AI for decision support systems and entrepreneurship	AI technologies for efficiency, productivity and profitability	Cluster
Camaréna (2020)	The authors focus on artificial intelligence adoption in implementing transitions to sustainable food systems. This study seeks to investigate how AI can contribute to improving food security, preserving environmental resources, promoting social and economic development, and ensuring overall sustainability in the food and agriculture sectors			X				X			E
Chu *et al.* (2019)	The authors introduce an AI-driven hybrid model aimed at improving the precision and dependability of grape price predictions. The study underscores the significance of precise forecasting, highlights the challenges it faces, specifically for grapes, and investigates the potential benefits of integrating advanced AI techniques, such as machine learning and optimization algorithms, to fulfil price forecasting and subsequently support more informed decision-making within the industry					X	X				F
Dadi *et al.* (2021)	The article discusses the challenges of agrifood supply chains and how digital technologies can refine them. The authors performing a systematic review, investigate the concept of digitalization in agrifood supply chains and highlight they key role it plays to develop intelligent, sensible and sustainable agrifood supply chain systems			X			X				E
Darapaneni *et al.* (2022)	The paper determines the challenges facing fishing farmers, highlighting the impact of diseases on fish productivity. The authors discuss AI-based fish disease detection systems that could be benefit micro and small fish farmers, and propose for the matter an underwater system based on image processing and AI technologies		X							X	A

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Table A1.

Table A1.

Authors	Topic	Methodology					Touchpoints				Cluster
		Mixed Method	*Qualitative*	*Literature Review*	*Conceptual*	*Quantitative*	*AI technologies for external stakeholders*	AI technologies for sustainability	AI for decision support systems and entrepreneurship	AI technologies for efficiency, productivity and profitability	
Dellino *et al.* (2018)	The authors present the development of a decision support system (DSS) aimed at enhancing the management of fresh and highly perishable food supply chains. The primary objective is to improve efficiency, reduce waste, and maintain product quality throughout the supply chain, from production to consumption					X	X		X		D
Dora *et al.* (2022)	The article examines the critical factors influencing AI adoption in food supply chains. The authors identify the main limitations of food supply chains and analyse the role of AI to address these challenges and promote sustainability and food supply chains efficiency		X				X				D
Doshi and Varghese (2022)	The authors discuss the intertwinement of artificial intelligence and renewable energy to optimize farmers practices with the aim of addressing challenges facing agriculture in suburban and rural areas		X					X			B
El Hachimi *et al.* (2021)	The authors discuss multiple machine learning models for crop yield and air temperature prediction. They illustrate the successful development of predictive models and recommend their capability to improve agricultural efficiency and sustainability					X				X	B
Espolov *et al.* (2019)	This article examines the impact of digitalization in agriculture by shedding the light on how it can transform the agribusiness and highlighting the challenges that hindering successful transformation	X								X	B
Fenu and Malloci (2021)	This paper analyses recent research on plant and crop diseases prediction at early stages, examining methodologies, data pre-processing, performance metrics, and challenges faced				X					X	B

(*continued*)

Authors	Topic	Methodology					Touchpoints				Cluster
		Mixed Method	*Qualitative*	*Literature Review*	*Conceptual*	*Quantitative*	*AI technologies for external stakeholders*	AI technologies for sustainability	AI for decision support systems and entrepreneurship	AI technologies for efficiency, productivity and profitability	
Fiore *et al.* (2017)	The article delves into the intersection of artificial intelligence techniques (machine learning) and consumer choices, assessing the role of these machine learning in predicting preferences for Type 1 wheat flour, and underscores the implications of these insights for promoting healthier and more sustainable food consumption patterns					X	X				D
Ganeshkumar *et al.* (2022)	The authors inspect agritech industry digital transformation focusing on artificial intelligence (AI) role in this process. They identify and examine both the benefits and issues related to AI-based products in the agriculture sector. They suggested that addressing these challenges is essential to explore full potential of AI in the agritech industry					X				X	A
Goel *et al.* (2022a)	The book chapter describes various solutions for crop monitoring and livestock monitoring systems. The authors highlight the potential and importance of machine learning based remote monitoring and predictive analysis for livestock monitoring as it could enhance productivity		X							X	B
Goel *et al.* (2022b)	The authors focus on the development and implementation of a machine learning-based system for remote monitoring and predictive analytics in agriculture. The primary goal of this system is to enhance the management of crop and livestock production by leveraging machine learning techniques for monitoring, data analysis, and prediction of various factors that influence agricultural productivity					X				X	B

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Table A1.

