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REVIEW ARTICLE

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Environmental, social and governance (ESG) in agriculture: trends and gaps on research

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ABSTRACT

Interest in the use of environmental, social and governance (ESG) frameworks to increase sustainability and reduce associated risks is growing in the agricultural sector. However, it remains unclear how and to what extent ESG could best be integrated into agricultural systems to benefit farmers. Drawing on the existing scientific literature, this article aims to (i) identify current and emerging themes in ESG research relevant to the agricultural sector, (ii) describe research gaps and thus opportunities to progress an ESG research agenda in Australia and (iii) propose potential future research directions based on the initial findings. This review demonstrates that research on ESG in the agricultural sector is in its early stages, but changing quickly and that there is an opportunity for academic research to advance our science-based knowledge of ESG in agriculture. We suggest that future research focus on ESG policy and management and innovative technologies with the goal of addressing ESG limitations and advancing the adoption of ESG principles and practices in agriculture. Specifically, we recommend that efforts be made to create sustainability credentials to improve the adoption of ESG in the agricultural sector to benefit sustainable producers and the potential of technologies for verifying improved ESG outcomes.

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KEYWORDS
Agriculture; Australia; ESG; sustainable finance; sustainability credentials

1. Introduction

Environmental, social and governance (ESG) frameworks are widely employed by financial institutions and corporations across various countries to enhance sustainability in distinct industry sectors (Li et al. 2021). These frameworks, which outline best practices across value chains, are dynamic and continually evolving. Initially focused on non-financial reporting, ESG has increasingly become integral to corporate values and management strategies for sustainable operations and investments (ASD 2023).

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In the agriculture sector, interest in ESG has surged due to the need to boost production while mitigating ESG risks (Figure 1). There is also a growing emphasis on adopting sustainable practices to meet consumer and international market expectations regarding resource management, social standards, and governance (S&P Global 2020). The demand for better social and environmental performance has led to the widespread promotion and adoption of voluntary sustainability standards, which can contribute to positive economic and governance outcomes (IISD 2022). Endorsed by the United Nations Climate Change Conference, ESG frameworks are increasingly influencing access to credit, insurance and markets, potentially becoming essential requirements for farmers aiming for market access (Generalova et al. 2023; Sood et al. 2023; Natalucci and Rohit 2021).

In this new and evolving context, addressing ESG challenges has become a critical issue for the agricultural sector (Lokuwaduge and Heenetigala 2017). ESG frameworks have been taken seriously by investors and identified as enablers in the transition to a more sustainable agriculture (Generalova et al. 2023). Mandatory reporting of sustainability risks and impacts by large and transnational companies (as agreed, for example, through the Kunming-Montreal Global Biodiversity Framework) will require monitoring and reporting along the entire supply chain. The prospective benefits to upstream suppliers, including farmers, of addressing climate-related risks, strengthening resilience to extreme conditions, reducing natural capital degradation and increasing ecological

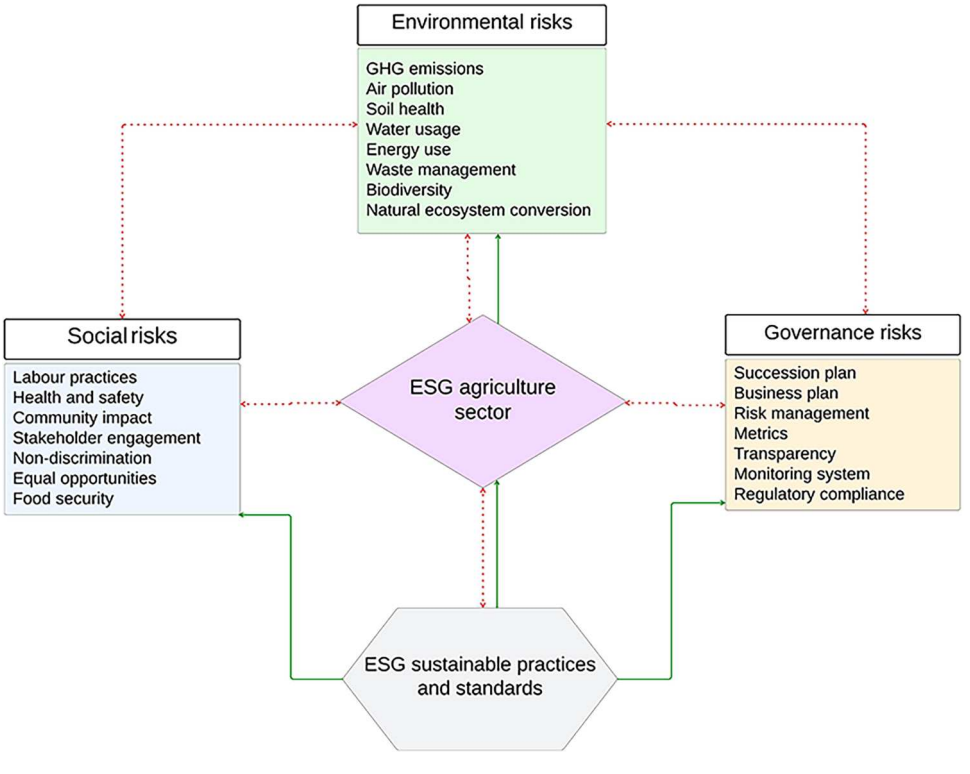

Figure 1. Links between ESG risks, impacts and sustainable practices in the agriculture sector: red line = negative impacts, green line = positive impacts.

governance (Banzet 2022) must be considered in relation to the challenges and costs of ESG implementation. In principle, implementation costs will be lower if ESG frameworks at the corporate and enterprise scales are integrated with other planning and governance initiatives (including market-based instruments such as carbon, biodiversity and water quality credits). The development of climate-smart agricultural practices, technologies and partnerships are essential to deliver more integrated local outcomes (Lockie 2020).

Despite evidence that improved management, investment and reporting practices are essential for the sustainability of agribusiness (IISD 2022), there is still much to be learned in relation to how ESG can best be integrated into agricultural systems and the role it will assume in promoting sustainable agriculture throughout the value chain. While in Australia, for instance, several ESG-aligned initiatives have been developed to support farmers to improve sustainability, it is still unclear how and to what extent these initiatives will facilitate or enhance ESG delivery outcomes. It is thus timely to review current knowledge of ESG in agriculture and to identify gaps in research that might limit its contribution to ESG adoption and, more importantly, to meaningful sustainability outcomes.

To this end, drawing on existing scientific literature on ESG, this study aims to contribute to a better understanding of ESG both globally and within Australia by answering two questions: (i) What are the current and emerging ESG research themes in the agricultural sector? (ii) What are the research gaps to progress with ESG research in the agriculture sector?

2. Method

A quantitative systematic literature review method was adopted to quantify and assess research gaps and emerging trends within the discipline (Pickering and Byrne 2013). The comprehensive methodology combines a systematic method for identifying the relevant literature and employs a quantitative methodology for coding the literature using categories and subcategories to summarise the results (Pickering, Johnson, and Byrne 2021). The approach begins with defining the topic, then setting the research questions, identifying keywords, identifying and searching databases, reading and assessing publications, structuring the database, drafting methods and evaluating key results and conclusions (Pickering and Byrne 2013).

As shown in Figure 2, the present quantitative systematic literature review was performed in accordance with the Preferred Reporting Items for Systemic Reviews and Meta-Analyses (PRISMA) approach to summarise the peer-reviewed literature on ESG in agriculture in the last 20 years (2004–2024). PRISMA consists of the following phases (Page et al. 2021):

Identification: A comprehensive search from several major databases (Web of Science, SCOPUS, ProQuest Platform, SAGE Journals, AgEcon and Google Scholar) was conducted from May to July 2024. We included primary databases for a more comprehensive search as well as databases specifically covering the topic of agriculture and business. ProQuest is the largest single periodical resource available, bringing together complete databases across all major subject areas including business. The search provided a total of 377 records. Duplicated records were removed from the analysis.

