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# Past and Future of Sustainability Indicator Research in Agribusiness: A Bibliometric and Forecasting Analysis

Marcelo Kratz Mendes[1] | Olga Cam[2] | Aurora Carneiro Zen[1] | Roger de Bem Jaeger[1] | Daniela Callegaro-de-Menezes[1] | Juliana Matos de Meira[2]

[1]School of Management, Federal University of Rio Grande do Sul (UFRGS), Porto Alegre, Brazil | [2]Sheffield University Management School, The University of Sheffield, Sheffield, UK

**Correspondence:** Marcelo Kratz Mendes (kratz.marcelo@gmail.com)

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## ABSTRACT

This study offers a forward-looking assessment of sustainability indicator research in agribusiness by integrating bibliometric mapping with ARIMA-based forecasting. Analysing 403 Scopus-indexed articles, bibliographic-coupling analysis identifies three contemporary thematic domains: Techno-Managerial Sustainability, Systemic and Agroecological Assessment and Normative Indicator Frameworks. Co-citation analysis reveals four intellectual foundations that connect this field to strategic management research, including resource-based perspectives, multi-criteria evaluation approaches, farm-level assessment tools and normative sustainability frameworks. Forecasts indicate the continued dominance of environmental and economic indicators through 2030, alongside persistent gaps in social and governance metrics. These patterns suggest structural challenges for integrating sustainability into strategic decision-making, capability development and organizational governance. Relating thematic clusters to central constructs in strategy research such as performance measurement, differentiation and long-term resilience, the study clarifies how the literature positions and mobilises indicators in discussions of competitive positioning in agribusiness. A research agenda is proposed to strengthen methodological coherence and advance underdeveloped dimensions.

## 1 | Introduction

Sustainability has become an imperative in agribusiness,[1] driven by escalating environmental pressures, socio-economic inequalities and evolving societal expectations for accountability in global food systems (Amamou et al. 2025; Rasmussen et al. 2017; Santiago-Brown et al. 2015). As agricultural production expands in response to global demand, it simultaneously exerts unprecedented pressure on biodiversity, carbon stocks, water cycles and rural livelihoods, revealing deep trade-offs between growth and ecological stability (German et al. 2011; Hosonuma et al. 2012; Rasmussen et al. 2017). Agribusiness occupies a central position in this dynamic, not only because of its environmental footprint but also due to its potential to catalyse inclusive development and climate-resilient practices (Santiago et al. 2025).

In this context, sustainability indicators emerge as widely used tools for operationalising the abstract principles of sustainable development, translating them into measurable, comparable and actionable metrics that inform strategy, governance and transparency (Amamou et al. 2025; Hák et al. 2016; Parris and Kates 2003). From the perspective of firms, such indicators may support alignment with ESG (environmental, social and governance) frameworks, responding to investor demands and strengthening internal risk management (Amamou et al. 2025; Milder et al. 2015), while the literature also suggests they can shape how decision flows and influence dynamics unfold within organisational strategy processes (Jaeger, Mendes, Schutte, and Zen 2025). However, despite the proliferation of frameworks, there is little consensus on which indicators best capture the multidimensional nature of sustainability, particularly in complex, transboundary value chains (German et al. 2011; Newton et al. 2013; Rasmussen et al. 2017). Such fragmentation between academic metrics and practitioners' needs weakens comparability, limits transferability and hinders strategic decision-making in the agribusiness sector.

Sustainability in business has evolved from an initial focus on financial viability to a multidimensional approach that encompasses environmental stewardship and social responsibility (Dyllick and Hockerts 2002; Elkington 1997). The Triple Bottom Line (TBL) framework (Elkington 1994) and the UN Sustainable Development Goals (SDGs) have encouraged agribusiness to shift from purely profit-driven metrics to more balanced approaches that integrate environmental and social outcomes (Schaltegger and Wagner 2006). Sector-specific tools (e.g., SAFA, RISE and IDEA)[2] provide structured assessment methodologies; however, many are limited in terms of cross-country comparability and practical application for smaller or resource-constrained operations (Streimikis and Baležentis 2020). Moreover, current ESG reporting practices often underrepresent governance and social dimensions, particularly in agribusiness settings, where stakeholder engagement, land tenure rights and labour conditions are critical. Sustainability control tools are not merely passive reporting mechanisms but can be interpreted as instruments of organizational transformation, with the potential to reshape internal practices and decision-making processes (Ligonie 2021).

The complexity of these challenges has catalysed the rise of sustainability science, a transdisciplinary, solution-oriented field that embraces the uncertainty, context-dependence and reflexivity inherent in real-world sustainability issues (Kates 2011; Lang et al. 2012; Vanhulst et al. 2025). For agribusiness leaders, advances in sustainability science are not just academic developments; they represent a strategic intelligence resource for navigating shifting policy landscapes, stakeholder expectations and market demands.

The current study is positioned within broader debates in business strategy and governance. Beyond their role in agribusiness assessment, sustainability indicators have significant implications for corporate governance and financial markets. Prior studies have demonstrated how disclosure practices influence firm legitimacy, governance and cost of capital (Elmanaseer and Gerged 2025; Gerged et al. 2021), while others indicate that novel metrics of organizational environmental responsibility can shape investment efficiency (Wang et al. 2024). These insights underscore that sustainability indicators are not merely technical measures but also strategic instruments that may carry implications for corporate value creation and long-term resilience.

Although earlier work underscores the role of disclosure and knowledge integration in environmental performance (Elmanaseer and Gerged 2025; Zahoor and Gerged 2021), a clear gap persists in the literature. Prior studies remain largely retrospective and descriptive (e.g., Ali and Perna 2021; Monteiro et al. 2023, 2024). Thus they offer a limited insight into how sustainability indicator research in agribusiness has evolved, how its intellectual foundations connect or how future trajectories are likely to unfold. There is also a need to enhance an understanding of how these strands intersect with strategic governance debates in agribusiness.

To address this gap, the study pursues three objectives: (1) to map the intellectual and thematic structure of sustainability indicator research using co-citation and bibliographic-coupling analyses; (2) to forecast emerging trends using Autoregressive Integrated Moving Average (ARIMA) modelling; and (3) to formulate a research agenda that highlights conceptual and methodological gaps with strategic relevance. Together, these aims provide a more integrated and forward-looking perspective on sustainability indicators in agribusiness.

In meeting its objectives, the study contributes in four main ways. First, it provides a theoretically grounded synthesis that reframes sustainability indicators as elements of strategic governance, clarifying how different indicator configurations support distinct strategic logics for agribusiness firms. Second, it advances bibliometric methodology by integrating co-citation and bibliographic-coupling analyses with ARIMA-based forecasting, offering an original retrospective-and-prospective understanding of how the field may evolve to 2030. Third, it deepens the strategic relevance of sustainability indicators by showing how the thematic clusters identified in the literature connect to exploitation, exploration, legitimacy building and dynamic capability development. Finally, it formulates a research agenda that provides strategic guidance for addressing the conceptual, methodological and governance challenges that will shape future developments in the field.

This article proceeds as follows. Section 2 outlines the methodological design, including data collection and bibliometric techniques. Section 3 presents the descriptive results. Section 4 analyses the intellectual and thematic structure of the field through bibliographic coupling and co-citation. Section 5 integrates forecasting results with managerial implications and sets out the research agenda. Section 6 provides the overall conclusion and outlines the limitations.

## 2 | Methods and Data

Bibliometric analysis is a vital tool to obtain a holistic view of a specific area of research, helping stakeholders identify trends and relevant issues (Farrukh et al. 2020). It has emerged as a methodological approach for mapping scientific knowledge and evaluating research trends across disciplines (Donthu et al. 2021; Linnenluecke et al. 2019). By enabling a rigorous, transparent and replicable process for analysing large volumes of academic literature, bibliometric techniques support the identification of dominant research themes, influential works and collaboration patterns over time (Donthu et al. 2021; Zupic and Čater 2015).

Bibliometrics provides a strategic lens to assess the evolution of scholarly contributions, uncover epistemological foundations and delineate thematic shifts and research frontiers (Farrukh et al. 2020; Linnenluecke et al. 2019). It offers a structured alternative to narrative reviews by minimising bias, documenting procedures and ensuring representativeness (Linnenluecke et al. 2019; Tranfield et al. 2003). For these reasons, it was selected as the most suitable methodology to achieve the objectives of this study.

This study integrated both descriptive analysis and science mapping techniques. The descriptive component examined the total number of publications per year and identified the most prolific journals, authors, institutions and countries. The science mapping included co-citation analysis of references, bibliographic coupling among documents and countries to reveal dominant themes and conceptual structures in the literature. While co-citation analysis detects intellectual linkages by identifying works cited together frequently, revealing networks of thought, influential authors and foundational texts (McCain 1990; Small 1973), bibliographic coupling, conversely, connects documents that share common references, allowing for the identification of research fronts and current thematic alignment among studies (Kessler 1963). When combined, these techniques provide complementary perspectives: co-citation unveils historical influences, while bibliographic coupling highlights contemporary associations (Donthu et al. 2021).

To support data visualization and clustering, we employed VOSviewer version 1.6.20, an specialised software that facilitates the graphical representation of bibliometric networks (Van Eck and Waltman 2014). Through the clustering algorithm embedded in VOSviewer, thematic structures and intellectual communities within the literature are made visible, aiding both conceptual mapping and agenda setting (Broadus 1987; Donthu et al. 2021).

The VOSviewer procedures were implemented with defined thresholds and clustering settings. For document-level bibliographic coupling, a minimum of 5 citations per document and a cluster size of 60 items were applied, while country-level coupling used a minimum cluster size of 5. Co-citation analysis used a minimum of 50 cited references. All maps were generated with VOSviewer's default layout and association-strength normalisation at a clustering resolution of 1.00. Items that did not reach the required threshold for a specific VOSviewer analysis were excluded from that network visualisation, yet they remained within the broader dataset and were still used in other analytical procedures. The selected parameters were chosen after exploratory testing showed that higher thresholds produced fragmented maps and lower thresholds generated overly coarse clusters, with the overall thematic structure remaining stable across small variations in parameter settings, indicating robustness.

In addition to the retrospective bibliometric analysis, this study incorporated forecasting techniques through the use of ARIMA models implemented in the R 4.5.1 statistical environment. This statistical method, recognised for its effectiveness in modelling time series data (Wilson 2016), is increasingly applied in bibliometric forecasting to estimate future publication trends (Domenteanu et al. 2025; Krishnan et al. 2022). Specifically, ARIMA modelling was employed in this research to project and forecast publication trajectories across key sustainability dimensions: economic, social, governance and environmental. This prospective component adds depth to the analysis by anticipating thematic evolution in the literature, a perspective often lacking in previous bibliometric reviews. Importantly, both the bibliometric maps and the ARIMA projections speak to the structure and evolution of scholarly attention; they do not test the organisational effectiveness of indicator systems nor causal impacts on firm performance.

It is also important to acknowledge the methodological limitations associated with ARIMA forecasting and to clarify the indicator classification procedure supporting the models. ARIMA relies on the assumption that historical publication patterns adequately represent the underlying data-generating process, which requires stationarity after differencing and the absence of structural breaks, a principle well established in time-series literature (Hyndman and Athanasopoulos 2018; Hyndman and Khandakar 2008; Wilson 2016). These conditions are often challenged in research domains affected by policy reforms, funding shifts or global crises, as highlighted by recent forecasting applications (e.g., Domenteanu et al. 2025; Krishnan et al. 2022; Wilson 2016).

Forecast accuracy is further constrained because no exogenous variables were included, even though editorial dynamics, geopolitical events and institutional incentives can strongly influence publication trajectories. As noted by Hyndman and Khandakar (2008), automated model selection based on information criteria can improve statistical fit but cannot compensate for omitted external drivers; therefore, projections should be interpreted cautiously. The forecasting procedure followed the conventional ARIMA($p, d, q$) structure, with models selected automatically using the AICc criterion implemented in *auto.arima* (forecast package). Residual diagnostics were assessed using Ljung–Box tests, with $p$-values $> 0.05$ indicating no evidence of remaining residual autocorrelation.

Regarding article classification, the coding procedure followed established recommendations for transparent and replicable qualitative categorisation in the content analysis literature (e.g., Bardin 2013; Stemler 2000). As the primary reference system, we adopted the Food and Agriculture Organization of the United Nations' (FAO) Sustainability Assessment of Food and Agriculture Systems (SAFA), which provides an agribusiness-relevant structure organised around four sustainability domains: environmental integrity, social well-being, good governance and economic resilience (Amamou et al. 2025; Scialabba 2014), fully aligned with the four indicator dimensions analysed in this study. When SAFA did not provide sufficient operational detail for studies explicitly framed around ESG disclosure and capital market reporting, we used the industry-based ESG metric architecture for Agricultural Products proposed by the Sustainability Accounting Standards Board and the International Sustainability Standards Board under the IFRS Foundation as a complementary reference to support consistent classification in borderline cases and multi-pillar indicator systems (SASB 2018; IFRS Foundation 2023).

