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Abstract: *This study aims to understand the relationship between digital servitization strategies and new sustainable practices in agriculture, focusing on the Brazilian agricultural machinery segment. The research adopts a qualitative, exploratory, and descriptive approach. In terms of technical procedures, it relies on interviews, document analysis, and bibliographical research, with data synthesized using content analysis in nine reports, five interviews, and 54 hours of document analysis. The main theoretical contribution is the development of a study that connects digital servitization with new agricultural technologies, highlighting advancements in sustainability within the agricultural industry. On an empirical level, the article examines a set of agricultural technologies proposed by the OECD (2019), discussing their benefits for sustainability and the resulting changes in the business models of companies within the segment. The evolution of servitization was evidenced in basic, digital, and smart services, and the seven technologies for innovation in agriculture were confirmed. A significant increase in the environmental dimension was identified (77.38% GRI environmental dimensions were declared), while the reported practices show that technological innovation promotes greater production efficiency and the preservation of natural resources.*

Keywords: agricultural industry; digital transformation; sustainable agriculture; GRI.

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Resumo: Este estudo objetivou compreender a relação entre estratégias de servitização digital e novas práticas sustentáveis na agricultura, com foco no segmento de máquinas agrícolas no Brasil. A pesquisa adota uma abordagem qualitativa, exploratória e descritiva. Em termos de procedimentos técnicos, baseia-se em entrevistas, análise documental e pesquisa bibliográfica, com dados sintetizados por meio de análise de conteúdo em nove relatórios, cinco entrevistas e 54 horas de análise documental. A principal contribuição teórica é o desenvolvimento de um estudo que conecta a servitização digital com novas tecnologias agrícolas, destacando os avanços em sustentabilidade no setor agropecuário. Em nível empírico, o artigo examina um conjunto de tecnologias agrícolas propostas pela OCDE (2019), discutindo seus benefícios para a sustentabilidade e as consequentes mudanças nos modelos de negócios das empresas do segmento. A evolução da servitização foi evidenciada nos serviços básicos, digitais e inteligentes, e as sete tecnologias para inovação na agricultura foram confirmadas. Identificou-se um aumento significativo na dimensão ambiental (77,38% das dimensões ambientais no GRI foram declaradas), enquanto as práticas relatadas demonstram que a inovação tecnológica promove maior eficiência produtiva e a preservação dos recursos naturais.

Palavras-chave: indústria agrícola; transformação digital; agricultura sustentável; GRI.

Resumen: *Este estudio busca comprender la relación entre las estrategias de servitización digital y las nuevas prácticas sostenibles en la agricultura, centrándose en el segmento brasileño de maquinaria agrícola. La investigación adopta un enfoque cualitativo, exploratorio y descriptivo. En cuanto a los procedimientos técnicos, se basa en entrevistas, análisis documental e investigación bibliográfica, con datos sintetizados mediante análisis de contenido en nueve informes, cinco entrevistas y 54 horas de análisis documental. La principal contribución teórica es el desarrollo de un estudio que conecta la servitización digital con las nuevas tecnologías agrícolas, destacando los avances en sostenibilidad dentro del sector. A nivel empírico, el artículo examina un conjunto de tecnologías agrícolas propuestas por la OCDE (2019), analizando sus beneficios para la sostenibilidad y los cambios resultantes en los modelos de negocio de las empresas del segmento. La evolución de la servitización se evidenció en los servicios básicos, digitales e inteligentes, y se confirmaron las siete tecnologías para la innovación en la agricultura. Se identificó un aumento significativo en la dimensión ambiental (se declaró el 77,38% de la dimensión ambiental GRI), mientras que las prácticas reportadas muestran que la innovación tecnológica promueve una mayor eficiencia productiva y la preservación de los recursos naturales.*

Palabras clave: *industria agrícola; transformación digital; agricultura sostenible.*

INTRODUCTION

The current economic and market landscape points to new models of service industrialization that are impacting a wide range of manufacturing sectors (Melotti et al., 2023; Baines et al., 2020), at the same time, new technologies have become essential for maintaining competitiveness (Minaya et al., 2023; Sá Porto et al., 2017). Instead of offering only products, companies are now providing complete solutions that combine products and services, replacing products entirely with new services (Daum, 2023; Baines et al., 2020). This shift, which involves changes not only in the portfolio but especially in the overall business model, is known as servitization.

Digital servitization refers to the integration of digitalization into servitization, with the o aim of transforming value creation processes, as well as reshaping relationships and structures within supply chains (Daum, 2023). It can be adopted as a strategy to increase financial returns and influence economic indicators.

The transition from traditional mechanization to digital servitization in agriculture reflects broader shifts in industrialization patterns. Not completely, but significantly, the review suggests Asia and Latin America and the Caribbean countries have experienced considerable progress regarding mechanization more recently, driven by farming system evolution, structural transformation, and urbanization (Daum, 2023). While mechanization historically boosted productivity by replacing manual labor (Oliveira et al., 2017; Pingali, 2007), digital servitization now extends this impact by integrating smart technologies that optimize resource use and reduce environmental footprints (Kohtamäki et al., 2020).

In Brazil, the service sector played a leading role in the Gross Domestic Product (GDP) in 2023, accounting for 59% of the country's total wealth (Federal Economic Council – Cofecon, 2023). In terms of agricultural sustainability, Brazil has preserved two-thirds of its territory covered by native forests, and 25.6% of the area located within agricultural properties productivity gains have led to a phenomenon known as the "forest-saving" effect, which has helped avoid approximately 775 million hectares of deforestation. Furthermore, between 1990 and 2021, total factor productivity in agriculture grew at an average annual rate of 3.1%, while greenhouse gas emissions increased by only 1.4%. These figures demonstrate the strong potential of agribusiness to support environmental restoration (Vieira Filho; Gasques, 2023).

Agribusiness plays a strategic role in the Brazilian economy (Christ et al., 2022). In organizational settings, sustainability has become essential for ensuring long-term business viability. It is embedded within the broader framework of environmental, social, and governance (ESG) dimensions (Brown et al., 2006). ESG refers to a set of criteria related to environmental responsibility, social impact, and corporate governance that should be considered when evaluating risks, opportunities, and their consequences. It serves as a guide for sustainable business practices, activities, and investments (ABNT, 2022).

In other words, ESG adoption in agribusiness aligns with global trends toward sustainable intensification, where digital servitization can reduce input waste while maintaining yield growth. This study explores digital servitization as a strategy to promote sustainability in Brazil's agricultural machinery industry, representing 99,04% of the market share. Before the rise of AgTechs (startups offering innovative solutions in agribusiness), the agricultural market was dominated by two main players: manufacturers of machinery and equipment, and input suppliers, among Brazilian AgTechs, 86.26% use Information and Communication Technologies (ICT)

to address challenges such as climate variability, pest control, and soil fertility improvement (Mikhailov et al., 2022).

Unlike earlier studies that focused on technical efficiency or the feasibility of technology adoption, this research aims to examine the presence of these new technologies within the Brazilian agricultural machinery industry, with a focus on ESG.

This research adds to the body of knowledge on servitization, proving that the leading companies in the agricultural machinery segment in Brazil are advancing in the use of new technologies to offer services that, occasionally, replace the sale of products. Furthermore, this information was cross-referenced with sustainability reports were used as secondary data, focusing exclusively on the Global Reporting Initiative (GRI, 2024) Content Index, which covers the content summary of the GRI reports from 2021, 2022, and 2023, representing the most recent three years of publication from the three main agricultural machinery manufacturers: John Deere, AGCO, and CNH which confirmed that digital servitization can enable strategies focused on sustainability triad: environmental, social, and governance/economic.