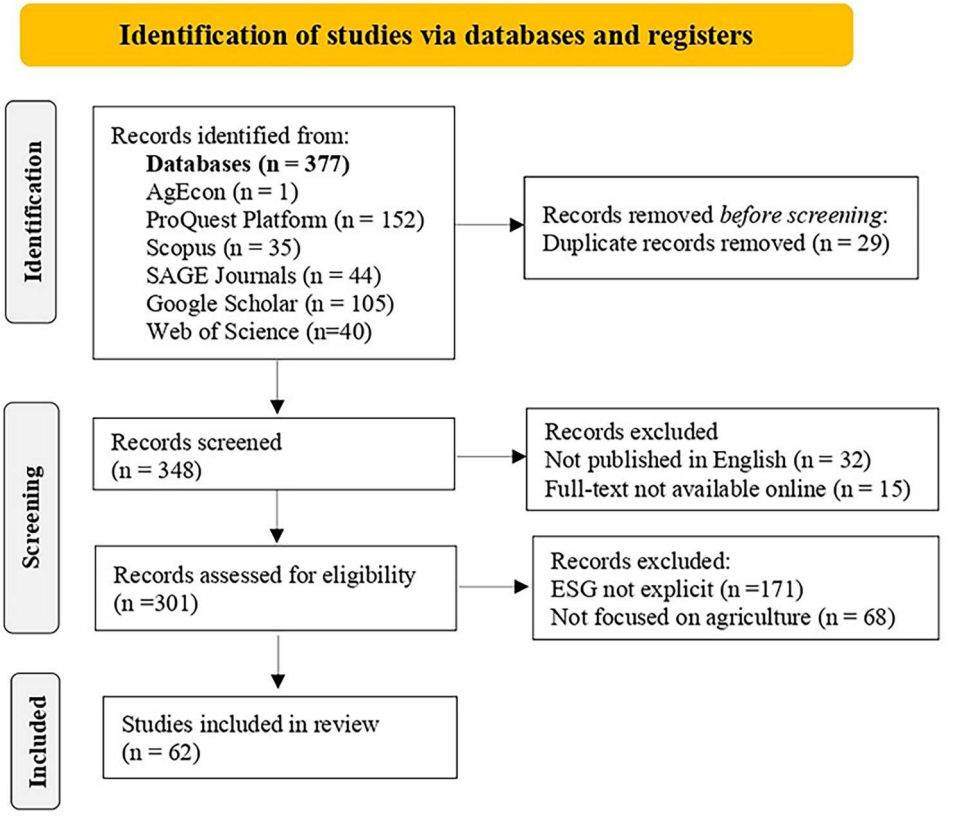

Figure 2. PRISMA workflow outlining the systematic review process (Page et al. 2021).

Screening: After defining the scope and aims of this study, we conducted a two-step screening process. First, we established eligibility criteria for including or excluding publications from further review. The criteria were: (i) published in English, (ii) published in peer-reviewed academic journals, (iii) published in 2004 or later and (iv) full-text available online. Publications that did not meet these criteria were excluded. Second, we assessed the publications for eligibility using the search terms 'ESG AND agriculture' to identify relevant records. We selected texts that (i) focused on agriculture, (ii) explicitly mentioned the term 'ESG' in the title, abstract or main body and (iii) included the term 'agriculture' explicitly in the title, abstract or main body. Publications that did not include both terms were excluded. The list of publications reviewed can be found in the supplemental information.

Analysis and synthesis of results: A quantitative analysis of selected publications was performed using a Microsoft Excel database. All publications retrieved in the screening process and included in the database were assessed and classified using the following criteria: (a) author, (b) article title, (c) geographic location, (d) year, (e) journal and (f) target audience. The extraction and classification were cautiously documented (Annex 1). Qualitative analysis and coding were carried out using NVivo qualitative data analysis software. Selected publications assessed for eligibility ($n = 62$) were transferred to NVivo for qualitative analysis and coding. This study employed an abductive thematic analysis, a

qualitative research method used to develop hypotheses and explanations from incomplete information (Thompson 2022). This creative and intuitive approach involves manually categorising data into codes, which are then examined, clustered and consolidated to uncover key and emerging ESG research themes in the agriculture sector. To synthesise the findings, we adopted an inductive narrative approach (Campbell et al. 2020), resulting in thirteen detailed themes.

3. Results

A total of 62 original peer-reviewed research publications were identified for inclusion and examined (Figure 2).

Over 80 per cent of the publications reviewed were published from 2022 onward, highlighting the recent surge in ESG research within the agricultural sector (Figure 3). This trend suggests that the number of ESG-focused publications in this field is expected to grow significantly by 2024, compared to previous years.

The quantitative assessment by geographic location (Figure 4) revealed that 45 per cent of the publications were categorised as 'location unknown', indicating they were not tied to a specific country. Many of these studies focused on how ESG principles are integrated within international agriculture companies and industries. The research spanned 21 individual countries, Africa and the European Union (Figure 4). China emerged as the leading country with the most publications (10 per cent), followed by Indonesia (5 per cent) and the European Union (6 per cent).

To tailor the analysis to the target audience, we categorised the content into eight distinct sectors: (1) agri-food and forestry businesses, (2) farmers and farmland, (3) public and private investors, (4) general businesses, including agriculture, (5) cooperatives, (6) government, (7) small and medium-sized enterprises and (8) non-specific. The non-specific category includes publications aimed at a general audience. Nearly 60 per cent of the publications focused on agri-food and forestry businesses, with farmers and farmland accounting for 15 per cent and investors comprising 11 per cent (Figure 5).

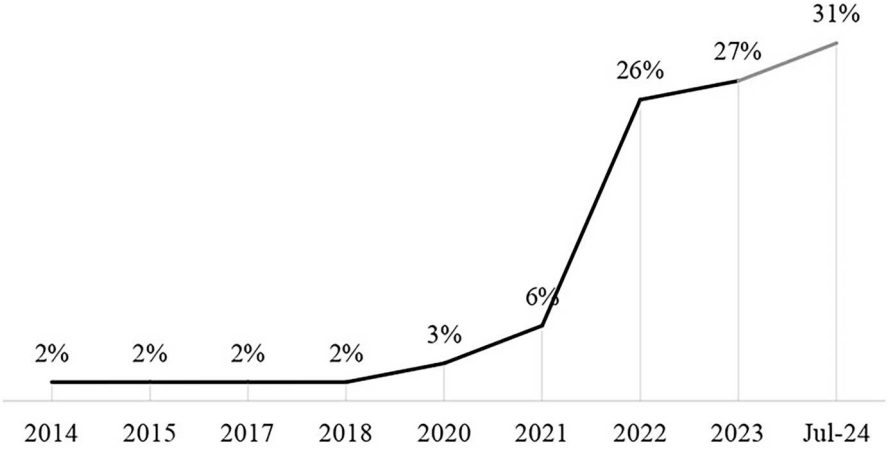

Figure 3. Quantitative assessment of reviewed publications per year.