Table A1.

Authors	Topic	Methodology					Touchpoints				Cluster
		Mixed Method	*Qualitative*	*Literature Review*	*Conceptual*	*Quantitative*	*AI technologies for external stakeholders*	AI technologies for sustainability	AI for decision support systems and entrepreneurship	AI technologies for efficiency, productivity and profitability	
Ikeda *et al.* (2021)	The authors discuss AI applications to plant growth management development to address the challenges associated to it. They present an agriculture support system for agricultural workers 'VegaCareAI'. They declare that it is a tool to boost crop productivity through vegetable classification, plant disease classification and insect pest classification					X					B
Issa *et al.* (2022)	The authors provide a comprehension of AI readiness and adoption identifying a set of strategic elements to help Agritech companies better control their "readiness process for AI adoption"	X								X	A
Jain and Choudhary (2022)	The authors examine the importance or crop yield in agriculture and provide an overview of information technology applications to crop management. They introduce "soil-based machine learning analytical framework" to forecast crop yield and perform a comparison among different machine learning techniques discussing their potential to level-up crop yield prediction					X				X	B
Khan *et al.* (2022)	The authors discuss machine learning techniques in agriculture and highlight several applications such as crop yield forecasting and precision agriculture. This book chapter identify potential benefits and limitations of machine learning for agriculture		X							X	B
Kim and Chung (2020)	The paper focuses on the development of a hybrid decision model that integrates expert knowledge with artificial neural networks (ANNs) to provide personalized nutrition management and dietary recommendations						X				D

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Table A1.

Authors	Topic	Methodology: *Mixed Method*	*Qualitative*	*Literature Review*	*Conceptual*	*Quantitative*	Touchpoints: *AI technologies for external stakeholders*	AI technologies for sustainability	AI for decision support systems and entrepreneurship	AI technologies for efficiency, productivity and profitability	Cluster
Kim *et al.* (2021)	This paper studies an AI-based method to detect growth deviations in Aloe arborescence L. by utilizing the VGG-16 convolutional neural network, attaining high accuracy in identifying watering and lighting problems for better hydroponic system management					X				X	D
Kumar *et al.* (2015)	The authors present the Crop Selection Method (CSM), an innovative machine learning approach to enhance agricultural planning by addressing the complexity of crop. By evaluating factors such as production rate, market price, and government policies, CSM aims to push up crop yield rates					X				X	B
Lachman and López (2019)	This paper examines the barriers to innovation in precision farming technologies in Argentina, focusing on the factors hindering market expansion from the supply side					X				X	A
Lao *et al.* (2010a)	This paper addresses the challenges in food distribution centres' inventory receiving activities due to the growing demand for customized services. It presents a Real-time Food Receiving operations management System (RFRS) to boost efficiency and organization in the food intake process				X					X	C
Lao *et al.* (2010b)	This article discusses the importance of inventory information management in the food industry and addresses the shortcomings of existing approaches. It presents the Integrative Food Handling System (IFHS), which aims to optimize inventory management in food warehouses through notification mechanisms and decision support systems				X				X		C

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Table A1.