The guiding question of this study is: Which technologies associated with digital servitization strategies can promote sustainable practices in the agricultural machinery segment? To answer this, the main objective is to understand the relationship between digital servitization strategies and new sustainable practices in agriculture, focusing on the Brazilian agricultural machinery segment**.** Through an empirical study, this research presents data on trends in digital servitization and sustainability within key players in the Brazilian agricultural machinery industry.

2 – DIGITAL SERVITIZATION IN THE AGRICULTURAL MACHINERY SEGMENT

Although there is no consensus, previous studies mostly use both Innovation Theory (Baines et al., 2020; Genzlinger, 2020) and Dynamic Capabilities Theory (Reichert; Ruffoni, 2021; Teece et al., 2018) to support their findings on positive results resulting from servitization strategies. Servitization is emerging as an effective strategy for more efficient food production, integrating services with advanced technologies. This approach enables agricultural companies to improve production processes while meeting increasing market demands for sustainability and innovation.

The concept of servitization was first introduced in the manufacturing sector as a business strategy to add value and create a competitive advantage through combined products and services (Vandermerwe; Rada, 1988). Also known as Product-Service Systems (PSS) (Baines et al., 2017), servitization has been defined as a process of product and service innovation (Lall, 1992) and continues to evolve as a key strategy in agriculture (Daum, 2023; Pereira; De Vargas, 2021).

According to Baines et al. (2020), the process of organizational transformation through servitization can be understood through four macro-stages and contextual factors exposed in Frame 1.

Frame 1 – Macro-stages and contextual factors of servitization

Macro-stages	Contextual Factors
Exploration: The initial stage of identifying opportunities to launch services. This includes analyzing competitive advantages, assessing internal resources, benchmarking, evaluating feasibility, and estimating the expected return on required investments.	**Customer Attraction**: External market-related factors influencing servitization progress with current and potential customers.
Engagement: Focuses on gaining internal support and acceptance for launching more advanced services. This stage may involve adjusting the business model and measuring KPIs.	**Technological Impulses:** External digital technology trends and advancements that drive or impact servitization.
	Value Chain Positioning: External factors related to the organization's role in the value chain, influencing its ability to adopt servitization.
Expansion: Aims to scale up advanced service offerings and reach a broader market. Marketing and sales teams play a key role, although significant revenue may not yet be realized.	**Organizational Readiness:** Internal factors based on the performance and reliability of the manufacturer's existing products, which influence the decision to initiate the servitization process.
Exploitation: The most advanced phase, focused on optimizing and maintaining the delivery of advanced services, which continue unless the business begins to incur losses.	**Organizational Commitment:** Internal factors present across all stages, related to the organization's capabilities and dedication to advancing service offerings. Recognized as a key factor for success.

Source: Adapted from Baines et al. (2020).

One of the main motivations for adopting servitization strategies is the opportunity to build closer relationships with customers, aiming to increase both loyalty and profitability (Silva, 2020; Souza, 2019). This shift involves moving from simple transactions to more relational agreements that strengthen long-term engagement (Genzlinger et al., 2020). However, Baines et al. (2020) point out that servitization represents a unidirectional and linear transition, from product-based to service-based offerings, which adds a layer of complexity to the process (Martinez et al., 2017). To better understand this transformation, Frame 2 presents the three levels of servitization capability.

Frame 2 – Firm servitization capacity model

Resources and Routines	**Servitization Capability Development Level**		
	Basic	**Intermediate**	**Advanced**
Product	Develops PSSs informally	Uses formal methodologies to develop PSSs; Incorporates hardware and software into products	Uses modularization techniques to adapts PSSs offering according to the product lifecycle
Process	Plans and controls service delivery; Controls service quality	Optimizes service delivery processes; Delivers services through digital platforms	Flexible service delivery; employs advanced manufacturing technologies
Transaction	Establishes partnerships to deliver services	Conducts customer relationship marketing; Service-centered marketing	Adapts the supply chain to allow product customization
Management	Controls and manages service costs	Trains and develops service teams; Has dedicated service departments	Service-centered business model
Orientation	To Product	To Outcome	To Use
Digitalization	Manual	Digital	Smart
Innovation	Low	Medium	High

Source: Reichert and Ruffoni (2021).

Servitization leads to new dynamics in customer relationships and requires adaptation from companies. In the agribusiness sector, these changes are particularly visible in the agricultural machinery industry, which plays a significant role in Brazil's economic landscape. The evolution of agri-food value chains has been accelerated by digital transformation. While digital technologies have been applied in agriculture since the early 2000s, their exponential growth has become increasingly evident in recent years (Mikhailov et al., 2022; Zhang, 2020; Sarker et al., 2020). Currently, industries generate 29% of their total revenue from services, and this share is expected to grow to 60% within the next 10 years (Accenture, 2020). OECD (2019) classifies agricultural technologies into seven groups, which are directly relevant to studies on digital servitization (Frame 3).

Frame 3 – Set of agricultural technologies proposed by the OECD

Description of Technologies	Relationship with servitization
1. **Digital Platforms:** collect data and provide broad access to information and services, as they enable B2B (Business to Business), B2C (Business to Consumer), and C2C (Consumer to Consumer) transactions.	The digital platforms facilitate service monitoring, bring customers closer together, eliminate geographical barriers, and provide access to new markets.
2. **Robotics and Drones**: This set includes new materials, 3D printers, advanced robotics, and drones.	Generates precise, secure, and agile data that benefits various agricultural operations.
3. **IoT**: Refers to the interconnection of everyday objects and devices. These connected objects can collect and share data remotely.	Enhance digital servitization by enabling software updates, mobility, and integration with machinery.
4. **Big Data Analytics:** Comprises a set of technologies that can monitor and extract information from large volumes of data related to transactions, purchases, internet searches, social media, streaming, in other words, establishing patterns, insights, and improving processes by extracting organized data.	Facilitates decision-making by collecting, storing, and analyzing data, from planting to harvest.
5. **Artificial Intelligence**: Involves modeling, simulation, and machine learning. AI can be: (i) Focused: a set of algorithms specialized in solving specific problems; (ii) Generalized: algorithms developed to be as capable as humans through machine learning techniques; (iii) Generative: algorithms that are more capable than humans in almost all tasks.	Contributes to cost reduction and automation of services; its full potential is still emerging.
6. **Cloud Computing:** The telecommunications network and ICT are intrinsically related and play key roles in communication, connectivity, and information dissemination. Cloud technologies, Blockchain, interoperability, and cybersecurity are also considered.	Complement data generation by enabling real-time data sharing and technological access essential for service delivery.
7. **Sensors:** These are devices that collect data and interface with the physical world in the short term, such as agricultural nanotechnology and precision agriculture. Nanosensors monitor and accelerate the diagnosis and treatment of plant diseases, nutrient absorption, and the application of pesticides.	Enable human/machine interaction and the customization of services based on use needs.

Source**:** The authors, based on the OECD classification (2019).

This paper proposes that digital servitization can contribute to sustainability and can be analyzed by assessing the level of servitization a company has reached at a given moment. This assessment is based on how the company has structured its macro-stages of technological development for service delivery and, additionally, how it has adapted its business model to contextual factors to mitigate the risks of non-servitization.

To address these challenges, sustainable business models must adopt innovative strategies, such as energy efficiency, circular economy practices, strong governance, and active social engagement. These approaches should align with the overall business strategy to help reduce costs, increase asset value, and mitigate organizational risks (ABNT, 2022).

The development of the categories and subcategories followed the main principles of the theoretical framework on Digital Servitization, Technologies, and Sustainable Agriculture (Frame 4), and was based on the content analysis methodology proposed by Bardin (2010).