Each document was manually assigned to one or more dimensions based on the indicator set and measurement constructs operationalised in the study, rather than on the paper's general narrative emphasis. Coding relied initially on the abstract and, when ambiguity remained, on targeted reading of the full text to identify indicator categories and their measurement focus.

Articles could receive multiple labels when the indicator group, system or index explicitly spanned more than one dimension, consistent with qualitative coding approaches that recognise the coexistence of multiple thematic meanings within a single unit of analysis (e.g., Hsieh and Shannon 2005). For composite or multi-pillar indices, classification was conducted at the level of constituent pillars rather than forcing assignment to a single dominant category.

Decision rules were applied systematically in borderline cases. Indicators were first mapped to SAFA themes and sub-themes and when SAFA lacked sufficient granularity for disclosure-oriented metrics common in ESG reporting, the SASB and ISSB industry-based framework was used to clarify the appropriate sustainability dimension. Disclosure metrics related to climate or resource exposure were coded as environmental when they measured biophysical pressure, regardless of whether they were framed in risk or reporting terms, while metrics centred on supplier conditions, safety or labour incidents were coded as social when they captured human outcomes. Metrics combining performance content with assurance structures were treated as potentially ambiguous and classified according to their primary analytical function: as governance when the emphasis was on auditability, traceability and control or as environmental or social when the emphasis was on substantive performance outcomes.

A small number of indicators did not align clearly with either SAFA or SASB and ISSB, as they were formulated as hybrid capability or infrastructure measures, particularly in techno-managerial and digital traceability studies. In such cases, a single-category assignment rule was applied based on the indicator's primary causal locus. Indicators measuring control capacity or decision rights were coded as governance, whereas those measuring efficiency or resilience were coded as economic. Remaining ambiguities were resolved through team adjudication and documented discussion until consensus was reached, following recommended procedures for ensuring intercoder reliability and negotiated agreement (e.g., Campbell et al. 2013).

At the initial round of independent classification (prior to reconciliation), we calculated a simple percentage agreement at the category level based on the presence or absence of each sustainability dimension per article (multi-label). Agreement rates were environmental (85%), economic (87%), social (78%) and governance (75%). Agreement was highest for environmental and economic indicators, reflecting clearer alignment with biophysical performance and efficiency-related constructs, whereas agreement was comparatively lower for social and governance categories, where indicators more often combined substantive performance content with disclosure or control mechanisms.

To illustrate how the coding rules resolved ambiguities, consider two borderline cases. First, climate and resource exposure disclosure metrics combined reporting structures with substantive environmental exposure. Applying the rule prioritising substantive measurement focus over disclosure format, these indicators were classified as environmental when they operationalised biophysical exposure or pressure rather than audit or control capacity. Second, digital traceability indicators combining assurance infrastructure with performance monitoring were coded as governance when the emphasis lay on control, accountability and auditability and as environmental when they directly measured environmental performance outcomes.

To ensure conceptual precision and avoid retrieving studies in which indicator terminology appeared only in peripheral contexts, a title-only search strategy was adopted. Preliminary tests using broader strings applied to abstracts and keywords considerably expanded the dataset but introduced substantial thematic noise, reducing the coherence of the final corpus. Title filtering therefore offered a more focused and analytically tractable dataset, although we acknowledge that this approach may omit studies employing alternative terminology. This limitation is recognised and may lead to underrepresentation of studies adopting different conceptual framings; however, the title-focused strategy was retained because it provided the highest thematic coherence and avoided the substantial noise observed in broader query tests.

Regarding database selection, bibliometric scholars often debate between Scopus and Web of Science (WoS) due to differences in indexing and coverage (Donthu et al. 2021; Farrukh et al. 2020). The research was conducted in July 2025 and both platforms were initially explored using the following query applied to article titles: sustainab* AND (agro* OR agri*) AND (performance OR indicator* OR kpi*). Filters of being an article as a type of document and in English as language were applied. The results revealed the following counts: Scopus retrieved 403 documents; WoS retrieved 285. Given its broader journal inclusion, especially in multidisciplinary and applied research fields such as agriculture and sustainability, Scopus was selected for the final data collection. Its extensive coverage ensures greater representativeness and relevance for this study's objectives (Donthu et al. 2021; Zupic and Čater 2015). After retrieval, abstracts were manually reviewed and full texts were consulted when needed to characterise each document's thematic focus for descriptive purposes, without serving as an exclusion criterion. During this review, no studies were identified as thematically misaligned with the research scope, as all addressed indicators in agribusiness either centrally or peripherally within their analyses. This methodological strategy aimed at enabling a robust understanding of the intellectual structure of sustainability indicators in agribusiness, while also mapping future directions and informing policy and scholarly agendas.

## 3 | Results and Descriptive Analysis

### 3.1 | Publications Timeline

The annual distribution of publications on sustainability indicators in agribusiness shows a clear exponential growth pattern, particularly from 2013 onward, as shown in Figure 1. From 1990 to 2012, output remained modest and relatively stable, typically below five articles per year. This pattern changed markedly after 2013, alongside intensified global sustainability discourse and the consolidation of major policy frameworks. Publications increased from 11 in 2013 to 64 in 2024, indicating a substantial expansion within a decade.

This growth reflects rising academic and institutional emphasis on sustainability indicators as tools for environmental governance, ESG alignment and agri-food system transformation. The projected count of 51 articles for 2025 suggests continued momentum, while acknowledging that annual variation may occur due to funding cycles, disruptions and publication dynamics.

### 3.2 | Sectoral Focus of Sustainability Indicator Research

To characterise sectoral focus, abstracts and, when necessary, full texts from the 403 articles were examined. As summarised in Figure 2, the corpus is heterogeneous, spanning industrial and smallholder systems, export-oriented production and agroecological contexts, indicating that sustainability indicators are applied across diverse agricultural settings. General agriculture is the most frequent context (164 publications), capturing studies that address indicators from a cross-cutting or system-level perspective rather than a single commodity focus.

This sectoral diversity helps explain the heterogeneity later observed in the bibliographic-coupling clusters, as different production contexts tend to foreground different sustainability dimensions and assessment logics.

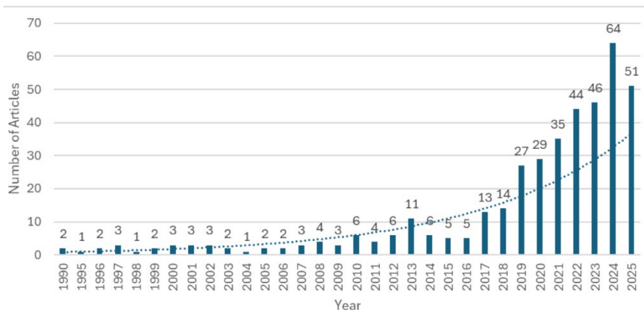


**FIGURE 1** | Publications by year. *Source:* Developed by the authors (2025).

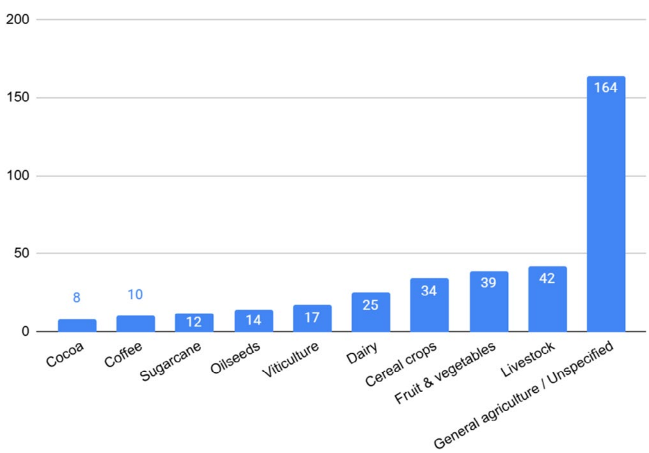


**FIGURE 2** | Number of publications by agricultural sector. *Source:* Developed by the authors (2025).

### 3.3 | Author, Institutional and Journal Profiles

Table 1 identifies the most influential authors, whose contributions reveal a field shaped by two recurrent emphases: data-driven and digital supply chain approaches to sustainability performance measurement and farm-level or composite frameworks designed to operationalise multidimensional assessment. Taken together, the most cited contributions point to an evolution from prescriptive indicator lists toward more adaptive and context-sensitive approaches, which later reappears as a key distinction across the cluster structure.

Table 2 highlights the institutional distribution of highly cited contributions and suggests a more decentralised and regionally grounded knowledge base, with growing influence from institutions outside traditional Western centres. The prominence of engineering and technology-oriented departments among the most cited affiliations is also consistent with the techno-managerial orientation observed in parts of the literature, especially where infrastructures, risk management and supply chain optimisation are central.

Table 3 shows that publication output concentrates in a relatively small set of journals, reflecting an editorial landscape that is strongly interdisciplinary rather than organised into disciplinary silos. Leading outlets tend to prioritise methodological innovation, systems perspectives and policy relevance, aligning with the field's plural methodological base and reinforcing why sustainability indicator research in agribusiness develops through overlapping epistemic communities that are later visible in the bibliometric clusters.

### 3.4 | Country-Level Patterns

Table 4 provides a dual ranking of countries by publication volume and by citation counts, revealing that productivity and influence do not fully overlap. China, India and Italy lead in number of articles, while the United States, India and the United Kingdom lead in citations, suggesting differences in average impact and the maturity of national research ecosystems. The pattern also indicates the coexistence of established centres of influence with expanding contributions from emerging research contexts that are gaining visibility within the field.

To deepen this view, the bibliographic coupling maps in Figures 3 and 4 show thematic proximity and temporal dynamics across countries (minimum cluster size: 5). The overlay visualisation indicates a concentration of more recent output in China and India (approximately 2020 to 2022), consistent with accelerated sustainability research in Asia. The cluster visualisation complements this by showing three epistemological communities: a regionally dense network anchored by China (including hubs such as Saudi Arabia and Egypt), a more internationally connected cluster led by India and linked to UK and Spanish partners and a European-oriented cluster (e.g.,

**TABLE 1** | The most productive authors (by no. of citations).

| Rank | Author | No. of articles | No. of citations | Top-cited publication (as author or coauthor) | Year of publication |
|---|---|---|---|---|---|
| 1 | Kamble, S. S. | 3 | 1378 | Achieving sustainable performance in a data-driven agriculture supply chain: A review for research and applications | 2020 |
| 2 | Sharma, R. | 3 | 612 | A systematic literature review on machine learning applications for sustainable agriculture supply chain performance | 2020 |
| 3 | Gómez-Limón, J. A. | 3 | 424 | Empirical evaluation of agricultural sustainability using composite indicators | 2010 |
| 4 | Ryan, M. | 3 | 363 | Measurement of sustainability in agriculture: A review of indicators | 2016 |
| 5 | Dillon, E. | 3 | 145 | Sustainability indicators for improved assessment of the effects of agricultural policy across the EU: Is FADN the answer? | 2018 |
| 6 | Lucantoni, D. | 3 | 128 | Assessing Transitions to Sustainable Agricultural and Food Systems: A Tool for Agroecology Performance Evaluation (TAPE) | 2020 |
| 7 | Marcis, J. | 3 | 93 | Sustainability performance evaluation of agricultural cooperatives' operations: a systemic review of the literature | 2019 |
| 8 | Galdeano-Gómez, E. | 3 | 90 | Deconstructing criteria and assessment tools to build agri-sustainability indicators and support farmers' decision-making process | 2018 |
| 9 | Piedra-Muñoz, L. | 3 | 90 | Deconstructing criteria and assessment tools to build agri-sustainability indicators and support farmers' decision-making process | 2018 |
| 10 | Silvestri, C. | 3 | 57 | Toward a framework for selecting indicators of measuring sustainability and circular economy in the agri-food sector: a systematic literature review | 2024 |

*Source:* Developed by the authors (2025).

Italy and the Netherlands) associated with agroecological and policy-grounded work. Overall, the country maps suggest a field undergoing diversification in both geography and thematic orientation, while remaining anchored in established collaborative infrastructures.

## 4 | Discussion of Clusters

### 4.1 | Bibliographic-Coupling Clusters

A similarity analysis based on bibliographic coupling of documents (minimum cluster size: 60) included 296 items and revealed three clusters, as shown in Figure 5: the red cluster (122 articles), the green cluster (90 articles) and the blue cluster (84 articles). Cluster labels were assigned through manual content analysis of thematic focus and the most cited documents by bibliographic coupling cluster are reported in Table A1 (Appendix A).

