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Data reporting in agri-food platforms: sharing, privacy, consumer demands, and public policies

Abstract – The objective of this work was to analyze the challenges and opportunities for building a sustainable, secure, and transparent data-sharing environment for ESG (environmental, social, and governance) reporting on agriculture and livestock. Driven by greenhouse gas emissions, climate change threatens agricultural sustainability through drought, heat waves, wildfires, and floods. As global mitigation agreements remain difficult, adaptation strategies are essential. Digital transformation, supported by information technologies and data analytics, offers powerful tools for sustainability. Precision and digital agriculture allow of the collection, analysis, and data sharing on farm management, supply chain, and certification, generating valuable insights into sustainable practices. Despite these advances, concerns about data privacy and security restrict their full potential, especially in ESG reporting. This paper examines data privacy and sharing in ESG platforms through a semantic network derived from a systematic literature review. It identifies factors influencing the willingness of stakeholders to share data and discusses how ESG platforms, such as Semeiar Digital, can support climate adaptation initiatives. The results show that technological safeguards, regulatory frameworks, and market incentives are vital to foster trust, participation, and transparency. Ultimately, a broad technological adoption is necessary to strengthen resilience and adaptive capacity in agricultural systems facing climate change.

Index terms: climate action, digital agriculture, ESG, interoperability, trust.

Relatórios de dados agropecuários em plataformas digitais: compartilhamento, privacidade, demandas do consumidor e políticas públicas

Resumo – O objetivo deste trabalho foi analisar os desafios e as oportunidades para se construir um ambiente de compartilhamento de dados sustentável, seguro e transparente para relatórios ESG (ambiental, social e governança) para a agricultura e a pecuária. Impulsionadas pelas emissões de gases de efeito estufa, as mudanças climáticas ameaçam a sustentabilidade agrícola, por meio de secas, ondas de calor, incêndios e enchentes. Como os acordos globais de mitigação permanecem difíceis, estratégias de adaptação tornam-se essenciais. A transformação digital, apoiada por tecnologias da informação e análises de dados, oferece ferramentas poderosas para a sustentabilidade. A agricultura digital e de precisão permite a coleta, análise e compartilhamento de dados sobre gestão da fazenda, cadeias de suprimento e

Ivan Bergier^(✉) 
Embrapa Agricultura Digital, Campinas, SP,
Brazil. E-mail: ivan.bergier@embrapa.br

Édson Luis Bolfe 
Embrapa Agricultura Digital, Campinas, SP,
Brazil. E-mail: edson.bolfe@embrapa.br

Debora Pignatari Drucker 
Embrapa Agricultura Digital, Campinas, SP,
Brazil. E-mail: debora.drucker@embrapa.br

Ricardo Yassushi Inamasu 
Embrapa Instrumentação, São Carlos, SP,
Brazil. E-mail: ricardo.inamasu@embrapa.br

Patricia Menezes Santos 
Embrapa Pecuária Sudeste, São Carlos, SP,
Brazil. E-mail: patricia.santos@embrapa.br

Urbano Gomes Pinto de Abreu 
Embrapa Pantanal, Corumbá, MS, Brazil.
E-mail: urbano.abreu@embrapa.br

Tamires Lima da Silva 
Embrapa Agricultura Digital, Campinas, SP and
Universidade Estadual Paulista, Botucatu, SP,
Brazil. E-mail: tamires.l.silva@unesp.br

Fabiane de Fatima Carvalho 
Embrapa Agricultura Digital, Campinas, SP,
Brazil.
E-mail: fabiane.carvalho@colaborador.embrapa.br

Luciana Alvim Santos Romani 
Embrapa Agricultura Digital, Campinas, SP,
Brazil. E-mail: luciana.romani@embrapa.br

Jayme Garcia Arnal Barbedo 
Embrapa Agricultura Digital, Campinas, SP,
Brazil. E-mail: jayme.barbedo@embrapa.br

Silvia Maria Fonseca Silveira Massruhá 
Embrapa Sede, Brasília, DF, Brazil.
E-mail: silvia.massruha@embrapa.br

✉ Corresponding author

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certificações, gerando informações valiosas sobre práticas sustentáveis. Apesar desses avanços, preocupações quanto à privacidade e à segurança de dados limitam seu pleno potencial, especialmente em relatórios ESG. Este artigo examina a privacidade e o compartilhamento de dados em plataformas ESG, por meio de uma rede semântica derivada de revisão sistemática da literatura. Identificam-se fatores que influenciam a disposição dos atores em compartilhar dados, e discutem-se como plataformas, como o Semear Digital, podem apoiar iniciativas de adaptação climática. Os resultados mostram que salvaguardas tecnológicas, marcos regulatórios e incentivos de mercado são vitais para gerar confiança, participação e transparência. Finalmente, uma ampla adoção de tecnologias é necessária para fortalecer a resiliência e a capacidade adaptativa em sistemas agropecuários para enfrentar a mudança climática.