Authors	Topic	Methodology *Mixed Method*	*Qualitative*	*Literature Review*	*Conceptual*	*Quantitative*	Touchpoints *AI technologies for external stakeholders*	AI technologies for sustainability	AI for decision support systems and entrepreneurship	AI technologies for efficiency, productivity and profitability	Cluster
Lee *et al.* (2021)	This paper examines senior customers' intention to use artificial intelligence food service stores. It explores the effect of different types of Motivated Consumer Innovativeness (MCI) on perceived usefulness and enjoyment, and how these factors affect trust and usage intention					X	X				F
Li and Xiao (2021)	The authors examine the use of data mining technology and 6G IoT communication in agriculture e-commerce, they debate about their ability to improve and boost efficiency and competitiveness of agricultural e-commerce. The article evidences the potential advantages of 6G IoT communication to agriculture industry to collect and analyse data					X	X				C
Liundi *et al.* (2019)	The authors discuss the potential of artificial intelligence (AI) to enhance rice productivity in Indonesia by examining current cultivation technologies and systems. They propose a model to predict optimal planting dates, considering different factors aiming to minimize yield gaps and increase efficiency				X					X	B
Lugonja *et al.* (2022)	The authors study the concept of smart agriculture identifies its' correlation to sustainable digital transformation. They refer to several technologies used in smart technologies and highlight "the importance of data analytics and predictive modelling" in improving agriculture production		X					X		X	B
Maulana *et al.* (2022)	The authors accentuate the importance of AI and the challenges associated to it in the agriculture sector identifying the different trends and patterns of research. They explain the use of scientometric analysis and highlight its' potential to ameliorate the understanding of AI in agriculture			X						X	A

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Authors	Topic	Methodology: *Mixed Method*	*Qualitative*	*Literature Review*	*Conceptual*	*Quantitative*	Touchpoints: *AI technologies for external stakeholders*	AI technologies for sustainability	AI for decision support systems and entrepreneurship	AI technologies for efficiency, productivity and profitability	Cluster
Morales and Elkader (2020)	The study explores the effects of Logistics 4.0 technologies on agriculture in developing nations, targeting three Sustainable Development Goals (SDGs): Zero Hunger, Clean Water and Sanitation, and Life on Land. The study highlights ten distinct technologies, and analyses their varying impacts on these SDGs. Ultimately, the study seeks to illustrate the potential of Logistics 4.0 technologies to promote sustainable agriculture in developing countries		X					X			A
Moreira *et al.* (2022)	The authors identify the benefits of using smart farm technologies (mobile applications, Convolutional Neural Network (CNN), edge-compute devices . . .) to enhance sustainability and efficiency in agricultural practices. The authors suggest that AgroLens could be further expanded and blended within smart farm systems to create a comprehensive and cost-effective leaf diseases diagnostics for farmers					X				X	B
Murugesan *et al.* (2019)	This paper delves into artificial intelligence and robotics application in Agriculture 5.0, in the context of crop yields prediction, utilizing machine learning and deep learning models across diverse crops and seasons. It highlights the possibility of enhanced accuracy					X				X	B
Nakandala *et al.* (2016)	The authors examine the important relationship between transportation costs and fresh food quality in the supply chain. This research focuses on developing an optimization model that balances the cost of transportation with the need to maintain the highest quality of perishable food in transit, so that consumers enjoy high quality food and businesses improve their efficiency and cost effectiveness					X	X				C

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Table A1.

Table A1.

Authors	Topic	Methodology: *Mixed Method*	*Qualitative*	*Literature Review*	*Conceptual*	*Quantitative*	Touchpoints: *AI technologies for external stakeholders*	AI technologies for sustainability	AI for decision support systems and entrepreneurship	AI technologies for efficiency, productivity and profitability	Cluster
Nayal *et al.* (2023)	The authors examine the potential of artificial intelligence and machine learning to address the challenges that the COVID-19 pandemic has posed to the agricultural supply chain in the Indian context. The study highlights how artificial intelligence and machine learning could optimize different aspects of the agricultural supply chain. The study highlights the key role artificial intelligence and machine learning play in developing more resilient and adaptive agricultural supply chains to address challenges, and to manage uncertainties		X				X				E
Nayal *et al.* (2022)	The authors investigate which factors influence AI adoption and highlight its' effect on supply chain risk mitigation (SCRM) that could be caused by disruptions like COVID-19. They conclude that "process factors, information sharing and supply chain integration" are key determinants that influence AI adoption and the later positively affect SCRM					X	X				E
Olan *et al.* (2022)	The authors investigate the theory of artificial intelligence supply chain financing and networks for the food and beverages industry. They suggest a novel conceptual meta-framework and conclude that AI based supply chain networks establish a sustainable financing stream for supply chain and discuss the study implications fin the food and drink industry		X				X				D
Pantazi *et al.* (2020)	This book provides an in-depth overview of the connection between decision-making in agricultural operations and the decision support features offered by advanced computational intelligence algorithms. It focuses on precision agriculture techniques	X								X	B