Frame 4 – Propositions and sub-propositions of the study

Categories	Subcategories	Propositions	Sub-propositions
1 Sustainability in Agriculture	1.1 Environmental 1.2 Social 1.3 Governance/Economic	P1) Servitization progresses to digital servitization once the company reaches the advanced level, as new technologies are developed or acquired, with the possibility of mapping this trajectory through the 4 macro-stages of Business Model evolution --- P2) The use of the servitization strategy associated with the digital transformation process has generated innovations in the agricultural machinery sector; --- P3) The success of implementing servitization strategies is partially linked to contextual factors.	sp.1.1) Servitization strategies, at any of the 3 levels, can promote innovation in products, services, and processes; sp.1.2) Digital servitization strategy can only occur at the advanced level; sp.1.3) Digital servitization can create opportunities for strategies aimed at the sustainability triad: environmental, social, and governance/economic; --- sp.2.1) Digital servitization strategies enable revenue growth as each macro-stage of the Business Model is organized. --- sp.3.1) Agricultural machinery industries have acquired new technologies to offer new digital services; sp.3.2) Agricultural machinery industries have developed new technologies to offer new digital services.
2 Levels of Servitization	1.1 Basic 1.2 Intermediate 1.3 Advanced		
3 Macro-stages (Business Model)	2.1 Macro-stage of Resource Exploration 2.2 Macro-stage of Engagement 2.3 Macro-stage of Expansion 2.4 Macro-stage of Execution		
4 Digital Technologies for Agriculture	3.1 Digital Platforms 3.2 Big Data 3.3 Robotics and Drones 3.4 Artificial Intelligence 3.5 Internet of Things 3.6 Cloud Computing 3.7 Sensors		
5 Contextual Factors	4.1 Customer Attraction 4.2 Technological Impulses 4.3 Positioning in the Value Chain 4.4 Organizational Readiness 4.5 Organizational Commitment		

Source: The authors (2024).

After this theoretical essay, we understand servitization as a strategy that leads to value creation. Measuring the relation between digital servitization and new sustainable practices in the agricultural machinery segment contributes to the development of digital services and sustainability.

3 – METHODOLOGICAL PROCEDURES

This research adopts qualitative methodologies, with an exploratory and descriptive approach. The technical procedures include interviews, documentary research, and bibliographic analysis. The study is characterized as theoretical-empirical, as it aims to generate knowledge for practical application (Gil, 2007).

After establishing the research question, the search terms were determined to search the databases: “servitization” “e” “sustainability” in Portuguese and “servitization” “and” “sustainability” in English. In addition, the radical term “agricultural machinery*” was inserted as a descriptor to ensure that the selected works would deal only with this topic. The search in the databases took place in February 2024, including Web of Science®, ScienceDirect®, Scielo®, Emerald®, and Capes®, focusing on identifying studies related to servitization, its

characteristics, and the shift to digital servitization through digital transformation processes and sustainable practices impacting the business model. However, no studies were found that specifically address this topic in the agricultural machinery segment.

The definition of the study object is based on the term "agricultural machinery." Although this term encompasses all types of agricultural equipment, simple or complex, motorized or not, it specifically refers here to motorized equipment with higher technological complexity, such as tractors, harvesters, and planters (Administrative Council for Economic Defense – CADE, 2020). In Brazil, three companies account for over 90% of domestic market sales (Anfavea, 2020)[4], John Deere leading the market (Table 1).

Table 1 – Domestic sales of agricultural machinery – Brazil – (2018) in units

Manufacturers*	Wheeled Tractors	%	Cobine harvesters	%	Sugarcane Harvesters	%	Interview Data
1 John Deere	11.614	29,93 %	2.372	41,19%	365	56,77%	Sales Manager of the Dealership (12/08/24)
2 AGCO							Sales Manager of the Dealership (12/08/24)
Valtra	6.903	17,79%	80	1,39%	20	3,11%	No acceptance
Massey-Ferguson	8.931	23,02 %	387	6,72%			Sales Manager of the Dealership (06/08/2024)
3 CNH							Sales Manager of the Dealership (06/08/2024); Senior Corporate Communications Analyst - CNH Industrial Brazil (16/08/2024)
Case	2.969	7,65%	1.018	17,68%	258	40,12%	
New Holland	8.014	20,65 %	1.902	33,03%			
***Agrale**	372	0,96%					Not included (tractors only)
Total	**38.803**	100%	**5.759**	100%	**643**	100%	

Source: Anfavea (2020). *The data only considers companies affiliated with Anfavea.

The criteria for selecting the interviews considered the largest companies in the segment. Five companies were contacted, four interviews were accepted and conducted. The brands and their managers were contacted through in-person visits to dealerships. After that, contact with the industries was made via email. The dates of the interviews are recorded in Table 1, and the average time was one hour each. The categories, defined in Frame 4, were deductively based on the theoretical framework. Ethical committee approval was not required due to the non-sensitive nature of the data; nevertheless, informed consent was obtained.

The second stage of document collection was conducted between June 3 and July 10, 2024, using secondary data sources produced by the companies under study. Additionally, documents from industry associations and representative organizations, such as the National Association of Motor Vehicle Manufacturers (Anfavea) and the Brazilian Association of Machinery and Equipment Manufacturers (Abimaq), were included in the document analysis. A total of approximately 54 hours were dedicated to gathering and organizing the collected materials. The third stage involved field research, carried out between June and August 2024, which resulted in five interviews and three on-site visits with sales managers from dealerships and a corporate communications analyst from the manufacturing companies. For data

[4] https://anfavea.com.br/site/informacoes-tecnicas/.

triangulation, sustainability reports were used as secondary sources, focusing specifically on the Global Reporting Initiative (GRI, 2024) Content Index. This index summarizes the GRI content from the 2021, 2022, and 2023 reports, representing the three most recent years of publication from the three leading agricultural machinery manufacturers: John Deere, AGCO, and CNH[5].

After data collection and analysis, the classification of the sections for each of the technologies was reviewed and confirmed through an interview with a PhD professor from the AI program and member of the Artificial Intelligence Center at the Federal University of Goiás (UFG/CEIA). The empirical content associated with each of the seven technologies for agriculture, proposed by the OECD (2019), was reviewed, validated, and adjusted based on the corresponding definitions. All interviews were transcribed and imported into MaxQda® version 24.4.1 for individual categorization (Bardin, 2010).

The main objective regarding the use of the method according to Bardin's (2010) positivist view should be critical unveiling, which, for her, requires methodological rigor from the researcher regarding the steps to be followed and, at the same time, an advanced understanding of the field. It is emphasized that the quantitative approach to content analysis uses frequency to unveil certain characteristics of the content, while in qualitative analysis the presence or absence of categories is evaluated under a constant comparison between empirical data and theory (Bardin, 2010). Quantitative content analysis was used, since frequency determines convergence of practices and opinions among the interviewees.

According to Seramim and Walter (2017), qualitative content analysis allows the use of comparison with the articulation between what is manifest (represented by the categories) and what is latent (expressions about what is being talked about). In this sense, the analysis process can bring congruences or even divergences, both used to produce results. Bardin (2010) further emphasizes that content analysis can be performed based on documents, interviews, or reports. In this study, it was decided to apply it to primary data from interviews, as well as to secondary data from document collection.

The pre-analysis phase is derived from the theoretical framework and establishes what Bardin (2002) defines as "categorical analysis," that is, a kind of significant categories thallowslow the classification of the constituent elements of the message. After transcription, pre-analysis comprises some sub-phases, defined as (i) floating reading, in which the first contact occurs to gain familiarity with the data. The second stage consists of (ii) document selection, at which point the corpus of analysis is defined, the field adopted as the focus of attention.