Termos para indexação: ação climática, agricultura digital, ESG, interoperabilidade, confiança.

Introduction

Brazilian agriculture holds a leading position globally, not only for meeting the rising demand for food, but also for being a benchmark for sustainable practices. Initiatives such as crop-livestock-forest (CLF) systems, no-tillage farming, and the restoration of degraded areas illustrate innovation and environmental commitment (Reis et al., 2025). To consolidate Brazil's role as a contributor to global environmental security, it is crucial to view agriculture as agribusiness aligned with sustainability, underpinned by the "Triple Bottom Line" (Elkington, 1998), and to adopt ESG (Environmental, Social, and Governance) practices introduced by the UN in 2004 (World Bank, 2007). For farmers, agribusinesses, and stakeholders, integrating ESG standards is now essential for regulatory compliance, consumer expectations, and market competitiveness (World Bank, 2023; Annosi et al., 2024).

Like other sectors, agriculture and livestock are undergoing digital transformation, which is driven by precision agriculture and data analytics to address climate challenges (Kwilinski et al., 2023). Aligning ESG reporting with this transformation has become a strategic priority. ESG reporting emphasizes environmental management, social equity, and transparent governance, while digital platforms can facilitate the adoption by collecting, analyzing, and sharing data from applications, sensors, and machinery related to farm management, supply chains, and

certifications (Liu et al., 2024). Yet, concerns about data privacy and security hinder effective implementation (Mendes et al., 2022). Farmers and agribusinesses recognize risks of data breaches, unauthorized access, and misuse, which limit the willingness to share information (Wiseman et al., 2019; World Bank, 2023). Since data sharing is central to platform functionality (Kwilinski et al., 2023), addressing these concerns is vital.

Digital platforms provide to farmers the access to vast datasets that can improve productivity and sustainability. Mobile and web-based applications offer timely knowledge, empowering decision-making (Singh et al., 2023). However, this reliance requires the governance frameworks of robust data, to protect intellectual property and privacy (Runck et al., 2022; Bergier et al., 2024). Trust is critical, as showed in finance, in which digital platforms transformed access to credit and financial services by leveraging user data (Guo et al., 2025). Similarly, agriculture generates enormous data on yields, soil, weather, livestock health, and supply chains. When shared effectively, such data can foster innovation, boost productivity, and enhance sustainability (Poppe et al., 2023; Kwilinski et al., 2023). Conversely, weak safeguards risk financial losses, reputational harm, and reluctance to share (Jouanjean et al., 2020). Farmers may also fear losing competitive advantages by revealing proprietary practices (Wiseman et al., 2019), while consumers are concerned about the protection of personal information (Mendes et al., 2022). Thus, data privacy and security are not only legal and ethical imperatives, but also strategic requirements for trust and data-sharing participation (Amiri-Zarandib et al., 2022; Farhad, 2024).

Understanding the factors influencing data sharing for ESG-reporting platforms is therefore critical. While essential for achieve its potential, barriers remain, particularly around farmers' and agribusinesses' willingness, to share sensitive data, and consumers' readiness to pay or share personal information for product transparency (Wiseman et al., 2019; World Bank, 2023). Digital agriculture can be defined as a set of communication, information, and analysis technologies that enable producers to plan, monitor, and manage agricultural systems (Bolfe et al., 2020). These technologies, including apps, APIs, and digital platforms, support sustainable production,

while meeting the demand for healthy, affordable food (Puntel et al., 2023).

The current literature has examined data privacy, security, and sharing in digital agriculture (Chamorro-Padial et al., 2025). However, there is a limited understanding of how these issues interact within ESG-reporting platforms, particularly concerning stakeholders' willingness to share data and the role of consumer demand. A further question emerges: can free market dynamics alone foster data sharing for ESG reporting, or are government policies and regulatory frameworks necessary to create enabling conditions?