(*continued*)

Authors	Topic	Methodology					Touchpoints				Cluster
		Mixed Method	*Qualitative*	*Literature Review*	*Conceptual*	*Quantitative*	*AI technologies for external stakeholders*	AI technologies for sustainability	AI for decision support systems and entrepreneurship	AI technologies for efficiency, productivity and profitability	
Priyadarshi *et al.* (2019)	This study aims to select the optimal demand forecasting model for selected vegetables at the retail stage based on performance analysis. The research compares various forecasting models, to help increase efficiency					X	X				C
Rahmouni *et al.* (2022)	The authors suggest an Artificial Intelligence of Things AIoT based framework for precision agriculture. They review existing frameworks and highlight the role of precision agriculture in improving efficiency and hence, productivity		X							X	B
Rahutomo *et al.* (2019)	This study discusses an AI-driven web application designed to boost pineapple counting efficiency in Indonesia's horticulture sector, leveraging Agricultural 4.0 technologies. This model streamlines resources utilization, including water, fertilizers, insecticides, and packaging materials, by minimizing human error and optimizing processes					X				X	B
Raith and Dustdar (2021)	This paper presents the use case of edge intelligence as a service platform from food computing to smart health				X					X	B
Richards *et al.* (2009)	This paper explores the implementation of plant genetics and farmer practices to enhance food security in Africa. The paper evaluates farmer seed systems, comparing supervised and unsupervised learning approaches, and proposes an unsupervised learning method				X			X		X	B
Rocha and Lagarteja (2020)	This article focuses on a smartphone application designed to assist mango farmers by identifying pests and suggesting adequate control measures, ultimately aiming to boost fruit production					X				X	B

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Table A1.

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Authors	Topic	Methodology					Touchpoints				Cluster
		Mixed Method	*Qualitative*	*Literature Review*	*Conceptual*	*Quantitative*	*AI technologies for external stakeholders*	AI technologies for sustainability	AI for decision support systems and entrepreneurship	AI technologies for efficiency, productivity and profitability	
Saranya *et al.* (2021)	The authors discuss the effects of climate changes on crop yield and propose the Bootstrap Aggregative MapReduce Rocchio Classification in order to ameliorate crop yield prediction accuracy					X				X	A
Secinaro *et al.* (2022)	The authors seek to understand the relationship between agriculture entrepreneurship and new technologies focusing on identifying the role emerging technologies (artificial intelligence, augmented reality and machine learning) could play to promote agri-businesses		X						X		A
Sitek *et al.* (2017)	The authors examine, introduce, the application of constraint-driven methods for optimizing food supply chain management and for addressing the challenges associated to it. They declare that a constraint-driven approach can be used to build a decision support system for food supply chain management					X	X				C
Skvortsov (2020)	This paper explores the potential of implementing artificial intelligence (AI) technologies in Sverdlovsk Oblast's agriculture and discusses the challenges and prospects for AI adoption					X				X	B
Sood *et al.* (2022)	This paper investigates the factors influencing the adoption of Artificial Intelligence in agriculture, aiming to contribute to sustainable agriculture practices and meet the growing food demands. The authors propose a framework in which they these factors into five groups, highlighting the importance building trust among farmers and customizing AI solutions for better technology adoption			X				X		X	A