The third sub-phase consists of (iii) the formulation of hypotheses and objectives, the moment when the initial analysis of the collected data takes place: at this stage, the information, still without complete analytical treatment, provided confirmations of the defined propositions and sub-propositions, which led to the last and most detailed phase of the analysis. The fourth and final stage consisted of (iv) the elaboration of indicators, also called enumeration, a sub-phase in which the material was interpreted - composed of the word, the phrase, or any other element that represents the exact cut to the meaning - according to the categories defined previously.

At this moment, there are perceptions between convergences and divergences among the interviewees, which allow for a process of exhaustive reflection and

[5] For more details on this methodological procedure, it is recommended to consult Christ et al. (2024).

comparison with the theory. Categorization allowed the grouping of similar data and the separation of those that diverged from the majority. Bardin (2002) argues that some precautions are essential. The researcher must be responsible for not leaving any data out of the corpus (exhaustiveness). Furthermore, sampling can be carried out, provided that the criterion of representativeness in relation to the whole is maintained, a condition absorbed here. The corpus must also meet similarity standards (homogeneity of data). Finally, the criterion of constant comparison between the data collected and the objective of the study (relevance) (Bardin, 2002).

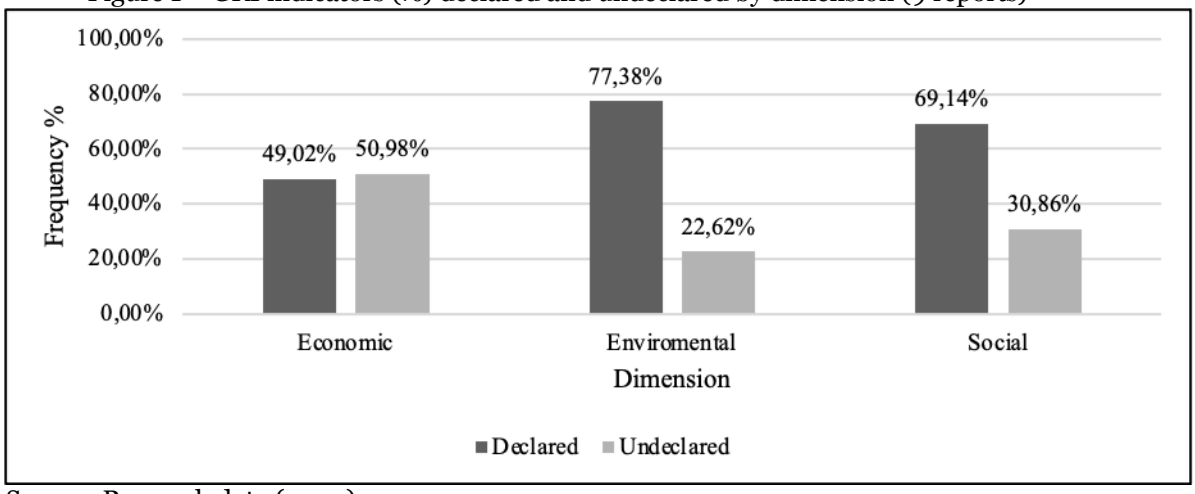
4 – RESULTS AND DISCUSSION

This section presents the results. Section 4.1 presents evidence regarding servitization in agriculture. Section 4.2 discusses the macro-stages of the business model. Section 4.3 presents digital technologies for agriculture. Finally, Section 4.4 addresses contextual factors, concluding the discussion of the findings.

4.1 – SERVITIZATION IN AGRICULTURE

Although ESG-related issues can be analyzed individually, they are interdependent and reveal a wide range of risks and opportunities that influence the social, technological, political, environmental, and economic aspects of an organization. These aspects must be carefully evaluated by companies committed to achieving sustainability (ABNT, 2022). Figure 1 presents the percentage distribution of each ESG dimension as reported by the organizations analyzed in this study.

Figure 1 – GRI indicators (%) declared and undeclared by dimension (9 reports)



Source**:** Research data (2024).

Among the **basic services** identified, all the companies unanimously offered simplified maintenance services and customer training, highlighted by one of the interviewees: "*The services today will represent 20%, the rest is product sales*" (E01). Another participant added: "*In the past, the service department was seen as a necessary evil; today, the company sees the department as if it were a business within a business that must generate income, and not only expenses*" (E02).

In addition, the three companies surveyed - John Deere, AGCO, and CNH Industrial - offer financial services, currently with greater scarcity (Henshel et al., 2025), as financing, consortiums, leasing, and insurance, creating tailored solutions

for agricultural machinery purchases to farmers through their own banks. The commonality of these offerings confirms their classification at the basic level of servitization, as proposed by Reichert and Ruffoni (2021), a stage that the market-leading companies have already achieved and surpassed. The initial asserts argues that: (P1) servitization advances to digital servitization after the company reaches the advanced level, as new technologies are developed or acquired. This evolution can be mapped through the four macro-stages of Business Model development.

This progression aligns with Pingali's (2007) observation that agricultural mechanization historically evolved from labor substitution to productivity-enhancing innovations. Just as mechanization transformed farming efficiency in the 20th century (Daum, 2023; Pingali, 2007), digital servitization now extends this impact by integrating smart technologies (e.g., IoT, AI) that optimize resource use and reduce environmental footprints (Kohtamäki et al., 2020).

At the intermediate level, the data revealed services that are primarily designed for digital delivery (Reichert; Ruffoni, 2021), alongside strong institutional support for connectivity infrastructure. As one interviewee stated: "*We are one of the founding companies of the ConectarAgro Association, which brings together companies from various sectors to enable 4G internet in all rural areas of Brazil, thus fostering Agriculture 4.0, in addition to benefiting schools, hospitals, and rural and remote communities*" (E04).

Another characteristic of this level is that companies have developed formal methodologies for service delivery, either independently or in collaboration with partners in the production chain. While digital services at this stage already create value (LALL, 1992), they are not yet considered "smart" (Reichert; Ruffoni, 2021). Documentary evidence also highlights the use of intelligence centers for real-time remote monitoring of machines (New Holland, 2024), and the implementation of digital ecosystems designed for smart agriculture (Massey Ferguson, 2024).

The offering of these services is rooted in technology and has driven innovation. While there is evidence of a shift from selling products to offering new services, the core of the business model has not yet transitioned from product sales to full-service provision, as occurs at the advanced stages of servitization (Reichert; Ruffoni, 2021; Baines et al., 2020).

At the basic and intermediate stages of servitization, incremental product innovations have enabled the integration of services, supporting sub-proposition sp.1.1: servitization strategies, at any of the 3 levels, can promote innovation in products, services, and processes. Although the companies are not yet fully service-centered (Reichert; Ruffoni, 2021; Baines et al., 2020), important changes in business models have been observed, particularly among dealerships, which have begun offering new services and adjusting their business structures (Reichert; Ruffoni, 2021; Kohtamäki et al., 2020).

Once primarily focused on machine sales and technical support, dealerships now recognize the need to provide digital and smart services. As one company document describes: "*The AFS Connect Center is changing the daily routine of the dealership. Each dealership is responsible for monitoring the daily activities of all machines in its region. It's a way to ensure faster and more accurate service, with connected services*" (Case IH, 2024).