The present study addresses these perspectives by asking: What factors influence farmers and agribusinesses willingness to share data on ESG platforms? Are consumers willing to pay or share data for access to product-sensitive information? What circumstances favor data sharing for platform success? Is a free market sufficient, or is government intervention required?

The primary objective is to provide a comprehensive analysis of these questions and offer insights into creating a sustainable, secure, and transparent data-sharing environment for ESG reporting in agriculture and livestock.

Materials and Methods

This section outlines the bibliometric methodology used to deepen the review of the scientific literature on data privacy and security in ESG digital platforms for agriculture and livestock. The literature search was carried out using a systematic approach called PRISMA (Page et al., 2021), to identify relevant studies on data privacy, data security, data sharing, and ESG digital platforms in agriculture and livestock. The search aimed to cover a comprehensive range of peer-reviewed articles.

Web of Science database was searched to identify high-quality research articles in multidisciplinary fields relevant to data management, privacy, security, and ESG practices in agriculture and livestock. A logical combination of the following keywords and search terms was used to identify relevant studies: *(data privacy OR data security OR data shar* OR ESG) AND (agri OR livestock OR food OR food suppl*) AND sustainab* AND (digital platform* OR Internet of Things OR IoT OR blockchain OR API* OR willingness*

to pay OR public polic OR market incentive* OR trust OR data governance)*. Following the screening for exclusion criteria (retracted publications), inclusion criteria (only articles and written in English), and constraining for the recent period 2014 to 2024, the search string retrieved 668 documents, for which the number of citations increased from 5 to 2,355 in the evaluated period, which represents an exponential citation growth rate of nearly 28% per year.

Based on the retrieved documents, an in-depth review was carried out, complemented by specific thematic searches on the Google Scholar platform.

Titles and abstracts of the retrieved documents have been digested in the latest version of the VosViewer, a software tool for screening, constructing, and visualizing bibliometric networks (Van Eck & Waltman, 2010). Setting a minimum occurrence threshold of 10 reduced the initial pool of 22,449 terms to 702. From these, applying a second filter that retained the 60% most relevant terms — those appearing frequently but unevenly across the corpus, thus concentrated within specific topics — resulted in a semantic network comprising 421 terms and 31,912 interconnections.

In Gephi, statistical measures known as network centralities were calculated, which are widely used to characterize the relative importance of nodes in a network (Bastian et al., 2009; Newman, 2010). Specifically, the average weighted degree was used to define the node size, reflecting the average number and strength of connections of each term, while betweenness centrality was used to adjust the size of the node labels, indicating the extent to which a term acts as a bridge linking different clusters of terms. To identify thematic communities within the network, we applied the modularity class-clustering algorithm (Blondel et al., 2008), which detects the groups of nodes more densely connected among themselves than with the rest of the network. These communities were represented with different colors, facilitating the interpretation of the semantic structure.

Results and Discussion

The insights described in the Introduction are explored here, with an in-depth review of the literature on ESG reporting in agriculture and livestock, highlighting technological, socioeconomic, and regulatory factors that shape its adoption and effectiveness. The integration

of ESG reporting with agriculture and livestock is advancing as a pathway to sustainable development, emphasizing ethical practices, transparency, and governance (Bocken et al., 2014; D'Amato et al., 2017). Digital platforms have proved to be essential for operationalizing these principles, enabling data collection, sharing, and analysis to improve efficiency, traceability, and compliance (Wolfert et al., 2017; Jakku et al., 2019). Despite the effectiveness of such platforms processing data – on soil, crops, livestock, water use, and supply chains (Klerkx et al., 2019; Medici et al., 2021; Kwilinski et al., 2023) –, the leveraging of the internet of things, remote sensing, blockchain, and artificial intelligence hinges on data availability and the willingness of farmers and agribusiness to share information (Kamilaris et al., 2019; Medici et al., 2021).

Concerns about privacy, security, and competitive disadvantage remain key barriers to participation (Wolfert et al., 2017; Eastwood et al., 2019; Rotz et al., 2019; Poppe et al., 2023). Regulations such as the European Union's General Data Protection Regulation (GDPR), the California Consumer Privacy Act (CCPA), and Brazilian General Law of Personal Data Protection (Lei Geral de Proteção de Dados Pessoais - LGPD) reinforce the need for secure and transparent handling of data (Ienca et al., 2019; Mendes et al., 2023; Ayala-Rivera et al., 2024). Governance frameworks including encryption, anonymization, and consent management (Hackfort, 2023), alongside blockchain-based solutions (Caro et al., 2018; Casino et al., 2019), are being tested to enhance integrity and trust. Yet, socioeconomic factors — trust in platforms, ownership concerns, and perceived value of data — remain decisive for farmer engagement (Jayashankar et al., 2018; Eastwood et al., 2019; Jouanjean et al., 2020; Lin, 2022; Hackfort, 2023; Wu, 2024).