The red cluster, termed Techno-Managerial Sustainability, is defined by an efficiency-oriented and infrastructure-centred view of sustainability measurement in agri-food systems. Its analytical signatures include performance indicators framed as operational control and optimisation, frequent attention to digital architectures for traceability and monitoring and an emphasis on scalable measurement across supply chains. These features are exemplified by anchor contributions such as Kamble et al. (2020) and Sharma et al. (2020), which exemplify how analytics, automation and digital infrastructures are positioned as central to sustainability performance assessment and governance in value chain contexts.

The green cluster, labelled Systemic and Agroecological Assessment, foregrounds integrated evaluation frameworks, transition processes and context-sensitive assessment logics. The cluster is characterised by multidimensional farm- or territory-level measurement, attention to stakeholder and participatory evaluation and a focus on sustainability as a system

TABLE 2 | The most productive institutions (by no. of citations).

| Rank | Department and/or institution | Country | No. of articles | No. of citations |
|---|---|---|---|---|
| 1 | Department of Civil Engineering, College of Engineering, Najran University | Saudi Arabia | 3 | 166 |
| 2 | Civil and Architectural Constructions Department, Faculty of Technology and Education, Suez University | Egypt | 2 | 162 |
| 3 | Department of Civil Engineering, El-Arish High Institute for Engineering and Technology | Egypt | 2 | 162 |
| 4 | Civil Engineering Department, Faculty of Engineering, Islamic University of Gaza | Palestine | 2 | 141 |
| 5 | Research Institute of Organic Agriculture (FiBL) | Switzerland | 2 | 140 |
| 6 | Lithuanian Centre for Social Sciences, Institute of Economics and Rural Development | Lithuania | 2 | 124 |
| 7 | Department of Economy, Engineering, Society and Business Organization, University of Tuscia | Italy | 2 | 47 |
| 8 | Department of Engineering, University of Rome Niccolò Cusano | Italy | 2 | 47 |
| 9 | Department of Agro-Industrial Technology, Faculty of Agricultural Technology, Universitas Brawijaya | Indonesia | 2 | 25 |
| 10 | Department of Socio-Economics, Faculty of Agriculture, Universitas Brawijaya | Indonesia | 2 | 25 |

*Source:* Developed by the authors (2025).

TABLE 3 | The most productive journals (by no. of articles).

| Rank | Journal | No. of articles | No. of citations | Country |
|---|---|---|---|---|
| 1 | *Sustainability (Switzerland)* | 23 | 624 | Switzerland |
| 2 | *Ecological Indicators* | 14 | 596 | Netherlands |
| 3 | *IOP Conference Series: Earth and Environmental Science* | 9 | 35 | United Kingdom |
| 4 | *Agroecology and Sustainable Food Systems* | 7 | 82 | United States |
| 5 | *Agriculture (Switzerland)* | 6 | 158 | Switzerland |
| 6 | *Agriculture, Ecosystems and Environment* | 6 | 404 | Netherlands |
| 7 | *Ecological Economics* | 5 | 861 | Netherlands |
| 8 | *Sustainable Production and Consumption* | 5 | 183 | Netherlands |
| 9 | *Environment, Development and Sustainability* | 5 | 167 | Netherlands |
| 10 | *Frontiers in Sustainable Food Systems* | 5 | 127 | Switzerland |

*Source:* Developed by the authors (2025).

property rather than a set of isolated metrics. Representative exemplars include Rigby et al. (2001), which provides farm-level indicator foundations across sustainability dimensions and Mottet et al. (2020), which consolidates agroecological transition assessment through the TAPE framework.

The blue cluster, termed Normative Indicator Frameworks, concentrates on the conceptual, ethical and procedural foundations of indicator design. Its core focus lies in methodological pluralism, composite metrics and debates about what should be measured, how indicators are constructed and how legitimacy and coherence are secured across contexts. Key references illustrating this orientation include Gómez-Limón and Sanchez-Fernandez (2010) and Binder et al. (2010), which illustrate the cluster's emphasis on composite indicators and the normative, systemic and procedural dimensions of indicator-based sustainability assessment.

Overall, bibliographic coupling highlights how contemporary research converges into distinct yet complementary paradigms, revealing where the literature aligns around shared references and how thematic domains cohere into research fronts that later inform the integrated interpretation developed in Section 5.

**TABLE 4** | The most productive countries (by no. of articles and no. of citations).

| Rank | Country (by articles) | No. of articles | Rank | Country (by citations) | No. of citations |
|---|---|---|---|---|---|
| 1 | China | 45 | 1 | United States | 2025 |
| 2 | India | 37 | 2 | India | 1939 |
| 3 | Italy | 35 | 3 | United Kingdom | 1896 |
| 4 | United States | 32 | 4 | France | 1009 |
| 5 | United Kingdom | 27 | 5 | Netherlands | 849 |
| 6 | Brazil | 24 | 6 | Italy | 835 |
| 7 | Indonesia | 21 | 7 | Spain | 833 |
| 8 | Spain | 18 | 8 | China | 723 |
| 9 | Netherlands | 17 | 9 | Australia | 623 |
| 10 | France | 16 | 10 | Germany | 553 |

*Source:* Developed by the authors (2025).

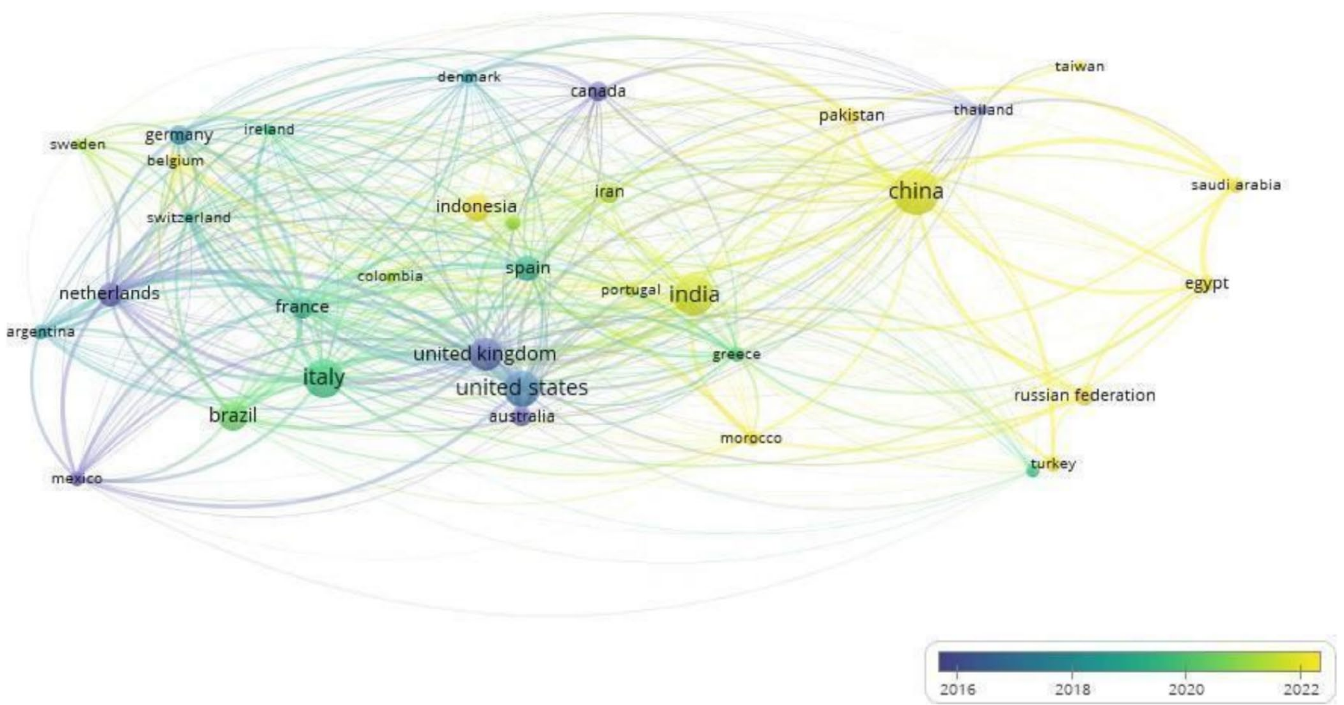


**FIGURE 3** | Bibliographic coupling of countries by temporal progression. *Source:* Developed by the authors (2025) through VOSviewer 1.6.20.

## 4.2 | Co-Citation Clusters

Co-citation analysis identifies the intellectual structure of a field by grouping references that are frequently cited together, revealing shared theoretical foundations. Using a minimum threshold of 50 cited references and including 431 items, the co-citation analysis yielded four clusters, presented in Figure 6. The most influential documents for each group are reported in Table B1 (Appendix B).

The red cluster, Strategic Foundations for Sustainable Supply Chains ($n = 147$), captures the strategy-oriented intellectual base linking sustainability to firm resources, capabilities and performance logics. Its signature references emphasise resource-based and capability perspectives as foundations for competitive advantage and supply chain governance under sustainability pressures. Barney (1991) provides the anchor for resource-based logic, while Seuring and Müller (2008) exemplify how sustainability is operationalised in supply chain strategy through integrated frameworks.

The green cluster, Indicators and Methodologies for Sustainability Evaluation ($n = 142$), consolidates core methodological approaches for indicator construction and evaluation, particularly multi-criteria decision tools and composite indicator logic. Saaty (1980) anchors the cluster through the Analytic Hierarchy Process as a foundational decision methodology, while Binder et al. (2010) exemplify the integration of normative

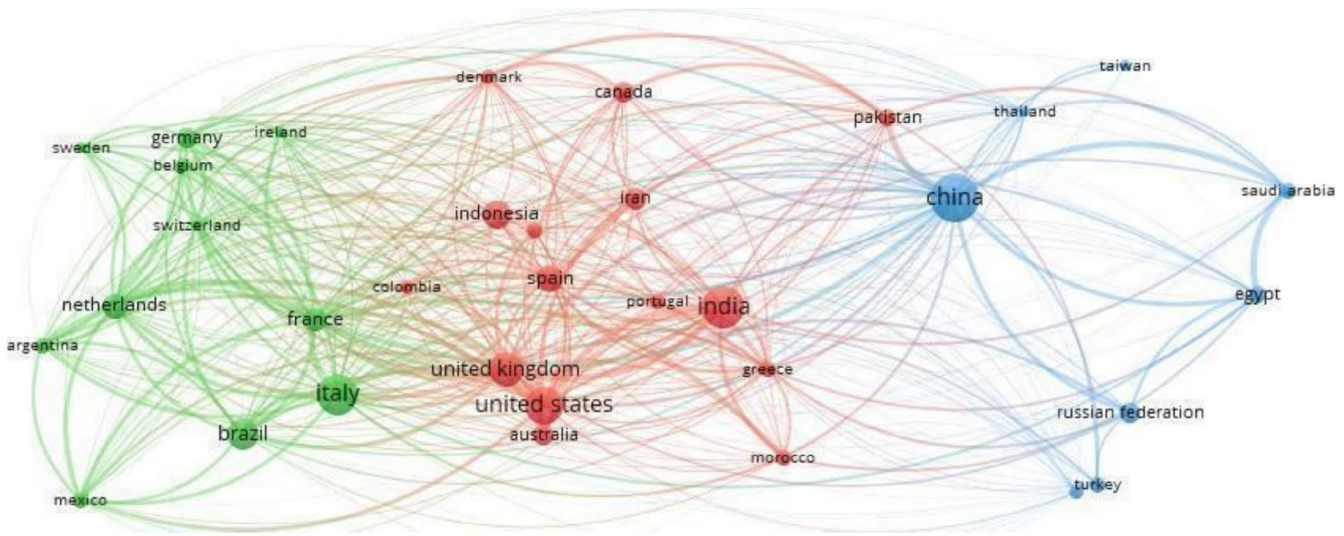


**FIGURE 4** | Bibliographic coupling of countries by cluster. *Source:* Developed by the authors (2025) through VOSviewer 1.6.20.