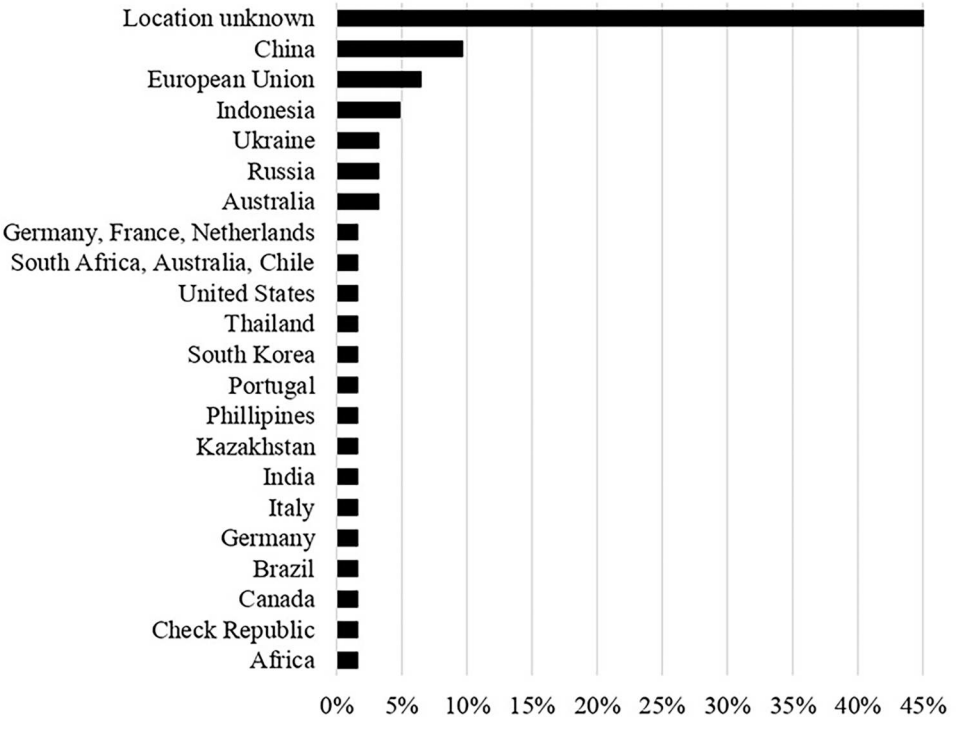

Figure 4. Quantitative assessment of reviewed publications per geographic location.

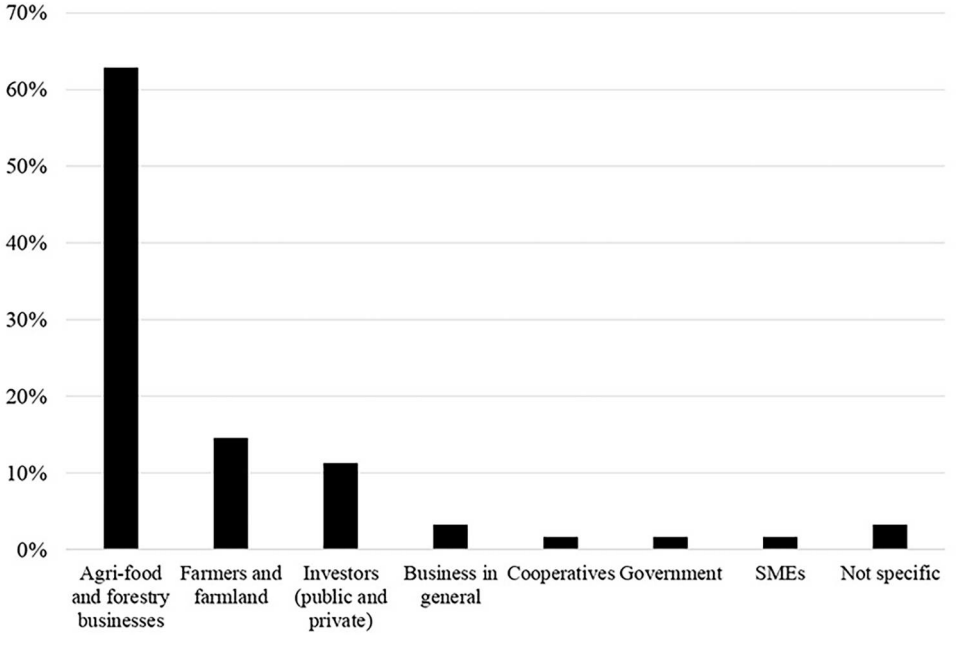

Figure 5. Quantitative assessment of reviewed publications per target audience.

Overall, this review indicates that ESG-focused studies within the agriculture sector remain limited, as previously highlighted by Galbreath (2013). However, there has been a noticeable increase in awareness and attention to ESG research in the agriculture sector over the past two years (Figure 3). While much of the scientific literature continues to concentrate on the financial performance of companies and data disclosure, our study reveals that new themes are emerging in ESG research specific to improve agriculture practices.

3.1 Current and emerging ESG research themes

Figure 6 presents a quantitative thematic analysis of the reviewed publications, which were categorised into 13 distinct themes. The most prevalent theme was sustainable finance and investments, featured in 17 publications. This was closely followed by data disclosure and corporate performance, with 16 publications. The topic of innovative technologies was addressed in 14 publications, highlighting the increasing interest in technological advancements within the context of ESG in agriculture. This focus on technology marks a departure from the traditional emphasis on finance and reporting. The remaining themes, which include corruption, greenwashing, ease of doing business, the bioeconomy, circular economy and green economy models, ESG certification, ESG management, sustainable practices, climate change and biodiversity, were less frequently covered, indicating they are emerging areas of interest within ESG research.

3.2 Data disclosure and corporate performance

Previous research has examined the relationship between data disclosure and the financial performance of firms without a unique conclusion (Lee and Suh 2022). In the agriculture sector, this is also a theme of primary interest, and the controversy is the same. Makarenko et al. (2022), for instance, verified that the more effort companies

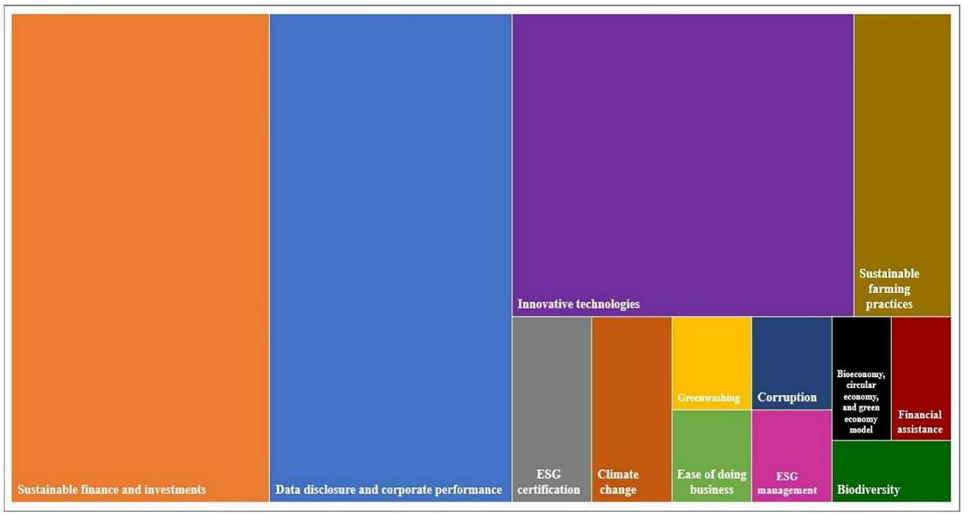

Figure 6. Thematic analysis of publications included in this study.

invest in sustainability transparency, the higher their position is in rankings, evidencing that companies' sustainability transparency is an important element for corporate performance. Zeng and Jiang (2023) observed that in China there is a positive correlation between ESG and corporate performance over time. In the European Union, companies with higher ESG scores have higher financial performance as suggested by Mititean (2023). According to Pirtea et al. (2021), ESG dimensions play a decisive role in counteracting risks related to the sustainability of the financial performance of agricultural companies, particularly by the environmental pillar. Buallay (2021) analysed ESG data from the Bloomberg database and observed that governance disclosure had a positive impact on market performance. Tarulli et al. (2023) suggested that agricultural firms disclosing more information on ESG and environmental practices should be rewarded with a lower cost of debt capital and have better access to financial resources due to a higher commitment with transparency.