On the demand side, consumers increasingly seek transparent information on product origins, practices, and impacts, often paying premiums for certified ESG credentials (Krystallis et al., 2005; McFadden & Huffman, 2017; Poore & Nemecek, 2018; Bennett & Claassen, 2023; Liu et al., 2024). Their willingness to pay varies by values and context, reinforcing the need for reliable, accessible, and standardized reporting (Yadav et al., 2020; Vehmas et al., 2024).

In South America, the ESG adoption in agribusiness reflects both challenges and opportunities. Brazil, in particular, balances scrutiny over deforestation

with the promotion of sustainable systems (Barbosa et al., 2025). Distributed ledger technologies are also emerging to strengthen traceability (Ordoñez et al., 2024). Policy frameworks can facilitate this transition through governance structures, incentives, and data access (Jakku et al., 2019; Poppe et al., 2023; Bergier et al., 2024), while initiatives like GO FAIR Agro Brazil mobilize interoperable standards (Wilkinson et al., 2016). Still, trust deficits, fragmented governance, and unequal digital readiness (Acemoglu & Robinson, 2012; Gächter & Schulz, 2016; Spadaro et al., 2023) may hinder smallholders more than large agribusinesses, if not carefully addressed.

Taken together, these findings highlight five interdependent aspects shaping agricultural ESG-reporting platforms: (i) privacy and data security; (ii) public policies; (iii) transparency and accountability; (iv) sustainable practices; and (v) technological, social, economic, and regulatory factors.

Taking all together, any digital platform should therefore consider a multi-scale and territorial perspective of production and planning, by linking different levels of characteristic agrosystem units: places, districts, cities, territories, and national scale, and the connection between these conceptual aspects (Figure 1). In this proposed logical concept, the potential stakeholders are considered: i) Consumers – direct sales, local short-term food trade channels, and restaurants; ii) traders – supply agents, sale retailers, and distributors; and iii) producers – farmers, associations, and cooperatives. Next, we show that this approach is supported by analysis of recent scientific literature.

The network of screened terms in titles and keywords from the retrieved scientific documents, via PRISMA and VOSviewer, provided a semantic network of 421 terms, and 31,912 interconnections. The graph obtained in Gephi (Figure 2) depicts the Circle Pack Layout with modularity as the first hierarchy, and degree and betweenness network centralities for the remaining hierarchies.

Overall, a complex web of themes is illustrated, which are related to technology, consumption, sustainable development, and socioeconomic factors (Figure 2). Each color-coded cluster reflects a particular thematic area, but all are interconnected, suggesting a holistic and interrelated approach to these subjects, in the context of global development goals and research

on sustainable innovation. The nodes (terms) of the web are grouped into four major clusters with distinct colors. The green cluster (left) focuses on technology and industry. Words like “technology”, “industry”, “application” and “supply chain” suggest this cluster is about technological advancements and their application in industries potentially related to digital transformation. The red cluster (right) is centered around adoption, household, income, and livelihood, possibly touching on themes of socioeconomic impacts, conservation, or vulnerability, particularly with regard to livelihood and income in the context of changing economic systems. The purple cluster (bottom center) concerns sustainable development, food systems, and nutrition. Words like “food system”, “nutrition”, “sustainable development”, “collaboration”, and “project” suggest a focus on global food security, sustainable practices, and initiatives targeting nutrition and socioenvironmental sustainability. The pink cluster (center right) is related to consumer behavior and product consumption, as seen by the words “product”, “consumption”, “consumer”, and “trust”. This could explore themes around how consumers

engage with products, potentially linking to trust in product quality, preferences, and market dynamics. Finally, the blue cluster (bottom center-right) addresses projects and initiatives in development, linking to the sustainable development goals (SDGs), ESG-reporting principles and related topics like food insecurity and the impact of global events associated with COVID-19 and climate change.