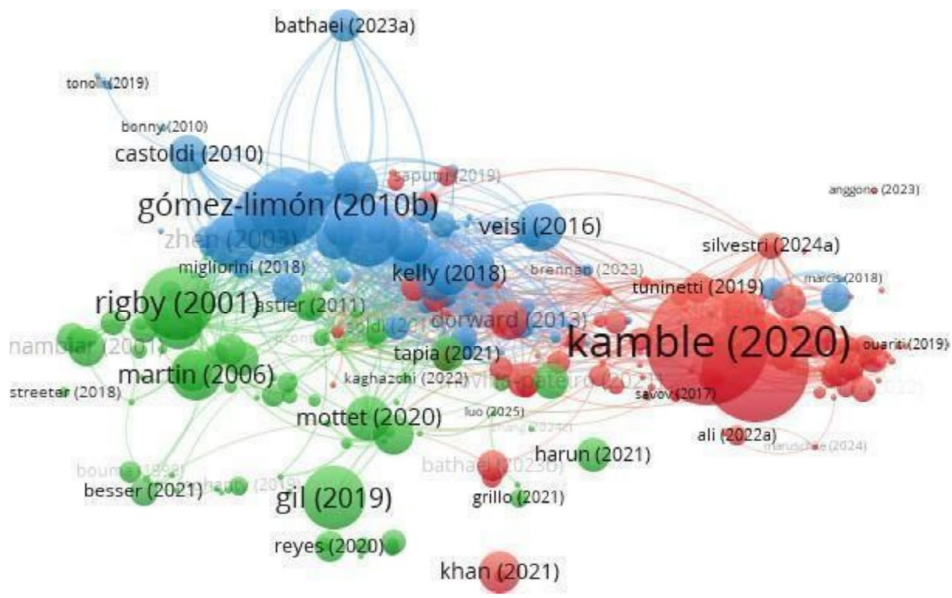


**FIGURE 5** | Bibliographic coupling of documents. *Source:* Developed by the authors (2025) through VOSviewer 1.6.20.

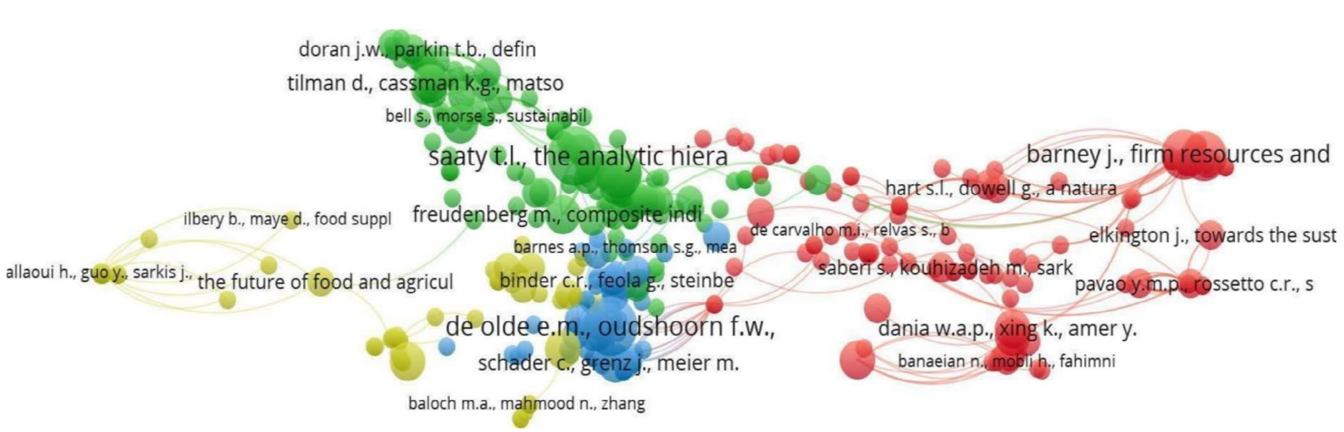


**FIGURE 6** | Co-citation analysis. *Source:* Developed by the authors (2025) through VOSviewer 1.6.20.

and systemic considerations into indicator-based assessment design.

The blue cluster, Farm-Level and Context-Sensitive Sustainability Assessment ($n=77$), is defined by applied assessment tools and participatory approaches that prioritise contextual adaptation, stakeholder input and farm-level operationalisation. Its signature includes bottom-up indicator development and tool-based evaluation of farming systems. Olde et al. (2016) anchors this cluster through comparative tool analysis in practice, while Schader et al. (2014) exemplifies integrated farm-level assessment approaches aligned with organic and sustainability evaluation.

The yellow cluster, Conceptual and Normative Dimensions of Sustainability in Agriculture ($n=65$), contains foundational policy and conceptual references that frame sustainable agriculture as a multidimensional and evolving construct. Its signature lies in global agenda setting, normative framing and comprehensive indicator architectures that influence how sustainability is conceptualised in agricultural contexts. The UN General Assembly (2015) anchors the cluster through the SDGs, while FAO (2017) exemplifies institutionally grounded framing of agriculture's sustainability challenges and priorities.

### 4.3 | Integrating the Cluster Structures

To provide coherence across findings, we linked the three bibliographic-coupling clusters with the four co-citation clusters through thematic analysis. Bibliographic coupling captures how recent research converges into techno-managerial, systemic-agroecological and normative-indicator domains, while co-citation reveals the intellectual foundations underpinning these domains, including strategy and capability perspectives, multi-criteria evaluation methods, context-sensitive assessment tools and normative sustainability frameworks. Table 5 summarises these relationships.

This integrated perspective underscores how the field's thematic and intellectual structures delineate its epistemological boundaries and future pathways. While bibliographic-coupling clusters map current empirical concentrations, co-citation foundations reveal the theoretical frameworks governing how problems are framed and which methods gain legitimacy. Collectively, these insights position sustainability indicators as strategic instruments rather than mere analytical tools, grounding the managerial and strategic implications explored in the next section.

## 5 | Future Trends, Managerial Implications and Research Agenda

### 5.1 | Forecasting Analysis

To examine publication trends related to different types of sustainability indicators (economic, social, environmental and governance), a time-series analysis was conducted using annual publication data collected from 1995 to 2024. Each indicator type was treated as a separate univariate time series and the data were converted into ts objects in R (version 4.5.1). The *auto.arima* function from the forecast package was applied to automatically identify the optimal ARIMA model parameters ($p, d, q$), allowing for drift when supported by the data; in the selected models, drift was included across all ESG series. Based on the fitted models, six-year forecasts (2025–2030) were generated to project the expected trajectory of publications across each ESG category. The individual forecast results are presented in Appendix C and the corresponding ARIMA specifications and residual diagnostics are reported in Table D1 (Appendix D). To facilitate comparison across indicator types, a comparative line

**TABLE 5** | Linking bibliographic-coupling clusters to co-citation foundations.

| Bibliographic coupling cluster | Corresponding co-citation foundations | Conceptual relationship |
|---|---|---|
| Techno-managerial sustainability | • Strategic foundations for sustainable supply chains | Resource-based view (RBV), dynamic capabilities and supply-chain strategy provide the theoretical basis for data-driven optimisation, KPI-oriented performance measurement and technological innovation. |
| Systemic and agroecological assessment | • Farm-level and context-sensitive assessment<br>• Indicator Methodologies and Evaluation Tools | Systems thinking, multi-criteria decision-making and participatory approaches underpin context-sensitive sustainability assessment tools such as RISE, SAFA and TAPE. |
| Normative-indicator frameworks | • Conceptual and normative dimensions of sustainability<br>• Indicator methodologies and evaluation tools | Ethical, procedural and conceptual literature informs indicator construction, legitimacy, stakeholder involvement and methodological coherence. |

*Source:* Developed by the authors (2025).

chart is presented in Figure 7. As detailed in the Methods section, these forecasts should be interpreted as exploratory mid-range projections, given the absence of exogenous variables and the reliance on historical publication patterns.

The ARIMA-based forecasts reveal differentiated growth trajectories among the four dimensions of sustainability indicators. Environmental indicators are projected to remain dominant, increasing from approximately 50 to over 80 publications by 2030, reflecting sustained academic emphasis. Economic indicators are also expected to grow steadily, reaching nearly 60 publications. Social indicators are forecast to rise from just under 30 to approximately 45 publications, while governance indicators are projected to maintain a more modest pace, remaining below 25 by 2030. These patterns suggest a continued imbalance in scholarly attention, with environmental and economic dimensions leading the discourse. As a result, these trends may shape where scholarly attention and research efforts are prioritised over the next few years and they provide an interpretive basis for discussing plausible strategic implications (to be examined in future empirical work).

### 5.2 | Managerial and Strategic Implications

To bring the value of the bibliometric findings into practice, we interpret the identified clusters through a business strategy lens. Because our evidence is bibliometric mapping and publication-trend forecasting, the implications below are framed as plausible interpretations of how the literature links indicator systems to strategic concerns. They should not be read as causal claims about what indicators will do inside firms or as evidence of the efficacy of specific tools. Instead, they point to conjectured mechanisms and propositions suitable for future empirical testing.

Our analysis indicates that the literature frequently portrays sustainability indicators not merely as compliance mechanisms but also as strategic instruments linked to core strategic decision-making processes. At both competitive and corporate levels, research commonly associates indicator systems with how firms allocate resources, configure governance structures and pursue growth trajectories within ESG-oriented markets. By mapping the bibliometric clusters to strategic management theories, we distinguish how different indicator configurations are framed as supporting distinct strategic logics and offer tailored implications for actors across the agribusiness value chain (see Table 6). These strategic configurations are also influenced by how organizations interpret their historical identity and cultural resources, which shape managerial choices and strategic pathways (Jaeger, Mendes, Fernandes, and Zen 2025).

#### 5.2.1 | Strategic Logics: Exploitation Versus Exploration of Sustainability

Firms face a strategic choice in configuring their sustainability intelligence systems based on their position in the value chain and their competitive priorities. For large-scale processors, traders and vertically integrated firms, the Techno-Managerial Sustainability cluster (Red Cluster) can be interpreted as consistent with a strategic, exploitation-oriented logic. By integrating digital infrastructures, such as blockchain traceability and IoT-based optimisation, these actors may pursue cost leadership and operational excellence. Here, indicators are often framed as control mechanisms to reduce transaction costs and ensure compliance across vast global supply chains. As noted by Jusoh et al. (2023), research in this stream argues that these capabilities can function as strategic resources for capturing value through verifiable ESG performance, thereby reinforcing precision- and efficiency-based differentiation. At the corporate level, this literature suggests that these capabilities may inform vertical integration decisions, strategic alliances with technology providers or acquisitions aimed at internalising sophisticated traceability assets, potentially turning ESG data into governance infrastructure.

Conversely, farmer cooperatives, niche producers and organizations embedded in local territories may leverage the frameworks identified in the Systemic and Agroecological cluster (Green Cluster), such as TAPE and RISE. These context-sensitive tools align with the exploration strategy approach (March 1991), potentially enabling firms to trial regenerative practices and co-create solutions with local stakeholders. Rather than standardization, the strategic goal here is differentiation and resilience-building

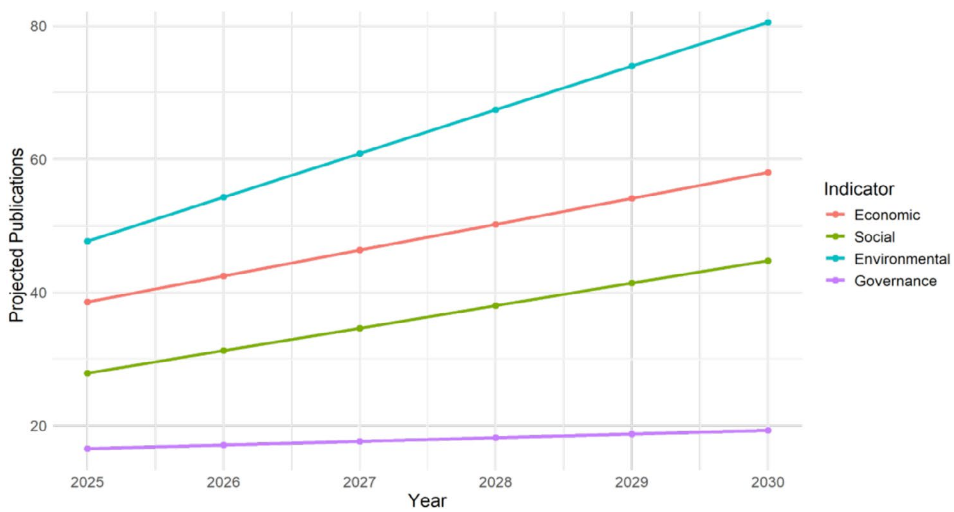


**FIGURE 7** | Forecast of publications by type of indicator (2025–2030). *Source:* developed by the authors (2025) through R 4.5.1.