Examining how companies in Indonesia comply with ESG standards, Sutikno et al. (2023) verified that companies tend to prioritise ESG elements that are easier to adapt and have a positive impact. The authors also found that industries like coal, oil and gas as well as agriculture are more likely to adopt comprehensive ESG standards such as the Global Reporting Initiative standard. Overall, Indonesian companies selectively adopt ESG components that are easier to disclose.

Gerber, Smit, and Botha (2024) examined the inconsistencies in ESG reporting among agribusinesses in Australia, Chile and South Africa, emphasising the need for uniform standards. The authors observed that South African agribusinesses reported on more material topics than their Australian and Chilean counterparts, with South African companies covering 29.71 per cent of key topics, while Australian companies covered just 14.29 per cent. Chilean agribusinesses reported similarly to South Africa, with 33.17 per cent coverage. The study highlighted the lack of attention to climate adaptation and resilience, despite their critical importance. The authors recommended a move towards mandatory ESG reporting and a greater focus on climate change, biodiversity and social issues within the agribusiness sector.

Feigin et al. (2023) conducted a systematic literature review aiming to summarise proposed solutions to climate change from 2002 to 2022 and suggested a unified approach to addressing the crisis. The review covered strategies like transitioning to renewable energy, reducing energy consumption, rethinking global transportation and implementing nature-based solutions. The authors highlighted the need for standardisation in ESG measures, which are currently inconsistent and lack transparency, making it difficult to assess true ESG performance. The study calls for global standardisation of ESG metrics and the creation of an independent regulatory body to ensure their credibility and effectiveness in combating climate change.

De Campos Filho and de Oliveira (2024) also verified that ESG principles are crucial in the agribusiness sector and that that companies implementing sustainable practices aligned with ESG strategies experience significant benefits, including enhanced growth, financial performance and competitiveness. Moreover, these strategies contribute to better sustainability and resource management. The authors emphasised the importance of an ethical and sustainable approach throughout the entire production process in agribusiness, integrating ESG considerations.

Despite the lack of consensus regarding the impact of sustainability disclosure on corporate performance (Halbritter and Dorfleitner 2015; Mititean 2023), most studies show a positive relationship between ESG and financial performance (Friede et al. 2015). The need to investigate the effects non-financial disclosure have on firms' performance has been highlighted in previous research (Tarulli et al. 2023). In the agriculture sector, it is not different. While some authors identified a positive correlation between ESG performance and financial performance (Mititean 2023; Tarulli et al. 2023; Makarenko et al. 2022; Ahmad, Mobarek, and Roni 2021), other empirical results demonstrated that ESG does not have a statistically significant influence on operational performance, financial performance and market performance of agriculture industries (Buallay 2021).

In Indonesia, Zuraida, Ihsan, and Husna (2024) analysed the use of PROPER program, considered crucial for assessing and encouraging environmental performance. According to the authors, some agriculture companies have achieved top rating, reflecting their strong commitment to environmental management. The authors also finds that ESG factors positively impact financial performance indicators like operational performance and financial performance, but not return on capital employed. The complex relationship between sustainability disclosure and financial performance is highlighted by unexpected negative association.

Conca et al. (2021) examined the relationship between ESG disclosure scores and financial performance among European-listed agri-food companies. The findings revealed a positive correlation between overall ESG disclosure and return on assets, suggesting that better reporting on ESG issues enhances profitability. Specifically, environmental and social disclosures positively impact operational performance, while governance disclosures show a slightly negative relationship with market value. The study highlighted the need for agri-food companies to improve governance reporting and maintain or enhance their environmental and social reporting practices.

Focusing on ESG disclosure, the number of companies using ESG frameworks to report on sustainability has increased in the last years (IFAC 2023). Transparent measurement and disclosure of ESG performance is considered crucial for businesses and disclosing reliable information is a major issue among stakeholders (Lokuwaduge and De Silva 2022). However, the main source of ESG information is corporate sustainability reports with significant limitations regarding data consistency, distinct standards and metrics (WRI 2019). The inconsistency of reporting methods is considered by investors as a significant obstacle to ESG disclosure and sustainability assessments (Kareiva et al. 2015). Increased transparency of social and environmental impacts in renewable energy infrastructure projects, for instance, is another topic that remains a debating point (Kennedy and Qayyum 2023). In some specific areas such as 'big water' (irrigation for food production), estimates of water footprints do not contain sufficient information to enhance understanding of water's role in the catchment-level, which could improve water management (Lankford 2022). In the Ukraine, ESG-efforts in agriculture are very limited and this is related to insufficient sustainability transparency and disclosure by agriculture companies (Makarenko et al. 2022).

Gaps related to the quality of reporting and the impact of ESG disclosure are also linked to limited research on ESG in agriculture. Makarenko et al. (2022), for example, analysed more than 2,300 academic papers on transparency issues, and only four explored the case of agriculture companies, evidencing the lack of attention for

that sector. The publications analysed in this study confirm what has been demanded by investors and regulators in terms of the quality of ESG information, data consistency and transparency (IFAC 2023).

3.3 Sustainable finance and investments

In this study, publications focused on distinct approaches to sustainable finance and investments were examined. Sustainable finance is defined as the process of taking ESG considerations into account when making investment decisions, leading to more long-term investments in sustainable economic activities and projects (European Commission n.d.). It has a key role in supporting distinct sectors to deliver sustainability. The European Commission's Sustainable Finance Strategy also emphasises the crucial role of the financial system in advancing a greener, more sustainable economy, with small and medium-sized enterprises playing a pivotal part in this transition. However, small and medium-sized enterprises often face challenges in integrating sustainability due to limited resources (Camelo and Nogueira 2024). Clear and transparent contract documents to enhance sustainability in financing, advocating for proactive contracting and legal design as tools to promote sustainable business practices, are crucial, particularly in the context of loan agreements (Kaave 2023).

In recent years, financial investment in agriculture has significantly changed the agricultural landscape. Financial actors are increasingly investing in a range of agricultural investment products, including agricultural commodity futures, commodity index funds, agricultural funds, farmland and commodity production firms (Clapp 2017).

Food security and agricultural products, water and financial returns from land, as an asset class, are highlighted as drivers of investment in farmland (Schaffnit-Chatterjee et al. 2012). Agricultural land is considered a stable long-term investment with the benefits of diversification, inflation protection and potential for attractive returns (PRI 2019). However, farmland investments have been criticised by non-government organisations due to the transformation of land used to support livelihoods and food security into an 'alternative asset class' (Ouma 2020, 76). Concern over the social and ethical implications of the 'assetisation' of farmland, according to Ouma (2020, 68), has become a major reputational risk for investors. To deal with this emerging phenomenon, referred to as land-grabbing (acquisition or long-term lease of large areas of land by investors) (De Schutter 2011), some institutional investors are reviewing their ESG criteria to incorporate more social concerns into investment decisions. Moreover, Chung and Adriaens (2023) verified that the lack of externality integration in land valuation affects lending and disclosure practices, as financial providers increasingly account for ESG risks. Farmland accounting for contamination, like shadow pricing, can influence land values based on future cash flows and inform sustainability-linked lending (Chung and Adriaens 2023). A study using a data fusion and hedonic pricing method was conducted by Chung and Adriaens (2023) to show that farmland prices in the Lake Huron area (United States) are influenced by nitrogen and phosphorus contamination. Contrary to expectations, contamination increases farmland prices, indicating that environmental contamination is not fully reflected in the costs and liabilities of water pollution from farming. The authors concluded that with rising regulatory interest in sustainable finance and agroindustry ESG practices, a sustainable risk pricing

approach is needed. Moreover, adjustments are necessary to promote sustainable practices like regenerative agriculture.