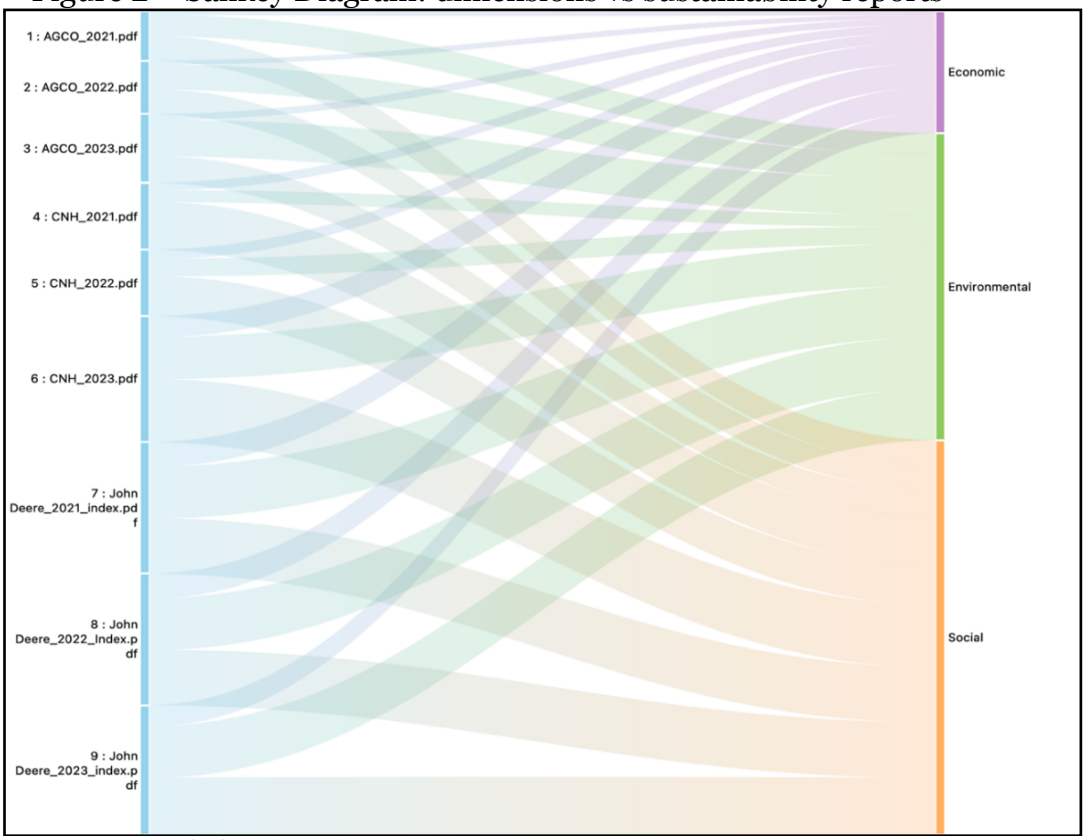
Another confirmed characteristic is the adaptation of the supply chain for product customization. Case IH, for example, has collaborated with leading companies and startups to create the AGXTEND solution ecosystem. This major initiative by CNH Industrial (Case IH – New Holland) aims to offer connected,

intelligent, and digital products and services. Together with six partners, they have introduced ten disruptive solutions to the market.

Digital servitization has been progressively implemented in the sector under study, as these strategies demand companies to embrace Digital Transformation (DT) and make strategic market adjustments (Reichert; Ruffoni, 2021; Kohtamäki et al., 2020). Empirical evidence, such as the use of AI, drones, and robotics, emphasizes the need for additional enabling technologies to deliver smart services. This supports sub-proposition sp.1.2: digital servitization strategy can only occur at the advanced level.

Based on Figure 1, it is evident that among the three pillars of sustainability, the environmental dimension is the most frequently reported, whereas the economic dimension appears least often in the analyzed reports. This may suggest a stronger emphasis by manufacturers on environmental and social sustainability, possibly driven by regulatory requirements or market expectations.

Figure 2 – Sankey Diagram: dimensions vs sustainability reports



Source: Research data (2024).

Figure 2 presents a comparative diagram of the ESG dimensions across the nine sustainability reports reviewed and reinforces the greater importance placed on the environmental and social aspects. The GRI data supports sub-proposition 1.3: digital servitization can enable strategies focused on the sustainability triad - environmental, social, and governance/economic dimensions.

The consistent reporting by John Deere suggests the company has achieved a mature stage in its sustainability practices, whereas AGCO and CNH appear to be in a phase of expansion and development. This reinforces the idea of a transitional movement, where companies that once concentrated solely on manufacturing and

selling products are now evolving their business models to incorporate service provision (Baines et al., 2020).

4.2 – MACRO-STAGES (BUSINESS MODEL)

In the analyzed segment, the Exploration stage is ongoing, as evidenced by the frequent launch of new products and updates to technological and smart services. These include not only new market offerings, but also regular software updates made available through digital platforms and company websites. The exploration of resources that contribute to environmental sustainability (ESG) is evident (Frame 2).

Frame 2 – Evidence on the importance of services for ESG aspects

"SUSTAINABILITY: Significant increase in agribusiness sustainability through reduced fuel consumption, lower use of fertilizers, and pesticides." (Case IH, 2024).	"Smart planting is one of the most important areas of precision agriculture. New Holland offers cutting-edge technology that enhances efficiency and productivity while reducing waste and environmental impact. By minimizing the use of pollutants in soil and water, we promote more sustainable agricultural practices." (New Holland, 2024).	"Variable rate application system: A system that distributes inputs based on the specific needs of each region within an agricultural production zone, respecting its spatial variability. Key benefits: Increased productivity uniformity, reduced input waste, and decreased environmental impact." (Massey Ferguson, 2024).
"Reduce environmental impacts" (Valtra, 2024).		

Source**:** Research data (2024).

In the **Engagement** macro-stage, the focus is on achieving internal acceptance within organizations for the launch of more advanced services. This stage involves recognizing new offerings, making necessary adjustments to the business model, and defining how results (Key Performance Indicators – KPIs) can be measured (Baines et al., 2020). There is also growing evidence of increased engagement from dealerships with these new services.

In the third macro-stage, **Expansion**, efforts are directed toward scaling the portfolio of advanced services and reaching broader market segments. This stage is mainly supported by marketing and sales teams, although significant revenue from these services has not yet been realized (Baines et al., 2020). The data suggest that the analyzed segment is currently in the fourth macro-stage, **Exploitation**, as it seeks to optimize the delivery of more advanced and efficient services in a structured and ongoing manner (Baines et al., 2020). Although the business model has not fully shifted from product sales to service-based offerings, the increasing range of digital technologies demonstrates progress (Frame 3).

Frame 3 – Evidence of the Execution macro-stage

"Capable of delivering up to a 3.5% savings in the use of fertilizers, pesticides, or seeds" (Valtra, 2024).	"Reduce up to 2.5 times the area lost due to compaction" (Valtra, 2024).
"Allows for an increase of up to 4% in the number of linear meters per hectare" (Valtra, 2024).	"An increase of up to 15% in productivity by improving the allocation and efficiency in the use of fertilizers" (Valtra, 2024).
"With the autopilot operating on Valtra machines, your production saves by preventing potential application failures or overlap of inputs" (Valtra, 2024).	"Reduce seed costs by implementing a project to stop planting in the sprayer's track" (Valtra, 2024).

Source: Research data (2024).

In addition to the progress of each macro-stage, the transition from digital to smart services has required the involvement of new partners and investment, which are detailed below.

4.3 – DIGITAL TECHNOLOGIES FOR AGRICULTURE

Among the seven technology groups for agriculture proposed by the OECD (2019), the use of **digital platforms** for service provision is a common practice across all five companies surveyed. These platforms facilitate the collection and exchange of information between dealerships and manufacturers, supporting more sustainable outcomes. Empirical evidence highlights the use of farm management platforms to gather data on vehicles and precision agriculture equipment, access customer support centers, and maintain direct communication with dealerships.

The application of **Big Data** technologies in servitization has also been confirmed, as they are used to enhance service offerings within broader value packages for customers. Once established for identifying patterns, generating insights, and improving processes through the organization of structured data (OECD, 2019), information sharing across different stages of the value chain has become common practice.