**TABLE 6** | Mapping sustainability indicator clusters to strategic implications.

| Bibliometric cluster | Primary strategic logic | Target actors and context | Strategic implications and value creation |
|---|---|---|---|
| Techno-managerial sustainability | Exploitation | Traders, processors, integrators | Digital control and efficiency: Leverage Blockchain/ AI to potentially reduce transaction costs and ensure standardised compliance. |
| (Red cluster) | (Operational excellence) | Focus on global value chains and efficiency. | Potential advantage: Cost leadership and verifiable traceability. |
| Systemic and agroecological | Exploration | Cooperatives, producers and NGOs | Adaptive resilience: Use participatory tools (TAPE/ RISE) to potentially capture ecological value and engage stakeholders. |
| (Green cluster) | (Niche differentiation) | Focus on local territories and regenerative practices. | Potential advantage: Premium differentiation and supply security. |
| Normative-indicator frameworks | Legitimacy | Retailers, certifiers and investors | Strategic identity: Move beyond compliance to potentially define ethical standards and governance transparency. |
| (Blue cluster) | (Proactive governance) | Focus on brand reputation and risk management. | Potential advantage: 'Social license to operate' and reputational risk mitigation. |
| Forecasted trends | Dynamic capabilities | All actors | Potential first-mover advantage: Anticipate regulatory shifts in social/governance reporting. |
| (Social and governance gap) | (Sensing and seizing) | Focus on long-term planning and innovation. | Potential advantage: Access to ESG finance and regulatory preparedness. |

*Source:* Developed by the authors (2025).

through adaptive governance, which may be important for managing enterprise risks in diverse ecological environments and supporting long-term stakeholder strategies. In governance terms, exploration tends to rely on relational coordination with communities and partners, contrasting with the contractual, audit-based coordination that dominates exploitation-driven ESG strategies.

### 5.2.2 | Legitimacy and Proactive Differentiation: Addressing the "Blind Spot"

The Normative-Indicator Frameworks (Blue Cluster) and our co-citation analysis highlight a critical strategic opportunity: the underdevelopment of governance and social indicators. Currently, many firms adopt a defensive ESG posture, focusing primarily on environmental metrics where data is abundant. However, retailers and investors seeking to mitigate reputational risk may consider a proactive differentiation strategy (Narver et al. 2004) by embedding governance metrics (transparency and accountability) and social indicators (labor rights and community engagement). In principle and subject to empirical validation, integrating these indicators into corporate strategy may be linked to brand positioning and capital structure choices, potentially improving access to sustainability-linked financing and reducing perceived ESG-associated risk premiums. As the normative frameworks suggest, participation in the design of these indicators may enable firms to shape their strategic identity and align corporate purpose with stakeholder expectations, thereby strengthening claims to long-term legitimacy and influencing narrative positioning.

### 5.2.3 | Strategic Foresight and Dynamic Capabilities

The ARIMA forecasting results indicate that while environmental indicators will remain dominant, social and governance dimensions are emerging frontiers. Interpreting this through the lens of dynamic capabilities (Teece 2018), agribusiness leaders may use these indicators as sensing tools to anticipate regulatory shifts and changing investor requirements. Firms that invest early in social and governance measurement capabilities may achieve a first-mover advantage, as suggested by arguments that early entrants shape market standards, develop reputation-based barriers and accumulate difficult-to-imitate capabilities (Lieberman and Montgomery 1988). From a corporate strategy standpoint, anticipating these shifts can guide portfolio diversification, divestment from noncompliant supply bases or investment in ESG-driven product lines designed to meet emerging certification or financing requirements. When the literature frames these indicators as engines of innovation that support low-carbon products or sustainability-linked financial instruments, managers may be positioned to move from reactive reporting toward measuring sustainability as a core driver of value creation and market access.

To consolidate these insights, Table 6 synthesises the relationships between the bibliometric clusters, the strategic logics they enable and their practical implications for agribusiness actors.

### 5.3 | Research Agenda

Building on the bibliometric findings and ARIMA forecasts, the proposed research agenda connects each future research need directly to the empirical gaps identified in the cluster analyses and forecasting results. The results highlight three main challenges: (1) the persistent dominance of environmental indicators, (2) the structural underdevelopment of social and governance metrics and (3) the rapid expansion of techno-managerial approaches driven by AI and data infrastructures. Future studies should therefore prioritise the following questions, each directly derived from these insights.

1. How can the development of social and governance sustainability indicators be accelerated to match the growing emphasis on environmental and economic metrics?

This question arises from the pronounced imbalance identified in both the bibliographic-coupling and forecasting analyses. The Blue Cluster reveals persistent conceptual fragmentation and limited methodological consolidation in social and governance metrics, while the ARIMA projections confirm that these dimensions remain comparatively underdeveloped relative to environmental and economic indicators. This structural gap highlights the need for advancing methodological approaches capable of capturing relational, institutional and procedural dimensions of sustainability.

2. What methodological pathways can improve the quantification of qualitative governance and social aspects in agrifood systems?

The normative-indicator cluster reveals conceptual fragmentation and methodological pluralism, which call for new operationalisation strategies to transform values (e.g., fairness, participation and labour rights) into valid and reliable indicators.

3. What risks does the persistent dominance of environmental indicators pose for policy design and business strategy in agribusiness?

The forecasting analysis confirms that environmental indicators will continue to grow fastest. Scholars should investigate institutional, funding and regulatory incentives that disproportionately prioritise environmental dimensions and evaluate how this bias may affect ESG decision-making.

4. How do international policy agendas and regional contexts shape indicator selection and influence the gaps between environmental, economic, social and governance dimensions?

Country-level patterns and bibliographic coupling reveal clear geographic epistemologies. Future research should examine how Global South contexts generate distinct indicator needs and how policy frameworks, such as the SDGs, shape research outputs.

5. How can AI, machine learning and data-driven methods be used to build more integrated, adaptive and real-time sustainability indicator systems?

This question directly links to the red cluster's digital innovation emphasis, where machine learning, blockchain and IoT were core themes. Future research should examine how these tools can support multidimensional ESG monitoring and decision-making.

6. What mechanisms can ensure that sustainability indicators remain adaptive to socio-environmental change and evolving policy demands over time?

Without mechanisms for continuous adaptation, indicator systems risk becoming outdated in the face of new regulatory pressures, technological advances and socio-environmental change. Developing approaches that enhance adaptability is therefore essential for ensuring the long-term relevance and robustness of sustainability indicators in agribusiness.

7. How can participatory and context-sensitive tools be integrated with AI-based approaches to ensure both local relevance and methodological rigour?

The question bridges the systemic/agroecological and techno-managerial clusters, responding to the field's fragmentation and the need for hybrid methodologies.

By integrating these academic and strategic perspectives, the study clarifies the intellectual structure of sustainability indicator research and sets out clear priorities for future scholarly work. These research directions address governance gaps, methodological imbalances and regional variation. While the contribution is primarily academic, stronger evidence in these areas can indirectly support policymakers and business leaders by improving the foundations on which sustainability measurement and decision-making rest.

## 6 | Conclusions and Limitations

The present study used bibliometric methods to synthesise dispersed knowledge and map the intellectual evolution of sustainability indicators in agribusiness. Through co-citation and bibliographic-coupling analyses, it identified the thematic structures, influential authors and emerging research fronts that characterise the field. By incorporating ARIMA-based forecasting, the study combined retrospective mapping with forward-looking trend assessment, addressing the fragmentation noted in prior literature (Donthu et al. 2021; Farrukh et al. 2020; Linnenluecke et al. 2019) and offering a comprehensive overview of current and future scholarly trajectories. By combining retrospective science mapping with forward-looking ARIMA forecasting, this study goes beyond previous bibliometric reviews (Ali and Perna 2021; Monteiro et al. 2023, 2024). In doing so, it also aligns with broader developments in sustainability science, where integrating empirical rigour with anticipatory and solution-oriented approaches has become increasingly central. This integrated approach provides a more strategically oriented understanding of how sustainability indicator research evolves and how it can inform business strategy in agribusiness.

The results show a substantial rise in publications since 2013, with three major thematic clusters emerging in the bibliographic-coupling analysis and four intellectual foundations revealed through co-citation analysis. Forecasts indicate continued dominance of environmental and economic indicators, with social and governance dimensions remaining comparatively underdeveloped. These patterns reflect broader shifts in sustainability science toward methodological pluralism, thematic diversification and increasing contributions from emerging economies, indicating a growing epistemological maturity in the field while also revealing persistent gaps in legitimacy to stakeholders and practical applicability. The enduring mismatch between academic indicator development and real-world usability remains evident (German et al. 2011; Rasmussen et al. 2017).

By achieving its objectives, the study contributes to the literature in different ways. First, it provides a theoretically informed mapping of sustainability indicator research that builds directly on the earlier literature reviewed in the introduction. The study thus extends the prior work on indicator frameworks, addresses the fragmentation between academic indicator design and practitioner needs (German et al. 2011; Newton et al. 2013; Rasmussen et al. 2017) and responds to calls for stronger integration of environmental, social and governance dimensions in agribusiness assessment (Elmanaseer and Gerged 2025; Zahoor and Gerged 2021). Second, the study advances existing bibliometric efforts (Ali and Perna 2021; Monteiro et al. 2023, 2024) by combining co-citation and bibliographic-coupling analyses with ARIMA-based forecasting. Such an integrated approach moves beyond retrospective mapping and provides a more dynamic understanding of how sustainability indicator research is likely to evolve to 2030. Third, the study strengthens the strategic relevance of sustainability indicators by showing how the thematic clusters identified in the literature connect to distinct strategic logics. Finally, it formulates a research agenda that provides strategic guidance for future development, addressing methodological imbalances, the persistent dominance of environmental indicators, the underdevelopment of governance and social dimensions and the growing influence of digital and data-driven approaches.

The findings suggest potential implications for business strategy, ESG integration and policy design. For agribusinesses, more integrated and stakeholder-informed indicator systems may support resilience, comparability and legitimacy (Ligonie 2021; Olde et al. 2016). The literature suggests managers may use more balanced indicators to strengthen risk governance, enhance supply-chain consistency and respond more effectively to market-based sustainability pressures. For policymakers, the uneven development of indicators may continue to challenge SDG implementation, underscoring the need for balanced and context-sensitive sustainability metrics (Hák et al. 2016; Vanhulst et al. 2025). Regulatory bodies and public institutions could incentivise the development and uptake of indicator sets that are both technically robust and contextually legitimate, particularly in regions dominated by smallholder agriculture.

Despite its methodological rigour, the study has several limitations. The title-only search using a narrow set of descriptors increased precision but may have reduced recall and favoured techno-managerial terminology over alternative concepts such as metrics, indices or assessment tools. Reliance on Scopus alone may also omit studies indexed in Web of Science or regional repositories. The exclusive inclusion of English-language publications risks underrepresenting non-Anglophone contributions, suggesting the value of multilingual searches in future reviews. Finally, ARIMA forecasts rely on historical publication patterns and do not incorporate exogenous shocks; combining forecasting with horizon-scanning or scenario analysis would improve robustness. Future studies should therefore consider multi-database, multilingual and mixed-method prospective approaches to capture the evolving complexity of sustainability indicators.

Overall the study provides a clearer more forward-looking understanding of sustainability indicator research and lays the groundwork for future scholarship that is more conceptually integrated, methodologically balanced and strategically relevant to the evolving needs of agri-food systems. As pressures on global food systems intensify, advancing sustainability indicators as credible, actionable and strategically meaningful tools remains a critical endeavour for both research and practice.

## Author Contributions

Marcelo Kratz Mendes conceptualised the study, conducted the data collection, analysed the collected data, performed the bibliometric and forecasting analyses and led the writing of the original draft. Olga Cam contributed to the theoretical positioning of the study, validation of the analytical procedures and substantive revisions of the manuscript. Aurora Carneiro Zen contributed to the discussion of results, refinement of the theoretical implications and critical review of the manuscript. Roger de Bem Jaeger contributed to the analysis and interpretation of the collected data, supported the development of the theoretical framing, contributed to the writing of the manuscript and participated in its critical revision. Daniela Callegaro-de-Menezes contributed to the discussion of results and the critical review of the manuscript. Juliana Matos de Meira contributed to the initial conception of the article and provided targeted feedback during the revision process. All authors read and approved the final version of the manuscript.

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## Endnotes

[1] Agribusiness is understood here as the integrated system of agricultural production, processing, logistics and market-oriented activities that collectively transform inputs into food and fibre products for consumers. The process encompasses farm-level production as well as upstream and downstream activities, reflecting a coordinated value-chain perspective rather than a narrow focus on farming alone (Amamou et al. 2025; Davis and Goldberg 1957; Rasmussen et al. 2017; Sahore et al. 2025; Santiago-Brown et al. 2015).

[2] Abbreviations: SAFA (Sustainability Assessment of Food and Agriculture systems); RISE (Response-Inducing Sustainability Evaluation); and IDEA (Indicateurs de Durabilité des Exploitations Agricoles).

## References


Ali, A., and S. Perna. 2021. "Sustainability Indicators in Agriculture: A Review and Bibliometric Analysis Using Scopus Database." *Journal of Agriculture and Environment for International Development* 115, no. 2: 5–21. https://doi.org/10.36253/jaeid-12083.

Amamou, A., S. Chabouh, L. Sidhom, A. Zouari, and A. Mami. 2025. "Agri-Food Supply Chain Sustainability Indicators From a Multi-Capital Perspective: A Systematic Review." *Sustainability* 17, no. 9: 9. https://doi.org/10.3390/su17094174.