In Africa, the planned expansion of the agribusiness sector for agrofuel production and commodity crops is pressuring the acquisition of land for agricultural purposes. Ewelukwa Ofodile (2014) examined whether bilateral investment treaties and land contracts in Ethiopia were addressing complex environmental, social and governance issues and concluded that few, if any, make specific reference to the human rights or environmental treaties that Ethiopia has ratified or to broader ESG issues.

In China, listed agricultural and forestry companies are becoming increasingly aware of their ESG responsibilities with ESG having a significant impact on stock liquidity, due to the close relation this industry has with environmental and social-related policies (Liang, Xue, and Zhang 2023).

Bortolotti, Loss, and van Zwieten (2023) verified that global sovereign wealth funds are becoming more interested in making sustainable investments with a particular focus on promoting the United Nations' Sustainable Development Goals. Nonetheless, the investments on the Sustainable Development Goals are still concentrated in Europe and America receiving the largest deal value. Those authors also observed that global sovereign wealth funds' investment in agriculture has come to the fore in 2020 and that solid ESG frameworks favours the execution of larger sustainable investment programs.

Kuandykova et al. (2023) examined how investment incentives can promote organic agriculture and rural development in Kazakhstan by applying ESG principles. The authors argued that while ESG principles can attract investment, strengthening public policies – like state incentives and tax benefits for organic producers – is essential to boost competitiveness and encourage direct investment. In India, Nayak, Mohanty, and Swain (2023) explored the financing of cooperative societies, focusing on the challenges and contributions of the National Cooperative Development Corporation. As the sole apex financial institution for cooperatives, the Corporation supports sustainable business activities, particularly in the dairy sector, by providing financial assistance for infrastructure, modernisation, and ESG-linked projects. Despite obstacles, cooperatives have significantly empowered farmers and contributed to their welfare. According to the authors, the Corporation's success is attributed to transparent loan appraisals and efficient disbursal processes, ensuring cooperatives' growth and alignment with national objectives.

Wang (2024) investigated how green finance affects the synergy between water, energy and food systems. The author suggested that financial institutions should actively adopt financial technologies to build a robust green information base, improve project screening and leverage existing green data such as ESG disclosure reports and environmental violation records.

A study focused on biogas companies in some Italian regions, provide valuable insights for managers, entrepreneurs, banks and policy makers, helping to guide future investments in alternative energy sectors. Iotti, Manghi, and Bonazzi (2024) found that there is a need to assess the investment structure, financing and debt service capacity of firms using interest coverage ratios, which are crucial for evaluating performance and securing loans. The growing capital in the biogas sector and ESG-compliant

investments highlighted the importance of accurately calculating interest coverage ratios to ensure debt sustainability.

Regarding the financial investments in distinct industries, both impact and ESG investors are more likely than conventional funds to invest in agriculture and forestry (Cojoianu, Hoepner, and Lin 2022). Also, impact investors are more likely to invest in natural resources than ESG and conventional investors. Finally, agriculture and forestry are the industries of choice for impact investors across Asia and Australasia, Europe and North America.

Havemann, Negra, and Werneck (2022) investigated the role of blended finance as a mechanism to mobilise additional private capital to achieve the transition to more sustainable agricultural systems and concluded that the integration of ESG issues in decision-making is still nascent. The authors highlighted that there are technical and operational challenges to mobilising financial resources and that more funding is needed to promote more sustainable agriculture investments. Among those challenges are efficient and effective impact monitoring of social and environmental performance, testing of new investment strategies and cultivation of appropriate structures for investing. The authors also argue that the transition will require significant additional capital not covered by the current financial market setup, which dissociates public and private funders.

Several financial institutions are engaging with ESG investments including universal owners (institutional investors) in livestock production. Brice et al. (2022) examined how universal owners become concerned about the ethical, political, and environmental issues surrounding meat and livestock production and how they have internalised those factors into financial markets. The authors observe that universal owners only engage with issues that present risks to the financial performance of their portfolio. Farm animal welfare, for example, is considered as 'merely' ethical and material only to individual companies or sectors and consequently is not internalised by those type of investors (Brice et al. 2022, 1565). In another study, Hinchliffe et al. (2024) observed that intensive livestock production has led to significant consolidation and financialisation within the industry, with major transnational corporations now dominating animal genetics, feed and market management. According to the authors, these corporations, while expected to adhere to regulations, often bypass or influence regulatory controls due to their power and global reach. The 2011 swine flu pandemic, for example, highlighted the challenges of governance and transparency in this sector. Moreover, recent analyses suggest that the financialisation of the livestock industry, particularly through investor-led governance, often prioritises reputational risks over operational sustainability.

Investigating the extent to which obesity prevention and population nutrition are considered by Australian institutional investors engaged in responsible investment, Robinson et al. (2020) found that ESG integration to be the most common approach. The authors observed that while many investors consider obesity and population nutrition, their strategies vary significantly, reflecting a broader trend in ESG integration that aligns with traditional financial analysis. However, the lack of standardised metrics for nutrition-related issues complicates consistent reporting. Despite the potential for institutional investors to enhance corporate governance, there remains substantial variation in how social issues are addressed in ESG practices and Australian institutional investors are often minimally addressed within ESG frameworks.

Finally, after examining some recent initiatives for responsible agricultural investment[1], Clapp (2017) verified that these initiatives are likely to mirror some investment weaknesses such as vague guidance, lack of concrete enforcement mechanisms and weak rates of participation.

3.4 Innovative technologies

The agriculture sector is undergoing a significant transformation driven by new technologies used to increase profits and maintain the sustainability of farm production. This new data-driven agriculture model has been referred as agriculture 4.0, digital farming or smart farming (Saiz-Rubio and Rovira-Más 2020). Moreover, this model is already transitioning to agriculture 5.0., which involves concepts such as internet of things, deep learning, big data analytics, sensors, fog computing, artificial intelligence and machine learning (Ragazou et al. 2022). The importance of innovative technologies to be developed in line with ESG principles is also an emerging theme identified in this study, especially in the context of changes in consumption patterns and increased consumer awareness.

Agriculture 5.0 is seen as the future for ESG-focused investors, offering significant potential to address climate change and other critical issues. However, the transition involves societal challenges, such as technological advancements, lock-ins and the need for stakeholders to adapt their behaviours quickly to adopt and customise new solutions (Haloui et al. 2024).

ESG principles can enhance the implementation of Industry 4.0 in agriculture by promoting social benefits such as improved worker safety and food quality, economic benefits like cost reduction through sensors and environmental benefits including decreased chemical use (Yap and Kong 2024). Despite these advantages, there is a significant gap in research on applying ESG to manage Industry 4.0 in agriculture. ESG considerations are crucial for improving sustainability, risk management and attracting ethical investment.