Three core characteristics of Industry 4.0 are identified as essential for creating a big data analytics framework: 1) Big data acquisition and integration; 2) Big data storage and processing; 3) Data mining and knowledge discovery in databases (Ustundag; Cevickan, 2018). Data confirm that these three components are being implemented in the main agricultural machinery companies present in Brazil.

The evidence is demonstrated in statements such as: "*SOILXPLORER is an integrated service solution combining hardware (sensor) and software (data processing) that provides high efficiency and precision in soil data collection, which will be converted into valuable information for the producer*" (Case IH, 2024).

The use of **robotics and drones** has also been confirmed in various stages of the production process, such as product applications and crop monitoring. The use of robotics is especially evident in autonomous pilot systems. In addition to improving central machine control, these systems enhance maneuver precision, helping to reduce input costs and minimize unnecessary machine movements. These technologies are being developed by AgTechs, startups that partner with major players in the agricultural machinery industry (Mikhailov et al., 2022), as in the case of Amazon (Silva et al., 2022).

This is further supported by document analysis, including the following excerpt: "*A revolutionary way to map, monitor, and manage crops using drone images, enabling a range of services that are constantly expanding, bringing artificial intelligence and technology to the field*" (Case IH, 2024). "*All of this so*

your property can access cutting-edge technologies from Agriculture 4.0, such as: remotely controlled autonomous machines, artificial intelligence, the Internet of Things, and drones for field mapping" (New Holland, 2024).

The results indicate that, in relation to **Artificial Intelligence**, both Focused AI (algorithms designed to solve specific problems) and Generalized AI (algorithms capable of making decisions through machine learning technologies) (Ludermir, 2021; Frank et al., 2019; Oecd, 2019) have contributed to automation processes and the development of complementary digital services. As one interviewee noted: "*Harvesters with embedded AI technology have stood out, machines that 'learn' while harvesting, and the new alternative propulsion technologies, such as biomethane, machine electrification, and the development of ethanol engines*" (E04). While Generative AI was not identified in the field research, some automated decision-making systems are already enhancing efficiency: "*The tractor's guidance system automatically turns on and off specific sections in already covered areas, resulting in economical applications*" (Massey Ferguson, 2024).

The **Internet of Things** has made it possible to control agricultural machines in real time, even across long distances. Case IH, in partnership with AgXtend, aims to support farmers in managing their properties more efficiently and increasing productivity by using IoT technologies and data communication systems, such as sensors and tracking devices (Case IH, 2024). This is further illustrated in the following example: "*Opere + is a free telemetry app that is easily usable by farmers of all sizes and machines of any model. It allows the capture of operation data even in areas without internet*" (New Holland, 2024).

The IoT also enables interaction between service providers and customers (Ventura; Meireles, 2022; Frank et al., 2019), supporting digital servitization strategies by allowing for remote software updates and integration between different technologies, regardless of equipment brand.

Cloud computing has provided the agricultural sector with key advantages, such as shared analytics and faster access to critical data for decision-making. As dealerships increasingly focus on supporting and monitoring new technologies in the field, the ability to access data during simultaneous operations has become essential. Although widely discussed in studies on digital agriculture (Chaves et al., 2022; Ventura; Meireles, 2022; Mukherjee et al., 2022; Casagrande; Torkomian, 2021; OECD, 2019), it was found that the current range of available solutions, including free options, has been sufficient to meet operational needs.

The use of **sensor and nanosensor** technologies is widespread and has enabled the delivery of new services with proven financial returns. These technologies support precision agriculture services (BOSONA AND GEBRESENBET, 2023; LIMA AND ROGGUIA, 2022) and are directly linked to greater efficiency and sustainability. Among the five brands analyzed, sensors emerged as the most frequently offered technology. For example: "*With automatic section control for ISOBUS implements, operators apply seeds, fertilizer, or pesticides without overlap*" (Massey Ferguson, 2024).

Sensors also align input application with ideal climate conditions: "*The Station is a sensor that determines different climate data and displays them on an ISOBUS terminal. It aids decision-making at the time of application by showing current climate data*" (Massey Ferguson, 2024). New Holland's precision agriculture solution, for instance, analyzes machine-generated data every 20 seconds and selects the best action from 280 million possibilities: "*Using sensors, it detects the distance*

between the ground and the boom, monitors the machine's slope, and intelligently adjusts the sprayer boom height" (New Holland, 2024).

All seven digital technologies mentioned contribute to services that support decision-making in the field. Operationally, machines make autonomous decisions regarding geographic movement, equipment function, planting volume and location, identification of necessary inputs, and optimal application quantities. Managerially, data control enables the evaluation of individual productivity, fleet monitoring (e.g., machine performance vs. fuel consumption), agronomic data management, and tracking of crop development history.

The value generated by these technologies, identified in earlier studies (Ventura; Meirelles, 2022; LALL, 1992), was also recognized by interviewees. It has enabled shared benefits among manufacturers, dealerships, and farmers, supporting the second research proposition: (P2) The use of a servitization strategy combined with the digital transformation process has generated innovations in the agricultural machinery segment.

Evidence such as services now representing approximately 20% of company revenue, the continued availability of basic services, and the expected launch of new smart services supports a positive relationship between technological investments and rising revenue in agriculture. These developments also reflect the transitions across the macro-stages of the business model. Thus, the following sub-proposition is confirmed: (sp.2.1) Digital servitization strategies enable revenue growth as each macro-stage of the Business Model is organized.

4.4 – CONTEXTUAL FACTORS

Regarding Customer Attraction, servitization strategies have been employed to strengthen relationships with customers, enhancing both loyalty and profitability (Silva, 2020; Souza, 2019). The shift in competition, from simple transactions to relational agreements, has been evident as one interviewee explained: "The company works with a CX–Customer Experience program, where we look at things from the customer's perspective" (E02).

Although these companies are positioned as innovation leaders, **Technological Impulses** remain limited within the Brazilian context. As noted by E01: "*Some things are developed here, but most come from outside Brazil, nothing is 100% Brazilian*". One of the main barriers to expanding digital servitization is the lack of access to reliable internet in rural areas. Nonetheless, technological advancement continues to be a key driving force in this sector, confirming the findings of Chaves et al. (2022), as it enables services to evolve based on consumer needs and preferences.

Technological development and the progression of digital servitization also influence **positioning within the value chain**. The agricultural industry has taken a leading role, coordinating new partnerships and directing the adoption of technologies that can be tailored to field-specific requirements. As one interviewee highlighted: "*With 49 R&D Centers spread across the world, the company is always interested in technology development. It's no coincidence that the company was elected one of the most innovative in Brazil and is one of the top patent filers in the country*" (E04).

The collected data also confirms a strong trend toward open innovation. For example: "*We believe in this open approach because we want to prepare our customers for the future of agriculture with the best digital products available in the*

market, whether they are developed by Fuse, in cooperation with partners, or by third parties" (Massey Ferguson, 2024).

Servitization has also driven transformations in how companies in the sector are structured, this relates to the concept of **Organizational Readiness**. The data show that not only manufacturers but also dealerships are shifting from traditional offerings to smart, tech-integrated solutions. One interviewee shared a telling example: "*We bought a drone for R$ 120,000 and thought we could sell line projects. It doesn't work. The contour lines in our region don't allow us to create a project. We've tried, and what we had to do was adapt a quad bike or the equipment itself and go out there to make all the markings with the equipment or the quad bike. The drone couldn't read the size and height of the contour, there isn't a standard for the curve; if there were one, we could just input it into a computer program and be done*" (E03). This highlights the need for companies to adapt both technologically and operationally to regional realities and constraints.