Bardin, L. 2013. *L'Analyse de Contenu*. Presses Universitaires de France.

Barney, J. B. 1991. "Firm Resources and Sustained Competitive Advantage." *Journal of Management* 17, no. 1: 99–120. https://doi.org/10.1177/014920639101700108.

Binder, C. R., G. Feola, and J. K. Steinberger. 2010. "Considering the Normative, Systemic and Procedural Dimensions in Indicator-Based Sustainability Assessments in Agriculture." *Environmental Impact Assessment Review* 30, no. 2: 71–81. https://doi.org/10.1016/j.eiar.2009.06.002.

Broadus, R. N. 1987. "Toward a Definition of "Bibliometrics"." *Scientometrics* 12, no. 5: 373–379. https://doi.org/10.1007/BF02016680.

Campbell, J. L., C. Quincy, J. Osserman, and O. K. Pedersen. 2013. "Coding In-Depth Semistructured Interviews: Problems of Unitization and Intercoder Reliability and Agreement." *Sociological Methods & Research* 42, no. 3: 294–320. https://doi.org/10.1177/0049124113500475.

Davis, J. H., and R. A. Goldberg. 1957. *A Concept of Agribusiness*. Division of Research, Graduate School of Business Administration, Harvard University. https://catalog.hathitrust.org/Record/004490506.

Domenteanu, A., P. Diaconu, and C. Delcea. 2025. "Bibliometric Insights Into Time Series Forecasting and AI Research: Growth, Impact, and Future Directions." *Applied Sciences* 15, no. 11: 11. https://doi.org/10.3390/app15116221.

Donthu, N., S. Kumar, D. Mukherjee, N. Pandey, and W. M. Lim. 2021. "How to Conduct a Bibliometric Analysis: An Overview and Guidelines." *Journal of Business Research* 133: 285–296. https://doi.org/10.1016/j.jbusres.2021.04.070.

Dyllick, T., and K. Hockerts. 2002. "Beyond the Business Case for Corporate Sustainability." *Business Strategy and the Environment* 11, no. 2: 130–141. https://doi.org/10.1002/bse.323.

Elkington, J. 1994. "Towards the Sustainable Corporation: Win-Win-Win Business Strategies for Sustainable Development." *California Management Review* 36, no. 2: 90–100. https://doi.org/10.2307/41165746.

Elkington, J. 1997. *Cannibals With Forks: Triple Bottom Line of 21st Century Business*. New Society Publishers.

Elmanaseer, M. I., and A. M. Gerged. 2025. "How Do Institutional Pressures Reshape the Association Between Corporate Sustainability Disclosure and Firm Value in Emerging Economies? The Moderating Role of the Audit Committee Function." *Business Strategy and the Environment* 34, no. 6: 7253–7283.

Farrukh, M., F. Meng, Y. Wu, and K. Nawaz. 2020. "Twenty-Eight Years of Business Strategy and the Environment Research: A Bibliometric Analysis." *Business Strategy and the Environment* 29, no. 6: 2572–2582. https://doi.org/10.1002/bse.2521.

Food and Agriculture Organization of the United Nations (FAO). 2017. *The Future of Food and Agriculture: Trends and Challenges*. FAO. https://openknowledge.fao.org/server/api/core/bitstreams/2e90c833-8e84-46f2-a675-ea2d7afa4e24/content.

Gerged, A. M., E. Beddewela, and C. J. Cowton. 2021. "Is Corporate Environmental Disclosure Associated With Firm Value? A Multicountry Study of Gulf Cooperation Council Firms." *Business Strategy and the Environment* 30, no. 1: 185–203. https://doi.org/10.1002/bse.2616.

German, L., G. Schoneveld, and P. Pacheco. 2011. "The Social and Environmental Impacts of Biofuel Feedstock Cultivation: Evidence From Multi-Site Research in the Forest Frontier." *Ecology and Society* 16: 24. https://doi.org/10.5751/ES-04309-160324.

Gómez-Limón, J. A., and G. Sanchez-Fernandez. 2010. "Empirical Evaluation of Agricultural Sustainability Using Composite Indicators." *Ecological Economics* 69, no. 5: 1062–1075. https://doi.org/10.1016/j.ecolecon.2009.11.027.

Hák, T., S. Janoušková, and B. Moldan. 2016. "Sustainable Development Goals: A Need for Relevant Indicators." *Ecological Indicators* 60: 565–573. https://doi.org/10.1016/j.ecolind.2015.08.003.

Hosonuma, N., M. Herold, V. De Sy, et al. 2012. "An Assessment of Deforestation and Forest Degradation Drivers in Developing Countries." *Environmental Research Letters* 7, no. 4: 044009. https://doi.org/10.1088/1748-9326/7/4/044009.

Hsieh, H.-F., and S. E. Shannon. 2005. "Three Approaches to Qualitative Content Analysis." *Qualitative Health Research* 15, no. 9: 1277–1288. https://doi.org/10.1177/1049732305276687.

Hyndman, R. J., and G. Athanasopoulos. 2018. *Forecasting: Principles and Practice*. OTexts. https://research.monash.edu/en/publications/forecasting-principles-and-practice-2/.

Hyndman, R. J., and Y. Khandakar. 2008. "Automatic Time Series Forecasting: The Forecast Package for R." *Journal of Statistical Software* 27: 1–22. https://doi.org/10.18637/jss.v027.i03.

IFRS Foundation. 2023. "Industry-Based Guidance on Implementing IFRS S2: Agricultural Products." International Sustainability Standards

Board. https://www.ifrs.org/issued-standards/ifrs-sustainability-standards-navigator/.

Jaeger, R. d. B., M. K. Mendes, B. S. Fernandes, and A. C. Zen. 2025. "Tradition-Based Firm: A Systematic Literature Review on Innovation and Tradition in the Organizational Context." *International Journal of Tourism Research* 27, no. 3: e70046. https://doi.org/10.1002/jtr.70046.

Jaeger, R. de B., M. K. Mendes, C. Schutte, and A. C. Zen. 2025. "Entrepreneurial Support Ecosystems in Emerging Economies: A Study on the Strategy-Making Processes." *Journal of Entrepreneurship and Public Policy*, ahead of print, December 30. https://doi.org/10.1108/JEPP-08-2024-0143.

Jusoh, R., Y. Yahya, S. Zainuddin, and K. Asiaei. 2023. "Translating Sustainability Strategies Into Performance: Does Sustainability Performance Management Matter?" *Meditari Accountancy Research* 31, no. 2: 258–293. https://doi.org/10.1108/MEDAR-02-2021-1203.

Kamble, S. S., A. Gunasekaran, and S. A. Gawankar. 2020. "Achieving Sustainable Performance in a Data-Driven Agriculture Supply Chain: A Review for Research and Applications." *International Journal of Production Economics* 219: 179–194. https://doi.org/10.1016/j.ijpe.2019.05.022.

Kates, R. W. 2011. "What Kind of a Science Is Sustainability Science?" *Proceedings of the National Academy of Sciences of the United States of America* 108, no. 49: 19449–19450. https://doi.org/10.1073/pnas.1116097108.

Kessler, M. M. 1963. "Bibliographic Coupling Between Scientific Papers." *American Documentation* 14, no. 1: 10–25. https://doi.org/10.1002/asi.5090140103.

Krishnan, N., R. Ranjith, and B. Lavanya. 2022. "Climate Change Prediction Using ARIMA Model." *International Journal for Research in Applied Science and Engineering Technology* 10, no. 6: 621–625. https://doi.org/10.22214/ijraset.2022.43777.

Lang, D. J., A. Wiek, M. Bergmann, et al. 2012. "Transdisciplinary Research in Sustainability Science: Practice, Principles, and Challenges." *Sustainability Science* 7, no. 1: 25–43. https://doi.org/10.1007/s11625-011-0149-x.

Lieberman, M. B., and D. B. Montgomery. 1988. "First-Mover Advantages." *Strategic Management Journal* 9, no. S1: 41–58. https://doi.org/10.1002/smj.4250090706.

Ligonie, M. 2021. "Sharing Sustainability Through Sustainability Control Activities. A Practice-Based Analysis." *Management Accounting Research* 50: 100726. https://doi.org/10.1016/j.mar.2020.100726.

Linnenluecke, M. K., M. Marrone, and A. K. Singh. 2019. "Conducting Systematic Literature Reviews and Bibliometric Analyses." *Australian Journal of Management* 45: 175–194. https://doi.org/10.1177/0312896219877678.

March, J. G. 1991. "Exploration and Exploitation in Organizational Learning." *Organization Science* 2, no. 1: 71–87.

McCain, K. W. 1990. "Mapping authors in Intellectual Space: A Technical Overview." *Journal of the American Society for Information Science* 41, no. 6: 433–443. https://doi.org/10.1002/(SICI)1097-4571(199009)41:6%253C433::AID-ASI11%253E3.0.CO;2-Q.

Milder, J. C., M. Arbuthnot, A. Blackman, et al. 2015. "An Agenda for Assessing and Improving Conservation Impacts of Sustainability Standards in Tropical Agriculture." *Conservation Biology* 29, no. 2: 309–320. https://doi.org/10.1111/cobi.12411.

Monteiro, S., P. Quesado, V. Ribeiro, et al. 2024. "Bibliometric Analysis of Sustainable Indicators in Agribusiness." In *Proceedings of the 3rd International Conference on Water Energy Food and Sustainability (ICoWEFS 2023)*, 59–69. Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-48532-9_6.

Monteiro, S., P. Quesado, V. Ribeiro, M. E. Fernandes, T. Eugénio, and J. Costa. 2023. "Measuring Sustainable Practices in Agribusiness: A Bibliometric Analysis." *Custos e Agronegócio Online* 19, no. 2: 197–221.

Mottet, A., A. Bicksler, D. Lucantoni, et al. 2020. "Assessing Transitions to Sustainable Agricultural and Food Systems: A Tool for Agroecology Performance Evaluation (TAPE)." *Frontiers in Sustainable Food Systems* 4: 579154. https://doi.org/10.3389/fsufs.2020.579154.

Mottet, A., A. Bicksler, D. Lucantoni, et al. 2020. "Assessing Transitions to Sustainable Agricultural and Food Systems: A Tool for Agroecology Performance Evaluation (TAPE)." *Frontiers in Sustainable Food Systems* 4: 579154. https://doi.org/10.3389/fsufs.2020.579154.

Narver, J. C., S. F. Slater, and D. L. MacLachlan. 2004. "Responsive and Proactive Market Orientation and New-Product Success." *Journal of Product Innovation Management* 21, no. 5: 334–347. https://doi.org/10.1111/j.0737-6782.2004.00086.x.

Newton, P., A. Agrawal, and L. Wollenberg. 2013. "Enhancing the Sustainability of Commodity Supply Chains in Tropical Forest and Agricultural Landscapes." *Global Environmental Change* 23, no. 6: 1761–1772. https://doi.org/10.1016/j.gloenvcha.2013.08.004.

Olde, E. M., F. W. Oudshoorn, C. A. G. Sørensen, E. A. M. Bokkers, and I. J. M. de Boer. 2016. "Assessing Sustainability at Farm-Level: Lessons Learned From a Comparison of Tools in Practice." *Ecological Indicators* 66: 391–404. https://doi.org/10.1016/j.ecolind.2016.01.047.

Parris, T. M., and R. W. Kates. 2003. "Characterizing and Measuring Sustainable Development." *Annual Review of Environment and Resources* 28: 559–586. https://doi.org/10.1146/annurev.energy.28.050302.105551.

Rasmussen, L. V., R. Bierbaum, J. A. Oldekop, and A. Agrawal. 2017. "Bridging the Practitioner-Researcher Divide: Indicators to Track Environmental, Economic, and Sociocultural Sustainability of Agricultural Commodity Production." *Global Environmental Change* 42: 33–46. https://doi.org/10.1016/j.gloenvcha.2016.12.001.

Rigby, D., P. Woodhouse, T. Young, and M. Burton. 2001. "Constructing a Farm Level Indicator of Sustainable Agricultural Practice." *Ecological Economics* 39, no. 3: 463–478. https://doi.org/10.1016/S0921-8009(01)00245-2.

Saaty, T. L. 1980. *The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation*. McGraw-Hill International Book Company.

Sahore, N., U. Awan, V. Chotia, and V. Agarwal. 2025. "Exploring the Potential and Limits of Green and Sustainable Agribusiness Practices as a Driver of Environmental Management." *Business Strategy and the Environment* 34, no. 6: 6885–6905.