The emerging focus on socially responsible artificial intelligence highlights the need to align artificial intelligence with human values and address risks while promoting societal sustainability (Chang and Ke 2024). Socially responsible artificial intelligence integrates key sustainability concepts such as corporate social responsibility, ESG and Sustainable Development Goals to enhance its impact. The increasing interest in ESG investments among corporate managers and investors underscores the relevance of socially responsible artificial intelligence. The environmental aspect of socially responsible artificial intelligence emphasises artificial intelligence's role in tackling climate change and fostering green practices, including energy optimisation, renewable energy development, sustainable agriculture, waste management, and smart transportation (Chang and Ke 2024).

Kim (2023) explored upcycling technology as an innovative approach to enhancing the food system. Upcycling goes beyond traditional recycling by creating higher value from discarded items. The study focused on food upcycling in South Korea, emphasising that a comprehensive strategy, including expert technical evaluations, is essential for progress. The research suggested increased involvement from agricultural cooperatives and companies, supported by government initiatives, to drive broader industrial adoption. However, the study also highlighted that the potential of agricultural by-products is currently constrained by low marketability and the need for improved mass processing techniques.

Blockchain is another technological innovation aligned with ESG principles with potential to improve supply chain transparency, enabling traceability of information and accountability in the sector (S&P Global 2020). In Canada, the use of blockchain is linked to the growing interest in ESG issues and increased requirements in ESG reporting in the food industry (Sengupta and Kim 2021). According to the authors, there are potential benefits of applying blockchain to supply chain traceability. First, it can significantly reduce the time, scope and costs associated with food product recalls. Additionally, blockchain technology minimises disputes in quality assurance within the food supply chain, enhancing overall accuracy. It also facilitates market expansion by providing robust quality assurance, which can lead to better pricing and value capture due to increased customer satisfaction. Furthermore, blockchain enables the distribution of value to stakeholders through Smart Contracts and offers the capability to integrate with other blockchain solutions, such as insurance products. Lastly, it addresses growing consumer demands for transparency regarding food origins and processes.

From another perspective, some publications analysed investments and challenges to promote technology innovation in the agricultural systems of Russia and China. In Russia, Pudeyan et al. (2023) verified a positive impact of innovatisation and informatisation in an agro-industrial complex on its productivity and improvement of the culture of management. However, the insufficient dissemination of ideas and requirements of responsible business policy, adoption of ESG principles and lack of transparency for external stakeholders are considered obstacles to innovation within the Russian agro-industrial complex and a barrier to the global green transition (Aleksandrov et al. 2023; OECD 2022).

In China, the traditional agricultural production model has led to overstocking, the rapid growth of imports and ecological degradation (Shi et al. 2023). However, technological innovation, integration and effective reform of the supply-demand structure of agriculture are regarded by Shi et al. (2023) as driving forces for sustainable growth. They suggest that ESG principles should be considered a reference for structural reform that should orient policies and decision-making processes.

The concept of smart farming is also of interest to researchers with publications growing from 2020 onwards (Ragazou et al. 2022). In Russia, scaling up the project 'smart farm' has been considered a measure to enable the green transition and large-scale implementation of ESG policy (Aleksandrov et al. 2023, 7). Although there is potential for new agriculture models to reduce environmental impacts and improve the sustainability of farm production, ESG investors are only focusing their interest on fighting climate change instead of considering other opportunities to increase investments in the agricultural sector (Ragazou et al. 2022).

In Brazil, the sugarcane sector has evolved to integrate ESG standards, with digitalisation playing a key role in standardising and monitoring ESG data (Molin, Wei, and da Silva 2024). Despite historically low technology adoption rates, advancements in information and communication technologies and precision agriculture are gaining traction to reduce costs and boost yields. In Brazil, government support and the influence of sugarcane mills are crucial in promoting these digital solutions aligned with ESG principles (Molin, Wei, and da Silva 2024).

Regarding the livestock farming, considering that the activity contributes significantly to greenhouse gas emissions, making emission reductions is essential for climate goals.

Technology like decision support systems can help, but success depends on farmer adoption and behavioural change. Münster and Grabkowsky (2024) analysed fourteen decision support systems features aimed at supporting greenhouse gas reduction and concluded that successful implementation of these systems depends on user adoption and satisfaction, which involves changing farming practices. Moreover, Münster and Grabkowsky (2024) emphasised the need for data protection and financial incentives for farmers to ensure effective use of decision support systems. In another study, Papakonstantinou et al. (2024) concluded that integrating precision livestock farming with sustainable practices offers a data-driven approach for sustainable agriculture, but addressing cost, complexity and animal welfare challenges is crucial.

Finally, a comparison between traditional and AgriFoodTech supply chains has demonstrated how differently those two models incorporate ESG and Sustainable Development Goal compliance (Visconti 2022). The study showed that some features of the AgriFoodTech ecosystem such as digital platforms and sustainable business planning can foster ESG compliance. According to the author, the AgriFoodTech model is consistent with ESG and Sustainable Development Goal standards, and in this model the sustainability issues can be overcome in a more efficient way. Visconti (2022) also highlights how corporate social responsibility is one of the most essential drivers of ESG. Indeed, in recent decades, research interest in corporate social responsibility topics in the agriculture sector has grown (Tarulli et al. 2023). According to Pirtea et al. (2021), corporate social responsibility should be implemented in agriculture as a value-creating strategy and fundamental tool of sustainable development and firm profitability.

3.5 Greenwashing

Greenwashing refers to a practice used by some businesses when they mislead ESG disclosures about a company's environmental actions (firm level) or the benefits of a product or service (product level), exaggerating and misrepresenting green credentials (De Silva Lokuwaduge and De Silva 2022). Greenwashing undermines consumer trust in green products and investor confidence in environmentally friendly businesses, harming both markets. Greenwashing occurs when there is a combination of poor environmental performance and positive communication about it (Delmas and Burbano 2011). While the studies about this emerging theme are limited, Montero-Navarro et al. (2021) suggest a growing research interest with special concern for ESG practices related to strategy and companies' performance in the agriculture sector. De Silva Lokuwaduge and De Silva (2022) observe that the lack of international standards on ESG-related taxonomy potentially contributes to an increased risk of greenwashing. Overall, it has been observed that ESG performance has a negative relationship with likelihood of greenwashing, i.e. firms with low ESG scores are more likely to greenwash than firms with high ESG scores (Lee and Raschke 2023).

3.6 The ease of doing business

Ease of Doing Business is an index published by the World Bank to rank and compare economies with respect to regulatory best practices (World Bank 2020). The role of the index's value is linked to economic development, economic growth, foreign direct

investments and good governance. Costantiello and Leogrande (2023) used an econometric model and estimated ease of doing business' value in the context of ESG for several countries. This study showed mixed results regarding the relationship between ease of doing business and ESG. It demonstrated that the ease of doing business value is positively associated with the prevalence of overweight, energy intensity level of primary energy, individuals using the internet, government effectiveness and cooling degree days. Conversely, the ease of doing business value was negatively associated with agriculture, forestry and fishing, forest area and strength of legal rights. Costantiello and Leogrande (2023) also verified that the ease of doing business's value is predicted to grow for almost all the countries for which the prediction was made, except for the United States, Japan and Thailand, where the value of the ease of doing business is predicted to decrease for political-economic reasons.

3.7 ESG management

ESG management is related to the strategy adopted by companies regarding their investment decisions, operations and supply chain management. Some aspects of ESG management, such as the relationship between ESG management and the size of agricultural companies, have been less studied. Cristea et al. (2022) explored how ESG management influences the size of public agricultural companies and assessed the global connections between ESG dimensions and company size. The authors emphasised the need to strengthen small and medium-sized agricultural companies to support corporate social responsibility initiatives and recommended embedding these companies within strategies that enhance ESG measures. Key areas highlighted include environmental product scores, overall corporate social responsibility strategies, external corporate social responsibility audits, management of controversies related to bribery, corruption, and fraud, independence of compensation committees and employee numbers. Noting the risks associated with negative impacts of ESG measures on total assets, Cristea et al. (2022) proposed adjusting targets such as those for carbon dioxide emissions. The authors also suggested policy adaptations for resource management, setting corporate social responsibility reporting regulations, improving governance and setting diversity targets, including increasing the inclusion of women on boards.