Consolidating these connections depends on collaboration across different actors, particularly through the active participation of smallholders. Associativism, expressed in cooperatives and farmers’ associations, provides an essential mechanism for family farmers to access digital platforms, share data securely, and strengthen their presence in value chains oriented by ESG principles. Such inclusion not only enhances their social and economic representation, but also ensures that the data generated by family farming contributes to global agreements on sustainability, food security, and climate governance. Trust, participatory governance, and market incentives are therefore key conditions for making this process viable (McFadden & Huffman, 2017; Wolfert et al., 2017). Besides,

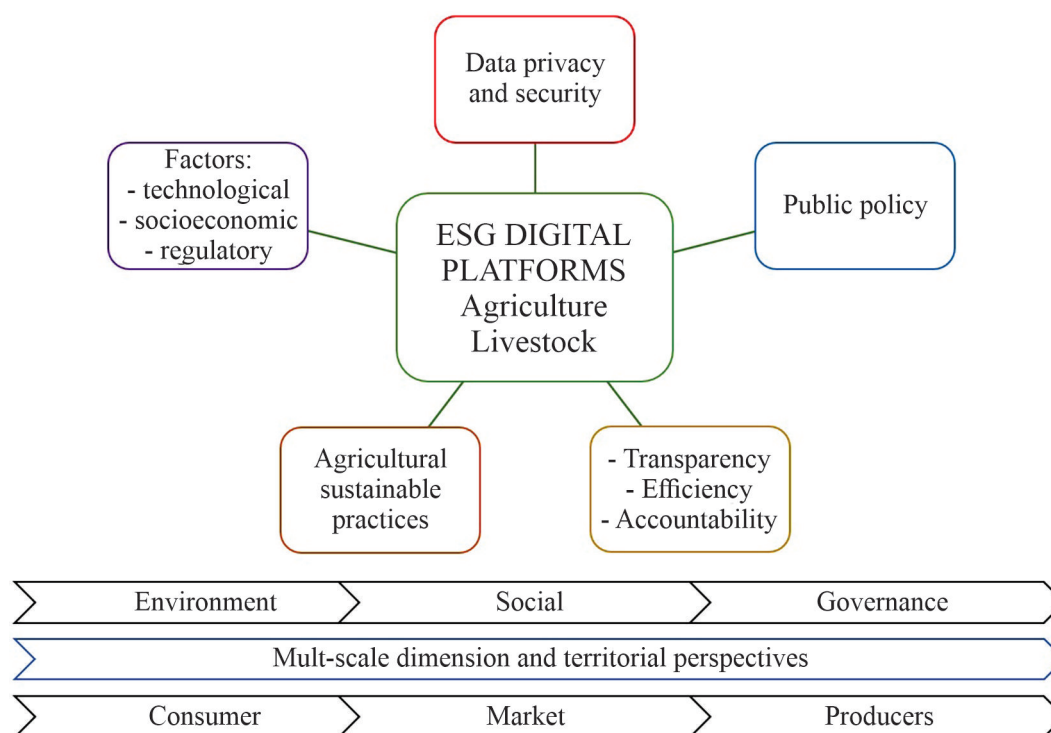


Figure 1. Conceptual ESG reporting for digital platforms of the agri-food sector.

evidence from China illustrates that cooperative membership significantly increases farm revenues and investment in production technologies, particularly in vulnerable regions (He & Chen, 2024). By reducing transaction costs, improving access to credit, and facilitating collective bargaining, cooperatives not only enhance farmers' income, but also strengthen their resilience against market fluctuations and climate risks. These findings highlight that fostering cooperatives can provide a practical pathway for empowering smallholders globally, ensuring that their participation in digital platforms is not merely symbolic, but translated into tangible economic and social benefits.

Some key terms like “product”, “consumption”, “technology”, and “adoption” appear to be more centrally placed, indicating them as core concepts or hubs that bridge different thematic clusters. Terms like “trust”, “performance”, “project”, and “initiative” also have connections across clusters, indicating their importance in linking different aspects of technology, consumption, and socioeconomic impacts. The

density of connections between nodes shows a high level of interconnectedness between these themes, suggesting that technology, consumer behavior, sustainable development, and livelihoods are all closely interconnected and mutually influential. For instance, “technology” (green) is closely tied to “product” and “consumer” (pink), showing that advancements in technology influence products and consumer behavior, while terms like “livelihood” and “income” (red) indicate how technology and consumer markets affect economic outcomes, which implies in the relevance of ethical public policies in regulating the former.