A related contextual factor identified in this research is **Organizational Commitment**. This is demonstrated by companies' continued efforts to offer high-quality, value-added products and services, predict potential failures, reduce costs through improved efficiency, and maintain long-term customer relationships. Commitment has been recognized as a key success factor in advancing servitization strategies. As noted by Baines et al. (2020) and reinforced in corporate communications: "*[...] the product improvement program that identifies certain potential failures before they occur, minimizing machine downtime and maximizing productivity*" (JOHN DEERE, 2024).

Despite producing efficient results, the implementation of digital servitization strategies is not straightforward. It requires a careful assessment of the complex organizational changes that companies undergo when adopting servitization (Martinez et al., 2017). The findings of this study corroborate the significance of five main contextual factors that facilitate the implementation of digital servitization strategies in the agricultural machinery sector.

The data substantiate that (i) customer attraction strategies, oriented towards attracting and retaining customers, are in effect. The second contextual factor indicates that the utilization of (ii) technological impulses enables digital and smart services to diversify and generate greater value. The novel opportunities engendered by digital transformation processes have precipitated changes in the configuration of transactions between the links in the production chain, resulting in a shift in (iii) positioning in the value chain.

The fourth factor, termed (iv) organizational readiness, is characterized by significant adaptations in the structure of work teams and dealership facilities. Finally, the contextual factor referring to (v) organizational commitment was evidenced in circumstances pointing to the offering of guarantees regarding the viability and efficiency of the new services, complemented by benefits that ensure greater preservation of renewable resources in the environment and health and safety for agricultural machinery operators.

Given the consistent presence of evidence related to these five factors for the implementation of servitization (Baines et al., 2020), the following proposition is supported: P3) The success of the implementation of servitization strategies is partially linked to contextual factors. The way companies have aligned their resources in response to both internal and external factors has shaped their digital and smart service offerings.

These efforts are reflected in R&D initiatives developed both locally and globally, as well as in partnerships with AgTechs. The adoption of open innovation between suppliers and manufacturers has driven progress in all technological areas identified by the OECD (2019) as priorities for agricultural innovation. This supports the sub-propositions: sp.3.1) Agricultural machinery industries have acquired new technologies for offering new digital services; and sp.3.2) Agricultural machinery industries have developed new technologies for offering new digital services.

After analyzing the study's propositions and sub-propositions from both theoretical and empirical perspectives, the initial argument is reaffirmed: digital servitization contributes to sustainability and can be assessed by examining the servitization stage a company is in. This is based on how it has structured its macro-stages of technological development and adapted its business model in response to contextual factors to avoid the risks of deservitization. This research confirms that digital servitization has emerged as a strategic business approach, aimed at adding value and creating competitive advantages in both products and services (Vandermerwe and Rada, 1988).

CONCLUSION

This study examined the technologies associated with digital servitization strategies in the Brazilian agricultural machinery sector, grounded in the theoretical framework of servitization. The main objective of the study was to understand the relationship between digital servitization strategies and new sustainable practices in agriculture, focusing on the Brazilian agricultural machinery segment. The analysis revealed a clear interaction between digital transformation and the progression through four macro-stages, evidencing the development of servitization across basic, digital, and smart service offerings.

The research also enabled a discussion of current technical standards and innovations in the agricultural machinery sector. Improvements in business models and the incorporation of emerging technologies have demonstrated the ongoing advancement of servitization, particularly through the adoption of smart services as value-generating strategies. The seven key agricultural technologies for innovation identified by the OECD were confirmed as being commonly adopted among the brands studied, within the broader framework of Agriculture 4.0.

Based on an analysis of sustainability reports, a notable increase in the environmental performance dimension was observed. The practices documented in these reports indicate that technological innovation is enhancing operational efficiency and promoting the conservation of natural resources, consolidating agribusiness as a sector during sustainable transformation.

The primary theoretical contribution of this study lies in its articulation of the relationship between digital servitization and emerging agricultural technologies, with a particular focus on sustainability advancements in the agricultural industry. From a managerial perspective, the study provides valuable insights for companies within the sector, offering guidance for the planning and implementation of digital servitization strategies aligned with sustainable practices through new service offerings. Propositions P1, P2, and P3, along with their respective sub-propositions, were confirmed through empirical evidence.

With this, it is expected that these results can spread servitization as a practice also for smaller companies. Furthermore, the scientific dissemination of the empirical results demonstrates that the use of technologies promotes a reduction in

the application of agricultural inputs resulting from precision agriculture that allowed significant waste, increases the appeal of the environmental, economic, and social pillars.

However, some limitations should be acknowledged. This study was conducted within a cross-sectional and static time frame, which reflects a specific set of resources, conditions, and economic contexts that may change over time. Furthermore, the research focused exclusively on the five brands with the highest market share in Brazil, which may not fully represent the experiences or realities of smaller agricultural machinery companies within the national industry. Triangulation with data from the GRI report complements the analysis of data on sustainable outcomes in the segment analyzed. However, the assessment of progress or indicators is one of the limitations of this study.

For future research, more specific questions are suggested, such as: Have the new technologies implemented through smart services contributed to sustainable practices among rural producers? And, have smaller agricultural machinery companies been able to access and implement digital servitization strategies focused on sustainability?

REFERENCES

ABNT. **ABNT PR 2030 — Ambiental, social e governança (ESG)** – conceitos, diretrizes e modelo de avaliação e direcionamento para organizações. Rio de Janeiro: Associação Brasileira de Normas Técnicas, 2022.

ACCENTURE. **Blueprint for service success**. 2020. Disponível em: https://www.accenture.com/content/dam/accenture/final/a-com-migration/r3-3/pdf/pdf-142/accenture-service-management.pdf

BAINES, T.; BIGDELI, A. Z.; BUSTINZA, O. F.; SHI, V. G.; BALDWIN, J.; RIDGWAY, K. Servitização: revisitando o estado da arte e as prioridades de pesquisa. **Journal Internacional de Gestão de Operações e Produção**, v. 37, n. 2, p. 256-278, 2017. https://doi.org/10.1108/IJOPM-06-2015-0312

BAINES, T.; BIGDELI, A. Z.; SOUSA, R.; SCHROEDER, A. Framing the servitization transformation process: a model to understand and facilitate the servitization journey. **International Journal of Production Economics**, v. 221, 2020. DOI: https://doi.org/10.1016/j.ijpe.2019.07.036

BARDIN, L. *Análise de conteúdo*. São Paulo: Ed. 70, 2010.

BOSONA, T.; GEBRESENBET, G. The role of blockchain technology in promoting traceability systems in agri-food production and supply chains. **Sensors,** v. 23, p. 42-53, 2023. DOI: https://doi.org/10.3390/s23115342

BROWN, D.; DILLARD, J.; MARSHALL, R. S. **Triple bottom line:** a business metaphor for a social construct. Universitat Autònoma de Barcelona, Departament d'Economia de l'Empresa, n. 06/2, 2006. DOI: https://doi.org/10.4324/9780203892978

CASAGRANDE, D. J.; TORKOMIAN, A. L. V. Servitização e sua influência no processo de difusão das tecnologias de agricultura de precisão na produção canavieira. **Cadernos de Ciência & Tecnologia,** v. 38, n. 2, p. 1-14, 2021. DOI: http://dx.doi.org/10.35977/0104-1096.cct2021.v38.26683

CASE IH. 2024. Disponível em: https://www.caseih.com/pt-br/brasil

CHAVES, J. K.; ALEMSAN, M. K.; FRONTELI, M. H.; PALADINI, E. P. Servitização digital: uma análise comparativa do serviço de carros por assinatura no Brasil. **Produto & Produção**, v. 23, n. 2, p. 43-60, 2022. https://doi.org/10.22456/1983-8026.123174

CHRIST, G. D.; BERNAL, A. O.; GALAFASSI, L. B.; CORONEL, D. A. O agronegócio brasileiro no comércio internacional: vulnerabilidade, retrocesso, oportunidade perdida ou situação ótima? **Informe GEPEC**, v. 26, n. 2, p. 190-209, 2022. DOI: 10.48075/igepec.v26i2.28426.