Santiago, J. L., C. Iglesias-Merchán, R. C. Navarro, and M. T. Gómez-Villarino. 2025. "Bridging the Gap: Evaluating Farmers' Sustainability Perceptions, Their Agricultural Practices, and Measured Soil Indicators Towards Promoting a Sustainable Viticulture." *Environments* 12, no. 5: 5. https://doi.org/10.3390/environments12050155.

Santiago-Brown, I., A. Metcalfe, C. Jerram, and C. Collins. 2015. "Sustainability Assessment in Wine-Grape Growing in the New World: Economic, Environmental, and Social Indicators for Agricultural Businesses." *Sustainability* 7, no. 7: 7. https://doi.org/10.3390/su7078178.

Schader, C., J. Grenz, M. S. Meier, and M. Stolze. 2014. "Scope and Precision of Sustainability Assessment Approaches to Food Systems." *Ecology and Society* 19, no. 3: 42. https://doi.org/10.5751/ES-06866-190342.

Schaltegger, S., and M. Wagner. 2006. "Integrative Management of Sustainability Performance, Measurement and Reporting." *International Journal of Accounting, Auditing and Performance Evaluation* 3: 1–19. https://doi.org/10.1504/IJAAPE.2006.010098.

Scialabba, N., ed. 2014. *SAFA Guidelines: Sustainability Assessment of Food and Agriculture Systems (Version 3.0)*. Food and Agriculture Organization of the United Nations.

Seuring, S., and M. Müller. 2008. "From a Literature Review to a Conceptual Framework for Sustainable Supply Chain Management." *Journal of Cleaner Production* 16, no. 15: 1699–1710. https://doi.org/10.1016/j.jclepro.2008.04.020.

Sharma, R. K., N. Abidi, and R. K. Misra. 2020. "Assessment of Agricultural Sustainability—A Study of Farmers Growing Basmati Rice under Conventional and Fair-Trade Systems in India." *International Journal of Sustainable Agricultural Management and Informatics* 6, no. 1: 1–21. https://doi.org/10.1504/IJSAMI.2020.106549.

Small, H. 1973. "Co-Citation in the Scientific Literature: A New Measure of the Relationship Between Two Documents." *Journal of the American Society for Information Science* 24, no. 4: 265–269. https://doi.org/10.1002/asi.4630240406.

Stemler, S. 2000. "An Overview of Content Analysis." *Practical Assessment, Research & Evaluation* 7, no. 17: 1–6. https://doi.org/10.7275/z6fm-2e34.

Streimikis, J., and T. Baležentis. 2020. "Agricultural Sustainability Assessment Framework Integrating Sustainable Development Goals and Interlinked Priorities of Environmental, Climate and Agriculture Policies." *Sustainable Development* 28, no. 6: 1702–1712. https://doi.org/10.1002/sd.2118.

Sustainability Accounting Standards Board. 2018. "SASB Standard for Agricultural Products." https://www.sasb.org.

Teece, D. J. 2018. "Business Models and Dynamic Capabilities." *Long Range Planning* 51, no. 1: 40–49. https://doi.org/10.1016/j.lrp.2017.06.007.

Tranfield, D., D. Denyer, and P. Smart. 2003. "Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review." *British Journal of Management* 14, no. 3: 207–222.

United Nations General Assembly. 2015. "Transforming Our World: The 2030 Agenda for Sustainable Development (A/RES/70/1)." https://undocs.org/A/RES/70/1.

Van Eck, N. J., and L. Waltman. 2014. "Visualizing Bibliometric Networks." In *Measuring Scholarly Impact*, edited by Y. Ding, R. Rousseau, and D. Wolfram, 285–320. Springer International Publishing. https://doi.org/10.1007/978-3-319-10377-8_13.

Vanhulst, J., P. Padilla-Navarro, A. Espinosa-Rada, R. Cantillan, R. Velásquez, and K. González Tapia. 2025. "The Reflexive Process in Sustainability Science: A Short Critical Review." *Environmental Science & Policy* 171: 104145. https://doi.org/10.1016/j.envsci.2025.104145.

Wang, Y., K. Albitar, and I. Chbib. 2024. "A Novel Metric for Corporate Environmental Responsibility and Its Impact on Investment Inefficiency." *International Journal of Finance and Economics* 30: 3003–3030. https://doi.org/10.1002/ijfe.3055.

Wilson, G. T. 2016. "Time Series Analysis: Forecasting and Control, 5th Edition, by George E. P. Box, Gwilym M. Jenkins, Gregory C. Reinsel and Greta M. Ljung, 2015. Published by John Wiley and Sons Inc., Hoboken, New Jersey, pp. 712. ISBN: 978-1-118-67502-1." *Journal of Time Series Analysis* 37, no. 5: 709–711. https://doi.org/10.1111/jtsa.12194.

Zahoor, N., and A. M. Gerged. 2021. "Relational Capital, Environmental Knowledge Integration, and Environmental Performance of Small and Medium Enterprises in Emerging Markets." *Business Strategy and the Environment* 30, no. 8: 3789–3803.

Zupic, I., and T. Čater. 2015. "Bibliometric Methods in Management and Organization." *Organizational Research Methods* 18, no. 3: 429–472. https://doi.org/10.1177/1094428114562629.

## Appendix A

**TABLE A1** | Most cited documents by bibliographic-coupling cluster.

| | **Red cluster (122 papers)—Techno-managerial sustainability** | | | |
|---|---|---|---|---|
| **Rank** | **Author (s)** | **Title** | **Year** | **No. of citations** |
| 1 | Kamble, S. S., Gunasekaran, A. and Gawankar, S. A. | Achieving sustainable performance in a data-driven agriculture supply chain: A review for research and applications | 2020 | 744 |
| 2 | Sharma, R., Kamble, S. S., Gunasekaran, A., Kumar, V. and Kumar, A. | A systematic literature review on machine learning applications for sustainable agriculture supply chain performance | 2020 | 583 |
| 3 | Trivellas, P., Malindretos, G. and Reklitis, P. | Implications of Green Logistics Management on Sustainable Business and Supply Chain Performance: Evidence from a Survey in the Greek Agri-Food Sector | 2020 | 123 |
| 4 | Liu, Y., Eckert, C., Yannou-Le Bris, G. and Petit, G. | A fuzzy decision tool to evaluate the sustainable performance of suppliers in an agrifood value chain | 2019 | 108 |
| 5 | Dorward, A. | Agricultural labour productivity, food prices and sustainable development impacts and indicators | 2013 | 93 |
| Green cluster (90 papers)—Systemic and agroecological assessment | | | | |
| Rank | Author (s) | Title | Year | No. of citations |
| 1 | Rigby, D., Woodhouse, P., Young, T. and Burton, M. | Constructing a farm level indicator of sustainable agricultural practice | 2001 | 290 |
| 2 | Bernardes Gil, J. D., Reidsma, P., Giller, K., Todman, L., Whitmore, A. and van Ittersum, M. | Sustainable development goal 2: Improved targets and indicators for agriculture and food security | 2019 | 225 |
| 3 | Martin, J. F., Diemont, S. A. W., Powell, E., Stanton, M. and Levy-Tacher, S. | Emergy evaluation of the performance and sustainability of three agricultural systems with different scales and management | 2006 | 152 |
| 4 | Pannell, D. J. and Glenn, N. A. | A framework for the economic evaluation and selection of sustainability indicators in agriculture | 2000 | 144 |
| 5 | Mottet, A., Bicksler, A., Lucantoni, D., De Rosa, F., Scherf, B., Scopel, E., López-Ridaura, S., Gemmill-Herren, B., Bezner Kerr, R., Sourisseau, J.-M., Petersen, P., Chotte, J.-L., Loconto, A. and Tittonell, P. | Assessing Transitions to Sustainable Agricultural and Food Systems: A Tool for Agroecology Performance Evaluation (TAPE) | 2020 | 122 |
| Blue cluster (84 papers)—Normative-indicator frameworks | | | | |
| Rank | Author (s) | Title | Year | No. of citations |
| 1 | Gómez-Limón, J. A. and Sánchez-Fernández, G. | Empirical evaluation of agricultural sustainability using composite indicators | 2010 | 321 |

(Continues)

**TABLE A1** | (Continued)

| | Red cluster (122 papers)—Techno-managerial sustainability | | | |
|---|---|---|---|---|
| **Rank** | **Author (s)** | **Title** | **Year** | **No. of citations** |
| 2 | Binder, C. R., Feola, G. and Steinberger, J. K. | Considering the normative, systemic and procedural dimensions in indicator-based sustainability assessments in agriculture | 2010 | 299 |
| 3 | Latruffe, L., Diazabakana, A., Bockstaller, C., Desjeux, Y., Finn, J., Kelly, E., Ryan, M. and Uthes, S. | Measurement of sustainability in agriculture: a review of indicators | 2016 | 229 |
| 4 | Zhen, L. and Routray, J. K. | Operational Indicators for Measuring Agricultural Sustainability in Developing Countries | 2003 | 159 |
| 5 | Veisi, H., Liaghati, H. and Alipour, A. | Developing an ethics-based approach to indicators of sustainable agriculture using analytic hierarchy process (AHP) | 2016 | 130 |

*Source:* Developed by the authors (2025).

## Appendix B

**TABLE B1** | Most cited documents by co-citation cluster.

| | | **Red cluster (147 papers)—Strategic foundations for sustainable supply chains** | | | | |
|---|---|---|---|---|---|---|
| **Rank** | **Author (s)** | **Title** | **Journal/Publisher** | **Year** | **No. of citations** | **Link strength** |
| 1 | Barney, J. | Firm Resources and Sustained Competitive Advantage | *Journal of Management* | 1991 | 5 | 80 |
| 2 | Jiang, W., Chai, H., Shao, J. and Feng, T. | Green Entrepreneurial Orientation for Enhancing Firm Performance: A Dynamic Capability Perspective | *Journal of Cleaner Production* | 2018 | 5 | 78 |
| 3 | Seuring, S. and Müller, M. | From a Literature Review to a Conceptual Framework for Sustainable Supply Chain Management | *Journal of Cleaner Production* | 2008 | 4 | 40 |
| 4 | Dania, W.A.P., Xing, K. and Amer, Y. | Collaboration behavioural factors for sustainable agri-food supply chains: A systematic review | *Journal of Cleaner Production* | 2018 | 4 | 27 |
| 5 | Kamble, S.S., Gunasekaran, A. and Gawankar, S.A. | Achieving Sustainable Performance in a Data-Driven Agriculture Supply Chain: A Review for Research and Applications | *International Journal of Production Research* | 2020 | 4 | 22 |
| Green cluster (142 papers)—Indicators and methodologies for sustainability evaluation | | | | | | |
| Rank | Author (s) | Title | Journal/Publisher | Year | No. of citations | Link strength |
| 1 | Saaty, T.L. | The Analytic Hierarchy Process | McGraw-Hill | 1980 | 6 | 48 |
| 2 | Binder, C.R., Feola, G. and Steinberger, J.K. | Considering the normative, systemic and procedural dimensions in indicator-based sustainability assessments in agriculture | *Sustainability Science* | 2010 | 5 | 34 |
| 3 | Freudenberg, M. | Composite Indicators of Country Performance: A Critical Assessment | *OECD Statistics Working Papers* | 2003 | 4 | 36 |
| 4 | Tilman, D., Cassman, K.G., Matson, P.A. and Naylor, R.L. | Agricultural Sustainability and Intensive Production Practices | *Nature* | 2002 | 4 | 28 |
| 5 | Belanger, V., Vanasse, A., Parent, D. and Allard, G. | Development of agri-environmental indicators to assess dairy farm sustainability in Quebec, Eastern Canada | *Ecological Indicators* | 2012 | 4 | 22 |
| Blue cluster (77 papers)—Farm-level and context-sensitive sustainability assessment | | | | | | |
| Rank | Author (s) | Title | Journal/Publisher | Year | No. of citations | Link strength |
| 1 | Olde, E.M., Oudshoorn, F.W., Sørensen, C.A.G., Bokkers, E. A. M., de Boer and I. J. M. | Assessing sustainability at farm-level: Lessons learned from a comparison of tools in practice | *Ecological Indicators* | 2016 | 6 | 61 |

(Continues)