Brazil has been undergoing significant climatic changes. Between 1980 and 2018, a consistent warming trend occurred across all regions, with average temperatures rising by approximately 0.5°C each decade. Data from the Standardized Precipitation Index (SPI) covering the period from 1962 to 2019 shows that, with the exception of the South, drought events have intensified since 2011, in comparison with the previous sixty years. Furthermore, future

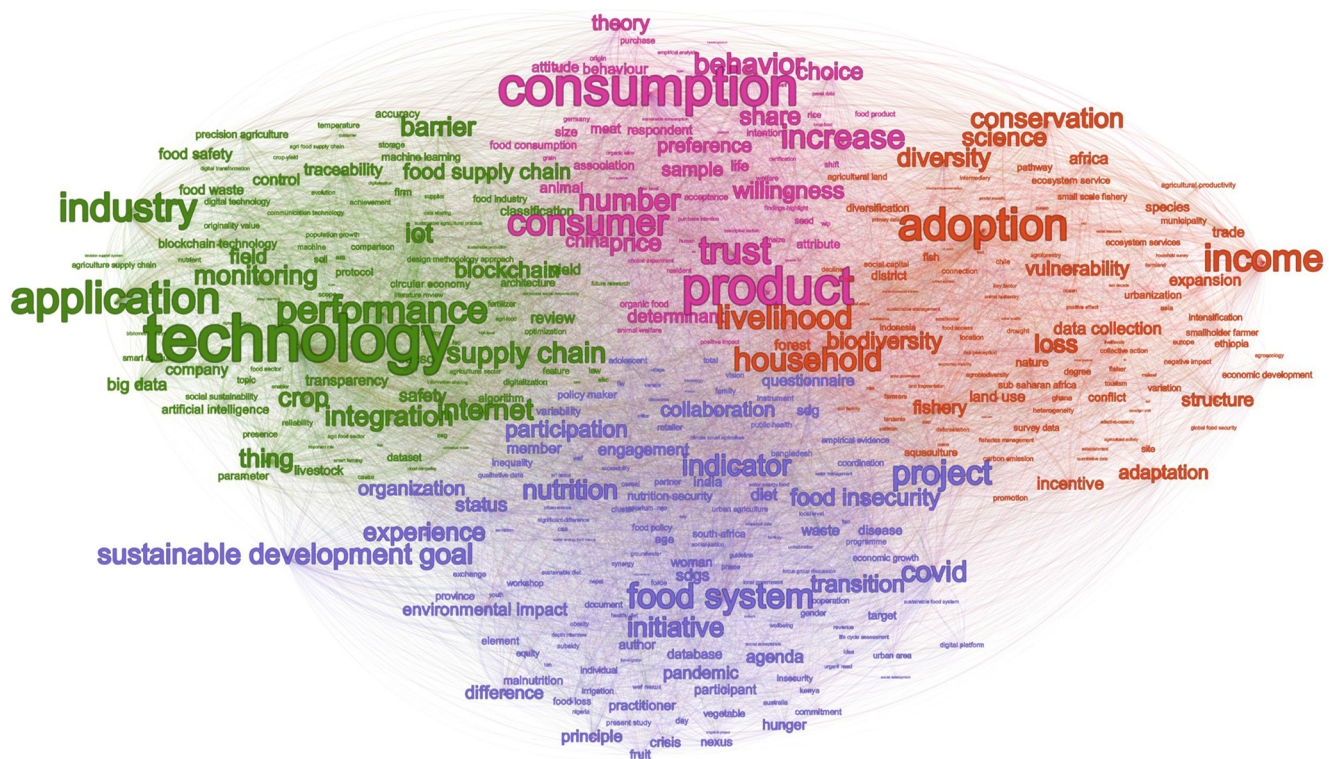


Figure 2. Semantic network visualized In Gephi, extracted from titles and abstracts of the 668 Web of Science retrieved documents, by combining PRISMA method and VOSviewer term screening.

rainfall projections based on the Coupled Model Intercomparison Project Phase 5 (CMIP5) models suggest an increased variability, leading to more intense wet periods and more frequent or severe dry spells over daily, weekly, monthly, and intra-seasonal timescales (Cunha et al., 2019; Alves et al., 2020; Santos et al., 2020). This highlights the heightened vulnerability of Brazil's agricultural sector, particularly for small and medium-sized farms that depend heavily on annual revenue production. The widespread adoption of digital innovations, such as digital ESG-reporting systems, is critical for increasing the adaptive capacity and resilience of the Brazilian agri-food sector to the impacts of climate change.