CONSELHO ADMINISTRATIVO DE DEFESA ECONÔMICA – CADE. Mercado de insumos agrícolas. **Cadernos do CADE***,* n. 1, p. 1-100, 2020. DOI: https://doi.org/10.52896/dee.cc1.020

DAUM, T. Mechanization and sustainable agri-food system transformation in the Global South: a review. **Agronomy for Sustainable Development**, v. 43, n. 15, p. 1-26, 2023. DOI: https://doi.org/10.1007/s13593-023-00868-x

FRANK, A. G.; MENDES, G. H. S.; AYALA, N. F.; GHEZZI, A. Servitization and Industry 4.0 convergence in the digital transformation of product firms: a business model innovation perspective. **Technological Forecasting & Social Change**, v. 141, p. 341-351, 2019. DOI: https://doi.org/10.1016/j.techfore.2019.01.014

GENZLINGER, F.; ZEJNILOVIC, L.; BUSTINZA, O. F. Servitization in the automotive industry: how car manufacturers become mobility service providers. **Strategic Change**, v. 29, n. 2, p. 215-226, 2020. https://doi.org/10.1002/jsc.2322

GIL, A. C. *Como elaborar projetos de pesquisa*. 4. ed. São Paulo: Atlas, 2007.

GRI. **Global reporting initiative - GRI standards**. 2024. Disponível em: https://www.globalreporting.org/how-to-use-the-gri-standards/gri-standards-english-language/

HENSHEL, D.; GIMENES, R. M. T.; GARCIA, D. C.; SOUZA, A. R. de. Operação barter como alternativa para financiamento, gestão de custos e riscos da produção agrícola. **Informe GEPEC**, v. 29, n. 1, p. 10-31, 2025. DOI: 10.48075/igepec.v29i1.32884.

JOHN DEERE. 2024. Disponível em: https://www.deere.com.br/pt/index.html
LALL, S. Technological capabilities and industrialization. **World Development,** v. 20, n. 2, p. 165-186, 1992. DOI: https://doi.org/10.1016/0305-750X(92)90097-F

LUDERMIR, T. B. Inteligência artificial e aprendizado de máquina: estado atual e tendências. **Estudos Avançados**, v. 35, n. 101, 2021. DOI: 10.1590/s0103-4014.2021.35101.007.

MARTINEZ, V.; NEELY, A.; VELU, C.; LEINSTER-EVANS, S.; BISESSAR, D. Exploring the journey to services. **International Journal of Production Economics**, v. 192, p. 66-80, 2017. DOI: 10.1016/j.ijpe.2016.12.030.

MASSEY-FERGUSON. 2024. Disponível em: https://www.masseyferguson.com/pt_br.html

MIKHAILOV, A.; CAMBOIM, G. F.; REICHERT, F. M. The application and benefits of digital technologies for agri-food value chain: evidence from an emerging country. **Revista de Administração do Mackenzie – RAM**, v. 23, n. 5, p. 1-29, 2022. DOI: https://doi.org/10.1590/1678-6971/eRAMR220114.en

MINAYA, P. E.; AVELLA, L.; TRESPALACIOS, J. A. The effects of digital servitization on business competitiveness: a case study of Spanish manufacturers. **Journal of International Entrepreneurship**, v. 21, p. 180-213, 2023. DOI: https://doi.org/10.1007/s10843-023-00333-6

MUKHERJEE, A. A.; SINGH, R. K.; MISHRA, R.; BAG, S. Application of blockchain technology for sustainability development in agricultural supply chain: justification framework. **Operations Management Research**, v. 15, n. 1, p. 46-61, 2022. DOI: https://doi.org/10.1007/S12063-021-00180-5

NEW HOLLAND. 2024. Disponível em: https://www.newholland.com.br/

OCDE. **Medir a transformação digital**: um roteiro para o futuro. Paris: OECD Publishing, 2019.

OLIVEIRA, R. D. de; SOUZA, C. C. de; MERCANTE, M. A. Análise e diagnóstico da sustentabilidade do assentamento rural Eldorado II, no município de Sidrolândia (MS). **Informe GEPEC**, v. 21, n. 1, p. 149-168, 2017. DOI: https://doi.org/10.48075/igepec.v21i1.14039

PINGALI, P. Agricultural mechanization: adoption patterns and impact. **Handbook of Agricultural Economics,** v. 3, p. 2780-2805, 2007. DOI: 10.1016/S1574-0072(06)03054-4.

RAMOS, J. A. A. **Tecnologia ISOBUS em tratores e máquinas agrícolas**. Trabalho de Conclusão de Curso (Graduação) – Escola Superior Agrária de Elvas, Porto Alegre, 2021.

REICHERT, F. M.; RUFFONI, E. P. Modelo de capacidade de servitização da firma. In: **Anais...** *XXXI Simpósio de Gestão da Inovação Tecnológica*, Anais [...]. 2021.

SÁ PORTO, P. C. de; CANUTO, O.; MOTA, A. A. L. As possibilidades de inserção do Brasil nas cadeias globais de valor. **Informe GEPEC**, v. 21, n. 1, p. 10-27, 2017. DOI: https://doi.org/10.48075/igepec.v21i1.17075

SARKER, N. M. D.; MURMU, H.; ROZARIO, E. Role of big data on digital farming. **International Journal of Scientific & Technology Research**, v. 9, n. 4, p. 1222-1225, 2020. DOI: https://doi.org/10.5585/exactaep.2021.17765

SERAMIM, R. J.; WALTER, S. A. O que Bardin diz que os autores não mostram? Estudo das produções científicas brasileiras do período de 1997 a 2015. **Administração: Ensino e Pesquisa,** v. 18 (2) p. 241–269, mai-ago 2017. DOI: https://doi.org/10.13058/raep.2017.v18n2.478

SILVA, D. F. N. da et al. **Potencial impacto da servitização na indústria de manufatura brasileira:** uma revisão sistemática. Trabalho de Conclusão de Curso. Campina Grande: Universidade Federal de Campina Grande, 2020. Disponível em: http://dspace.sti.ufcg.edu.br:8080/jspui/handle/riufcg/17044

SILVA, M. L. A.; LUCAS, M. M. B.; PINTO, L. M. R. Startups da floresta, negócios de impacto e a sustentabilidade na Amazônia. **Informe GEPEC**, v. 26, n. 2, p. 30-49, 2022. DOI: https://doi.org/10.48075/igepec.v26i2.28223

TEECE, D. J. Profiting from innovation in the digital economy: enabling technologies, standards, and licensing models in the wireless world. **Research Policy**, v. 47, n. 8, p. 1367-1387, 2018. DOI: https://doi.org/10.1016/j.respol.2017.01.015

VALTRA. 2024. Disponível em: https://www.valtra.com.br/

VANDERMERWE, S.; RADA, J. Servitization of business: adding value by adding service. **European Management Journal**, v. 6, n. 4, p. 314-324, 1988. DOI: https://doi.org/10.1016/0263-2373(88)90033-3

VENTURA, M. A. A.; MEIRELLES, D. S. Arquitetura do valor na Indústria 4.0: uma abordagem dos smart-service providers. **Anais**...In: XXIII Simpósio de Administração da Produção, Logística e Operações Internacionais. 2022.

ZHANG, D. The innovation research of contract farming financing mode under the block chain technology. **Journal of Cleaner Production**, v. 270, 2020. DOI: https://doi.org/10.1016/j.jclepro.2020.122194

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