3.8 ESG certification

Another emerging theme from this study was ESG certification. ESG certification is a credential issued to a company which complies with specific criteria, based on third-party verification, with potential to enhance brand and company value (Lai and Zhang (2022). It entails disclosing business information for evaluation by external markets, which can signal positive market intentions and increase stakeholder scrutiny, thereby encouraging more green initiatives (Pedersen, Fitzgibbons, and Pomorski 2021; Chen, Dong, and Lin 2020).

Jones et al. (2024) explored the social, economic and environmental impacts of voluntary certification schemes in coffee production, assessing their role in fostering sustainable practices. While consumer interest in coffee sustainability is rising, understanding remains limited and often centres on environmental issues like deforestation and

pesticide use. Certification schemes simplify this complexity, serving as a proxy for consumers and a social contract with farmers, signified by logos that represent rigorous standards. Coffee producers typically focus on sustainability standards that address working conditions, biodiversity and economic stability, while companies align these efforts with broader ESG commitments.

Shushunova et al. (2022) evaluated the application of ESG certification in city farming construction. The authors compared the market of urban green roof farms with the ESG certification methodology, based on ESG scores, and verified that ethics programs, sustainable technologies and responsible use of natural resources are the main areas of ESG risk management for the companies they evaluated.

3.9 Corruption

Political corruption, a key factor of concern in respect to governance aspects of ESG, can negatively impact companies in many distinct ways, affecting markets, corporate decision-making and voluntary ESG disclosure (Hoang 2022). Laureti, Costantiello, and Leogrande (2022) estimated the level of control of corruption of several countries using data from the ESG World Bank database. The authors verified that control of corruption is a variable positively associated to government effectiveness, political stability and absence of violence/terrorism and primary education. Conversely, they showed that the ratio of female to male labour force participation, gross domestic product, strength of legal rights, value added by agriculture, forestry and fishing and greenhouse gas net emissions (and removals) by land use change and forestry are negatively associated to control of corruption. They also highlighted that the countries with significant percentages of gross domestic product from agriculture (low-income countries) have less ability to fight against corruption.

3.10 The bioeconomy, circular economy and green economy model

The bioeconomy, circular economy and green economy model is a holistic economic solution which integrates three different models of development. Kaewhao (2023) examined ESG knowledge among agriculturists of Maha Sarakham Province in Thailand and found that they have a higher level of knowledge about the environmental dimension followed by governance and social dimensions. The author also verified that green economy, ESG dimensions as well as bioeconomy lead the food security management of agriculturists in the province.

3.11 Sustainable farming practices

Sustainable farming practices aim to balance profitability, environmental health as well as social and economic equity. These practices promote overall sustainability by preserving soil health, preventing water pollution and protecting biodiversity (UNEP 2021). Khan et al. (2024) recommended that sustainability managers implement circular economy principles to minimise waste and enhance material recycling, collaborate with suppliers on closed-loop systems and design recyclable products. They also suggested diversifying farmer incomes through alternative crops, optimising resource use with precision

agriculture and improving economic efficiency. Additionally, the authors found that knowledge-sharing platforms and technologies like blockchain can facilitate best practices and ensure supply chain transparency and adherence to sustainability standards.

Based on Yap and Leow's research (2023), the enhanced sustainable farming practices under ESG include precision agriculture, controlled environment agriculture, improved crop breeding, agricultural biotechnology, packaging innovations, reducing food waste and regenerative practices. The authors suggest that green-minded leadership model in developing countries should be based on ESG standards. According to the authors, environmental governance and institutional frameworks play a crucial role in agricultural practices, and effective ESG elements must be integrated into leadership models. Future research should also explore how ESG measures impact financial performance in developing countries, like studies in developed nations.

Biochar derived from biomass waste offers significant potential for advancing carbon neutrality and a circular economy. Its cost-effectiveness, versatile functionality and thermal stability make biochar-based catalysts crucial for sustainable biorefineries and environmental protection (Yuan et al. 2023). To maximise these benefits, it is essential to assess and standardise environmental and economic impacts, providing clear guidelines for industries and policymakers. According to Yuan et al. (2023), by converting biomass waste into high-performance catalysts, it is possible to support various United Nations' Sustainable Development Goals and ESG goals effectively.

Skiter et al. (2022) recommended enterprises to embrace innovative technologies to tackle sustainable development challenges. According to the authors, key measures include adopting alternative energy sources such as solar, tidal, wind and biomass and utilising artificial intelligence in agriculture. Implementing internet of things platforms can optimise agricultural processes and reduce resource consumption. Additionally, developing mathematical models that incorporate ESG factors can drive effective ESG transformation. Artificial intelligence can enhance sustainability by improving irrigation, power efficiency and more, although its impact on sustainability must be carefully managed to balance benefits and risks.

3.12 Climate change

Examining climate change mitigation strategies in France, Germany and the Netherlands, Wang, Dong, and Mei (2023) verified that all three countries incorporate diverse policy instruments to reduce greenhouse gas emissions while considering institutional requirements, fairness, economic effectiveness and transformative potential. However, each country displays unique sectoral emphases: France on ecological housing loans, Germany on transportation digitisation and the Netherlands on sustainable agriculture.

Li et al. (2024) observed that climate change significantly hampers corporate ESG performance. However, reducing internal and external resource misallocation can mitigate these adverse effects. Notably, resource-based cities see a relative improvement in ESG performance due to climate change, suggesting a partial break from the resource curse. According to the authors, larger, mature enterprises better manage these negative impacts, while external pressures from public and analyst scrutiny can further drive improvements in ESG performance.

3.13 Biodiversity

Da Fontoura et al. (2024) introduced a method to integrate the no-net-loss principle into ESG frameworks, focused on Brazil's biomes. The no-net-loss principle aims to offset biodiversity losses from human activities. The authors proposed the Equivalent Biodiversity Area metric to support no net-loss objectives and biodiversity gains. The study recommended integrating legal reserves and ecological restoration into ESG policies, encouraging landholder collaboration and aligning with broader environmental efforts like watershed revitalisation and biodiversity credits markets. This approach can promote a unified, data-driven strategy for biodiversity conservation, enhancing corporate environmental stewardship.

3.14 Financial assistance

Pan et al. (2024) examined the challenges farming households face in boosting incomes through financial assistance from the International Fund for Agricultural Development, highlighting the importance of ESG practices in promoting sustainable development in China's agricultural sector. The study underscores how strong ESG performance enhances market competitiveness, fosters green innovation and strengthens supply chain relationships, ultimately contributing to rural revitalisation and China's goals of carbon peak and carbon neutrality.

4. Discussion

This study aimed to better understand the current and emerging ESG research themes of academic interest as well as to identify research gaps to progress with ESG research in the agricultural sector in Australia.

4.1 Current and emerging ESG research themes of academic interest

Our study revealed that ESG research in the agricultural sector is a relatively new field, with significant attention given to the connections between ESG frameworks, financial returns, data disclosure and corporate performance in agricultural companies. However, emerging themes have surfaced over the past two years, indicating a potential shift in focus, notably considering innovative technologies. Despite this, research on these new ESG themes remains limited. Given the growing importance of ESG in agriculture and the urgent need to find effective solutions for ESG challenges, there is a clear and pressing opportunity to advance academic research in this area.