The initiatives of the Semeiar Digital “Center of Science for Development in Digital Agriculture”

(Centro de Ciências para o Desenvolvimento em Agricultura Digital) (Embrapa, 2024), which implement smart-farming solutions within agrotechnological districts (Distritos Agrotecnológicos (DATs) — pilot regions for innovation in the biomes: Amazon, Cerrado, Caatinga, and Atlantic Forest (Figure 3) — play a critical role in empowering small and medium farmers through ESG reporting. The DATs of Semeiar Digital have experienced an increase in agricultural drought. Compared to the 2000-2012 period, the exceptional, extreme, and severe drought intensity categories increased by 7.3, 5.4, and 2.2 times, respectively, in the 2013-2024 period (Silva et al., 2025), showing that technological innovation in the agribusiness sector is crucial for the sustainability of Brazil's small and medium-sized farms.

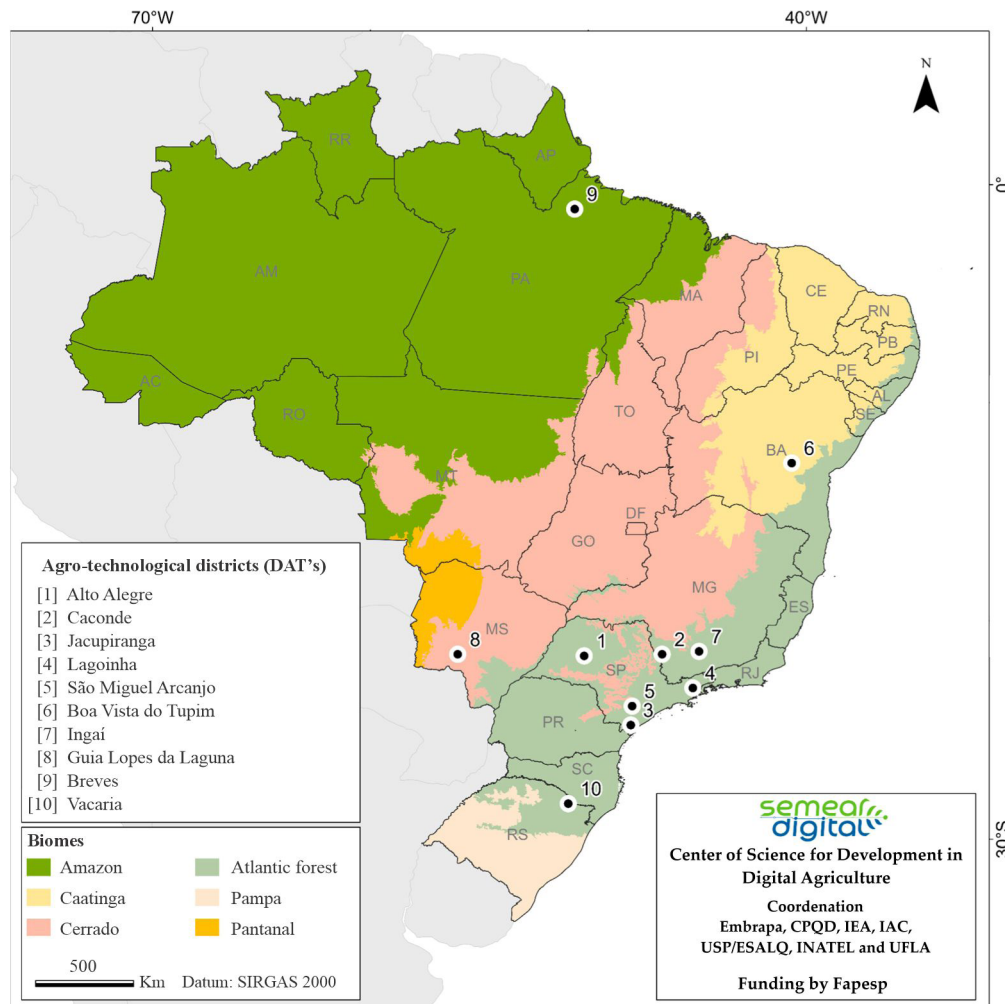


Figure 3. Location of the Agro-Technological Districts of the Semeiar Digital Center in Brazil (Embrapa, 2024).