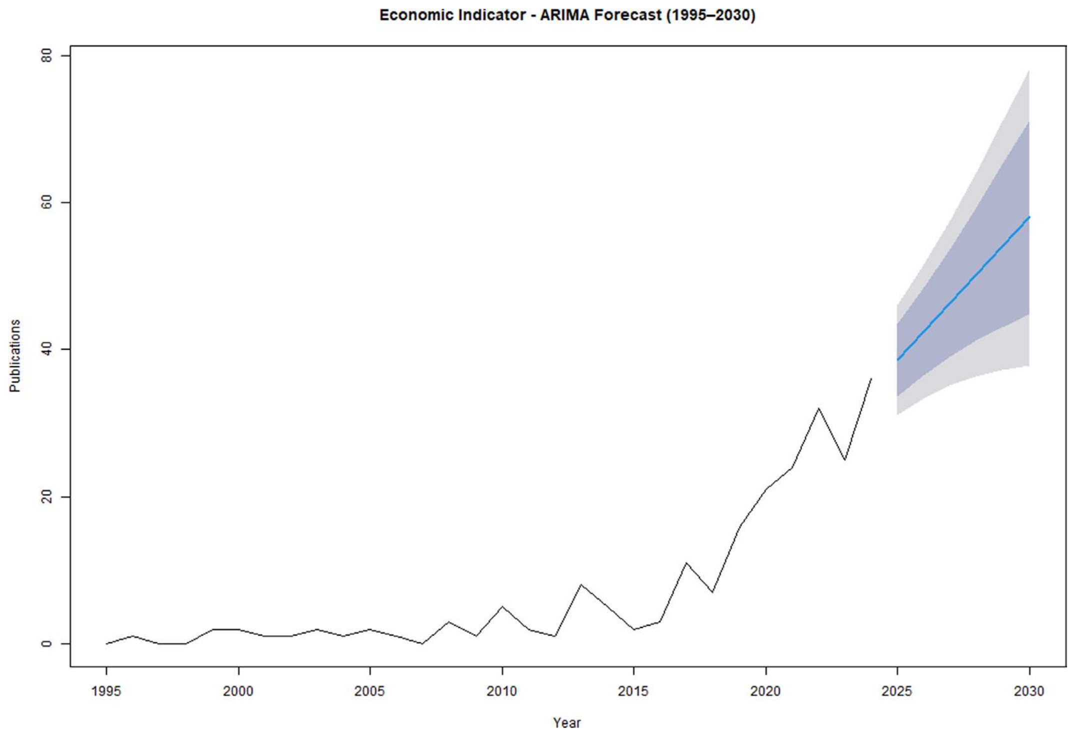
**TABLE B1** | (Continued)

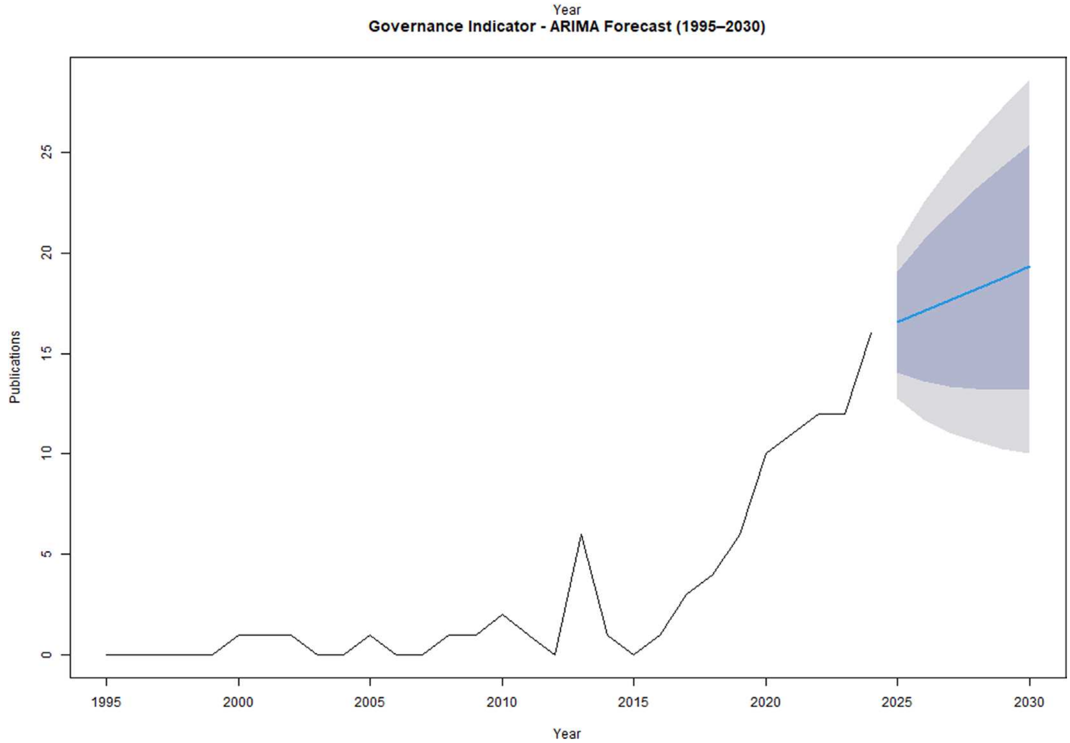
| | | Red cluster (147 papers)—Strategic foundations for sustainable supply chains | | | | |
|---|---|---|---|---|---|---|
| **Rank** | **Author (s)** | **Title** | **Journal/Publisher** | **Year** | **No. of citations** | **Link strength** |
| 2 | Schader, C., Grenz, J., Meier, M.S. and Stolze, M. | Scope and precision of sustainability assessment approaches to food systems | *Ecology and Society* | 2014 | 4 | 57 |
| 3 | Pannell, D.J. and Glenn, N.A. | A framework for the economic evaluation and selection of sustainability indicators in agriculture | *Ecological Economics* | 2000 | 4 | 43 |
| 4 | Gayatri, S., Gasso-Tortajada, V. and Vaarst, M. | Assessing Sustainability of Smallholder Beef Cattle Farming in Indonesia: A Case Study Using the FAO SAFA Framework | *Journal of Sustainable Development* | 2016 | 3 | 48 |
| 5 | Rigby, D., Woodhouse, P., Young, T. and Burton, M. | Constructing a farm level indicator of sustainable agricultural practice | *Ecological Economics* | 2001 | 3 | 36 |
| Yellow cluster (65 papers)—Conceptual and normative dimensions of sustainability in agriculture | | | | | | |
| Rank | Author (s) | Title | Journal/Publisher | Year | No. of citations | Link strength |
| 1 | Bathaei, A. and Streimikiene, D. | A Systematic Review of Agricultural Sustainability Indicators | *Agriculture* | 2023 | 4 | 15 |
| 2 | UN General Assembly | Transforming Our World: The 2030 Agenda for Sustainable Development | United Nations | 2015 | 4 | 3 |
| 3 | FAO | The Future of Food and Agriculture: Trends and Challenges | Food and Agriculture Organization of the United Nations | 2017 | 3 | 30 |
| 4 | Rigby, D., Woodhouse, P., Young, T. and Burton, M. | Constructing a farm level indicator of sustainable agricultural practice | *Ecological Economics* | 2001 | 3 | 17 |
| 5 | Velten, S., Leventon, J., Jager, N. and Newig, J. | What Is Sustainable Agriculture? A Systematic Review | *Sustainability* | 2015 | 3 | 15 |

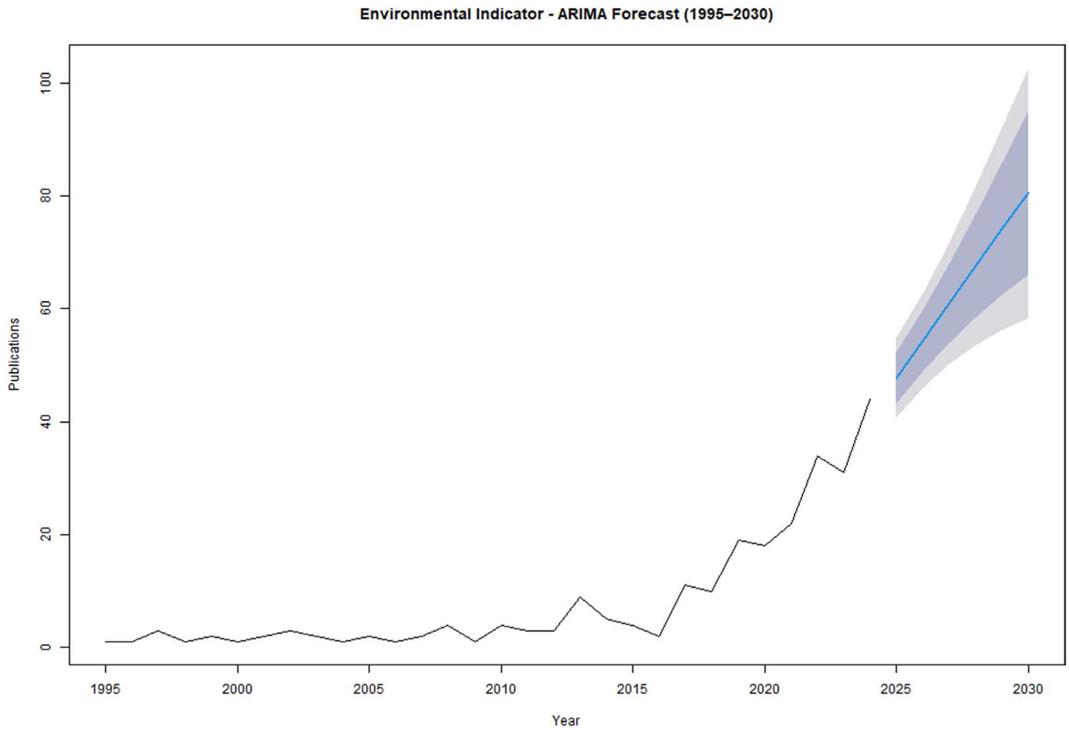
*Source:* Developed by the authors (2025).

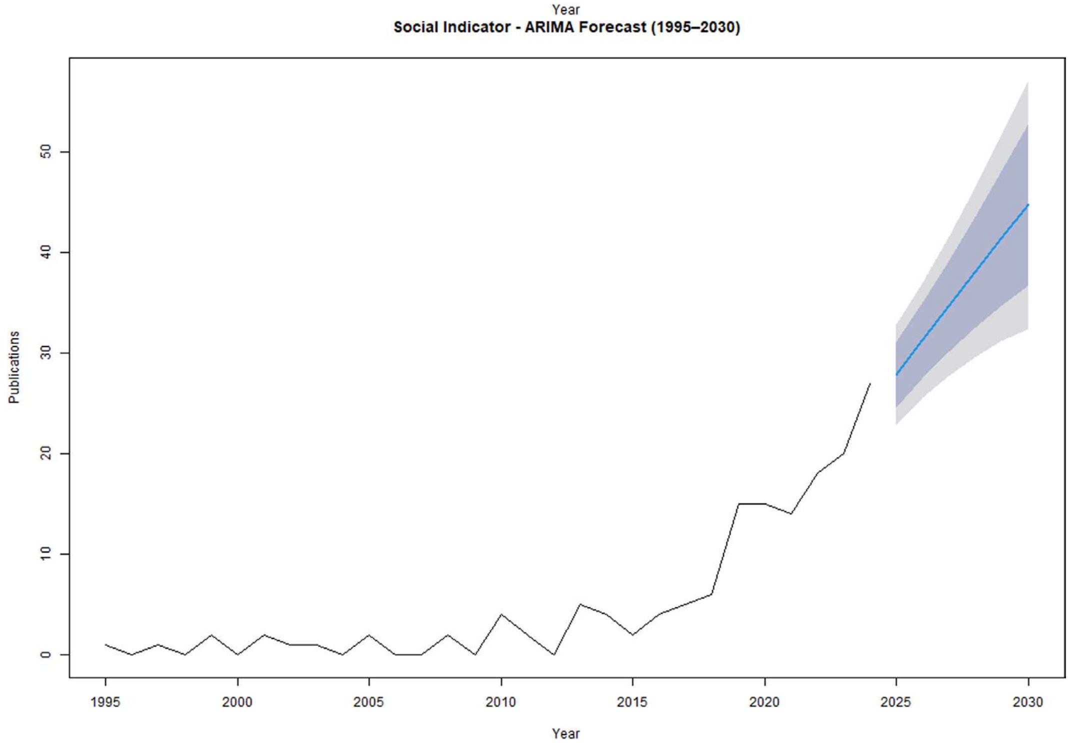
# Appendix C

Indicators forecast graphic.






*Source:* developed by the authors (2025) through R 4.5.1.

## Appendix D

**TABLE D1** | ARIMA model specification, drift term and residual diagnostics.

| Series | ARIMA($p$, $d$, $q$) | Drift | AICc | Ljung–Box $p$ (residuals) |
|---|---|---|---|---|
| Economic | (2,1,1) | Yes (1.95) | 186.1 | 0.27 |
| Environmental | (1,1,1) | Yes (2.70) | 203.5 | 0.11 |
| Social | (1,1,0) | Yes (1.35) | 168.2 | 0.34 |
| Governance | (1,1,0) | Yes (0.44) | 125.4 | 0.42 |

*Note:* Ljung–Box test computed on model residuals (lag = 10; degrees of freedom adjusted for fitted ARIMA parameters).
*Source:* Developed by the authors (2025) through R 4.5.1.