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Authors	Topic	Methodology					Touchpoints				Cluster
		Mixed Method	*Qualitative*	*Literature Review*	*Conceptual*	*Quantitative*	*AI technologies for external stakeholders*	AI technologies for sustainability	AI for decision support systems and entrepreneurship	AI technologies for efficiency, productivity and profitability	
Spanaki *et al.* (2021)	The authors discuss data sharing practices in agriculture and identify the main challenges facing the sector. They propose a data sharing agreement as a template of AI adoption to data management. They suggest that developing platforms, infrastructures, policies and legal frameworks for data usage remain critical for the farming sector	X								X	A
Spanaki *et al.* (2022)	The article explores the topic of artificial intelligence and food security. It identifies the potential benefits and challenges of AI-based agritech drones for smart agrifood operations and stress on the implication of the study for food security		X					X			A
Taghikhah *et al.* (2021)	The article discusses consumer behaviour shifts towards organic food products. Based on machine learning algorithms, the authors identify an attitude behavioural gap between intention and actual behaviour, focusing on cognitive factors. They conclude that affective factors and cues could result in spontaneous purchasing behaviour, causing them to behave against their intentions					X	X				F
Tassiello *et al.* (2021)	The article discusses consumer-voice assistant interaction in the purchasing process of food and beverages products and explore the psychological power it has on consumer decision making process					X	X				A
Ting *et al.* (2014)	The authors discuss the use of data mining techniques to analyse logistics data in the red wine industry in order to ensure quality and promote sustainability in the food supply chain					X	X				C

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Table A1.

Table A1.

		Methodology					Touchpoints				
Authors	Topic	*Mixed Method*	*Qualitative*	*Literature Review*	*Conceptual*	*Quantitative*	*AI technologies for external stakeholders*	AI technologies for sustainability	AI for decision support systems and entrepreneurship	AI technologies for efficiency, productivity and profitability	Cluster
Valls *et al.* (2010)	The authors address the challenges associated with sewage sludge disposal management on agricultural soils. They propose a multi-attribute preference approach for evaluating and rating suitable soils					X				X	E
Vuppalapati (2022)	This chapter provides an introduction to AI techniques and heuristics, as well as methods for processing agricultural, climatology, and satellite radiometer datasets. It also examines association mining, clustering techniques, and concludes with a focus on wheat commodity risk modelling for Egypt		X							X	E
Yan *et al.* (2015)	The authors identify the most significant variables for accurate pest risk prediction. They explore the use of multiple regression analysis and artificial neural networks (ANNs) to predict crop pest risks, aiming to improve pest management strategies					X				X	C
Yang *et al.* (2020)	The article discusses AI implementation for dynamic pricing and information disclosure in the fresh produce market, identifying the main challenges facing the sector and argue about the potential benefits of employing AI to boost efficiency and sustainability. The authors find that quality-based pricing system is an efficient strategy for not only for producers and consumers, but also for the environment, as it reduces food waste					X		X		X	F
Yang *et al.* (2020)	This paper examines the role of artificial intelligence and Internet-of-Things in creating a collaborative business ecosystem for the Chinese fish farming industry, considering Celefish as a case study. The authors emphasize the importance of digital technologies in fostering value co-creation and sustainability		X					X			B

(continued)

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Authors	Topic	Methodology					Touchpoints				Cluster
		Mixed Method	*Qualitative*	*Literature Review*	*Conceptual*	*Quantitative*	*AI technologies for external stakeholders*	AI technologies for sustainability	AI for decision support systems and entrepreneurship	AI technologies for efficiency, productivity and profitability	
Zhu and Chang (2020)	The authors explore an interesting relationship between anthropomorphic AI-powered robotic chefs and consumer perceptions of food quality. By examining the impact of human-like characteristics of robot chefs on consumer expectations and satisfaction, this study provides valuable insight into the potential advantages and challenges of integrating AI-driven humanoid robots into the culinary industry. The results will not only help us understand consumer behaviour and psychology associated with advanced technology, but also guide the future development and deployment of robotic chefs in various foodservice environments					X	X				F

Source(s): Authors' elaboration