The actions of Semear Digital in the DATs aligns with the Brazil's Law 12187/2019, Decree 11815/2023, the Low-Carbon Agriculture Plan (Plano Setorial para Mitigação e Adaptação às Mudanças Climáticas para Consolidação de Economia de Baixa Emissão de Carbono na Agricultura - ABC Plan), and the Conference of the Parties. Brazil's Law No. 12187 of 2019 established the National Policy on Climate Change (Política Nacional sobre Mudança do Clima - PNMC), outlining principles, objectives, and instruments to mitigate greenhouse gas emissions, and promote sustainable development in Brazil. Decree No. 11815/ 2023 further regulates the National Policy on Climate Change (PNMC), by updating guidelines for implementing measures to mitigate greenhouse gas emissions and adaptation to climate change. This includes sectorial plans and monitoring mechanisms. Additionally, Brazil's Low-Carbon Agriculture Plan (Plano ABC) supports sustainable farming by promoting techniques such as crop-livestock-forestry integration, no-till farming, and the use of bioinputs. These techniques aim to reduce greenhouse gas emissions, improve soil health, and boost agricultural productivity, while aligning with the country's climate commitments.

Another initiative, the "Collaborative Development Project for Precision and Digital Agriculture to Strengthen the Innovation Ecosystem and the Sustainability of Brazilian Agrifood Chains," emphasizes the organization of field data generated through precision and digital agriculture practices. These data are intended for use in traceability audits, certifications, and ESG reporting (Agência Brasileira de Cooperação, 2024). Given the sensitive nature of this information, particularly concerning farmers' data, adherence to Brazil's LGPD is paramount for ensuring privacy and ethical handling.

The Conference of the Parties (COP), established under the United Nations Framework Convention on Climate Change (UNFCCC) in 1994, serves as the primary global platform for negotiating international climate action, aiming to limit global warming, enhance adaptation strategies, and mobilize financial support. The conference's future is crucial for addressing urgent climate challenges and ensuring that global temperature rise stays well below 1.5°C. Nationally Determined Contributions (NDCs) emerged at COP21 in Paris in 2015. The NDC is a

document that defines each country's participation in the Paris Agreement, the largest climate agreement in history. The two latest COP focused on strengthening commitments to the Paris Agreement (COP28), and on operationalizing carbon markets and achieving greater financial security across multiple sectors (COP29). However, difficulties in reaching agreements between parties, to mitigate radiative trace gas emissions, have shown that adaptation strategies, including data platforms for ESG reporting, must be implemented very soon to avoid water, food, and energy insecurities (Assad & Assad, 2024), which could be a hot topic at the upcoming COP30 in Pará state, Brazil.

Conclusions

1. Data sharing in ESG-reporting platforms depend on trust, data ownership, perceived benefits, and governance. Stakeholders share data when they trust the platform, the organizations managing it, and the rules governing its use.

2. Digital platforms enhance transparency and accountability, but face persistent barriers related to privacy and security.

3. Consumer demand for transparency and willingness to pay reinforces the value of ESG-compliant products.

4. Supportive public policies and regulatory frameworks complement market incentives in promoting associativism and data sharing.

5. A secure, sustainable, and transparent digital environment requires the integration of technological, socioeconomic, and regulatory strategies.

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Author contributions

Ivan Bergier: conceptualization (lead), data curation, formal analysis, investigation, methodology, resources, supervision, validation, visualization, writing – original draft, writing - review & editing; writing – original draft; **Édson Luis Bolfe:** formal analysis (equal), methodology (supporting), validation (equal), visualization (equal), writing - review & editing (equal); **Debora Pignatari Drucker:** formal analysis (equal), validation (equal), writing - review & editing (equal); **Ricardo Yassushi Inamasu:** investigation (supporting), writing - review & editing (supporting); **Patricia Menezes Santos:** investigation (supporting), writing - review & editing (supporting); **Urbano Gomes Pinto de Abreu:** investigation (supporting), writing - review & editing (supporting); **Tamires Lima da Silva:** investigation (supporting), writing - review & editing (supporting); **Fabiane de Fátima Carvalho:** investigation (supporting), writing - review & editing (supporting); **Luciana Alvim Santos Romani:** project administration (lead), investigation (supporting), validation (supporting); writing - review & editing (supporting); **Jayme Garcia Arnal Barbedo:** project administration (lead), investigation (supporting), validation (supporting), writing - review & editing (equal); **Silvia Maria Fonseca Silveira Massruhá:** funding acquisition (lead), investigation (supporting), writing - review & editing (supporting).

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