In our study, we identified several gaps and emerging themes in ESG research, including greenwashing, ESG management, certification, sustainable practices, climate change and biodiversity. Notably, the theme of innovative technology has seen a significant rise over the past two years, nearly matching the number of publications in the two traditionally dominant themes. Innovative technologies are increasingly recognised as crucial for ESG integration, with studies on their role in enhancing ESG across various economic sectors experiencing substantial growth (Mneimneh et al. 2023; Le et al. 2022; Saxena et al. 2023; Zhang and Jin 2022).

ESG certification has been studied within the finance sector (Rudd 2023; Lai and Zhang 2022; Wu, Xiong, and Gao 2022; Wong et al. 2021), but is still very embryonic within the agricultural sector. This calls for more research, for example on the effectiveness and benefits that ESG certification could bring to farmers not only in terms of production but also providing additional revenue streams.

As for greenwashing, increased science-based knowledge could mitigate the associated risks. Our study suggests that some attention has been paid to greenwashing research in agriculture (Zeng and Jiang 2023; Montero-Navarro et al. 2021). However, given the limited number of publications linking ESG and greenwashing in the agriculture sector there appears to be an opportunity for researchers to examine these relationships more closely.

ESG management is another theme identified in this study which has been extensively examined within the finance sector (Niu, Park, and Jung 2022; Lim et al. 2022; Park and Jang 2021), but remains incipient in the agriculture sector. Indeed, our study suggests that expanded research in this area would be strategic given the potential to contribute to overcoming challenges related to increased transparency and comparability of distinct metrics and methodologies.

Finally, it is important to highlight that there are other significant themes not yet fully examined in the literature, demanding future research. The integration of natural capital and other ESG issues to support ESG strategies and nature-related disclosures, for instance, should be more closely studied by academics given the complexity it involves and the high impact it can have in the agriculture sector.

4.2 Research gaps to progress with ESG research in the agriculture sector in Australia

Although ESG-related initiatives have progressed rapidly in Australia over recent years, only two publications on ESG in the agricultural sector were found in our study. Redressing the current paucity of country-specific research in Australia and elsewhere could facilitate the delivery of ESG positive outcomes such as effective governance and higher disclosure quality.

ESG regulations and non-financial disclosures are becoming permanent and important elements for several economic sectors (Szewczyk and Szustak 2023). In some countries, the adoption of global ESG standards and reporting are more often becoming a mainstream sustainability practice (Dathe, Müller, and Helmold 2023). In Europe, for example, ESG expectations are both more advanced than in many other jurisdictions and a potential barrier to market access for suppliers unable to meet ESG compliance, customer preferences for sustainable products, investors and financiers' preferences and the likelihood of being undervalued (Gossain 2023). In Australia, ESG initiatives have been discussed among distinct economic sectors. However, the role of ESG in promoting sustainable agriculture credentials is still in its early stage. There has been increased progress in the implementation of Task Force on Climate-Related Financial Disclosures recommendations (Chua et al. 2022), but there are still low levels of climate-related disclosure by most companies (Wedari, Jubb, and Moradi-Motlagh 2021). It is also important to mention that the Australian Sustainable Finance Taxonomy, an ongoing joint industry-government initiative, is under development, which could accelerate sustainable investments to achieve net-zero by 2050 with the potential for delivering more

sustainable outcomes in the agriculture sector. Moreover, there is potential for the Australian Sustainable Finance Taxonomy to strengthen ESG strategies and to help reduce measurement divergence between ESG assessments, decrease uncertainty in investment decisions and reduce companies' average cost of capital (Norang et al. 2023; Dumrose, Rink, and Eckert 2022).

4.3 Conceptual framework for advancing ESG research in Australian agriculture

This conceptual framework aims to address identified gaps and leverage emerging trends in ESG research, ultimately advancing sustainability and improving ESG practices in Australian agriculture.

4.3.1. Policy standardisation and roadmap development

To address inconsistencies and gaps in ESG strategies within Australian agriculture, a unified policy framework is essential. Policy makers should adopt a proactive approach and develop a comprehensive standard that enhances the quality, transparency and credibility of ESG strategies. This framework should include:

- Common standards: Establish a consistent ESG measurement and reporting standard to unify frameworks and data.
- Long-term roadmap: Create a strategic plan that builds on existing ESG progress, aligns national and international sustainability credentials and supports trade enhancements.
- Advancement of frameworks: Improve and innovate current agricultural sustainability frameworks by aligning them with ESG standards and frameworks to create a robust foundation for sustainability in agriculture.

4.3.2. Enhancement of ESG management and frameworks

To improve the effectiveness of ESG management, it is crucial to examine and refine existing frameworks and tools. This includes:

- Framework assessment: Conduct detailed evaluations of current Australian ESG frameworks and tools to assess their effectiveness and integration.
- Management capacity: Strengthen managerial capabilities in ESG through better tools and frameworks, facilitating more transparent and accountable ESG reporting. Develop and implement transparent communication strategies.
- Alignment and integration: Ensure that ESG frameworks and tools are aligned and integrated, providing clear metrics, consistent data and accurate measurements of ESG performance.

4.3.3. Leveraging technology for ESG verification

Technological advancements hold significant potential for improving ESG outcomes in agriculture. To harness this potential, we suggest:

- Integrating technology: Integrate fragmented literature on ESG technologies to address environmental, social and economic challenges in the agricultural sector and enhance the utility and application of ESG technologies in agriculture.

- Improving transparency: Use technology to increase transparency and accuracy in ESG reporting and verification.
- Fostering compliance: Implement technologies that support ESG compliance and facilitate the widespread adoption of ESG policies across the sector.

4.3.4. Advancing ESG sustainable practices

- Support and resources: Facilitate the transition to sustainable practices by offering targeted support and resources from both public and private sectors, especially for small farming businesses.
- Integrating ESG: Incorporate ESG frameworks into sustainability practices using metrics and data-driven strategies to enhance environmental stewardship and overall sustainability.
- Leveraging sustainable practices: Adapt strategies to the specific national context to achieve effective emissions reduction, carbon neutrality, water security and biodiversity.

5. Conclusion

While there is evidence that the agricultural sector could benefit from continued progress with ESG, our study shows that the academic literature on ESG in agriculture is limited. As with studies of other economic sectors, research into ESG in agriculture is also focused predominantly on the financial performance of the companies based on the analysis of ESG indices. Notwithstanding, our study also identifies several emerging themes and calls for further studies to progress on ESG research in Australia and elsewhere.

Our study also contributes with significant theoretical implications for academics. Given the relatively recent emergence of ESG research and the gaps that remain in the extant literature, we argue researchers could better examine trends and implications of ESG frameworks not only to improve ESG strategies, but also to drive ESG adaptation and new research topics. Current ESG limitations could also benefit from future research in these areas.

The lack of granularity in many existing studies limits comprehensive understanding of ESG benefits. Further investigations are also needed to effectively integrate new ESG themes with metrics and effective measurement to evaluate positive ESG outcomes from sustainable agriculture and farming practices.

Further research is also needed regarding the complexities and dynamics of ESG in the agricultural sector, the nature of synergistic relationship between ESG, sustainability on farm and potential to use an ESG framework for sustainable investment tools.

Finally, a possible limitation of this work could be based in the criteria adopted to select articles for reviewing. The focus only on peer-reviewed scientific publications could have resulted in a relatively limited sample of publications incurring in restricted interpretation of our findings.

Note

1. Principles for responsible agricultural investment; Voluntary guidelines on responsible governance of tenure of land; Principles for responsible investments in agriculture and food systems; Farmland principles – principles for responsible investment; Global Compact.

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