DIGITAL TRANSFORMATION IN THE AGRICULTURAL SUPPLY CHAIN

Companies and farms need to constantly reassess themselves to not miss opportunities that help them do their business.

Elder JM Bruno

2022

Nuffield Brazil project number 017

Supported by

Scholar contact details:

Name: Elder José de Mello Bruno

Organization: MaxxAgro Agronegócios Ltda.

Adress: Rua C-248, 219. Goiania, GO, Brazil

Phone: +55 (62) 99905-2105

Email: elder.bruno@maxxagro.com.br

Website: www.maxxagro.com.br

Social media: https://www.linkedin.com/in/elderbruno/

In submitting this report, the Scholar has agreed to Nuffield publish this material in its edited form.

NUFFIELD BRASIL Contact Details
Telephone: +55 (61) 99640 8888
Email: info@nuffield.com.br

Executive Summary

Digital transformation is crucial for businesses in today's fast-paced agribusiness world. It plays a key role in improving profits by making operations more efficient and enhancing customer relationships. This summary highlights the opportunity to use digital technology to improve core business processes, enhance customer experiences, and streamline the supply chain.

The major challenge of digitalization in the agricultural chain is connectivity in the field, resistance from leaders and products, as well as legislation issues in many countries.

The main goal of embracing digital technologies is for businesses to be more agile, engage better with customers, and spark innovation within teams.

Key opportunities for digitalization within the business are:

1. **Technology Integration**: invest in tools like cloud computing and the Internet of Things (IoT) and Artificial Intelligence to upgrade technology systems.
2. **Process Automation**: look for repetitive tasks that can be automated using software, which will save time and reduce costs.
3. **Enhancing Customer Experience**: using data analytics and AI, to better understand customers' needs. It is important to keep interactions consistent.
4. **Empowering Employees**: provide training and resources to help employees develop digital skills. Encourage a culture of innovation will allow informed engagement of staff to identify relevant digital opportunities.

By maintaining a proactive attitude and adopting relevant new technologies, companies can meet consumer demands and stand out in our industry. Real digital transformation involves a solid data strategy and strong governance around technology and innovation. Adoption should greatly improve operations, customer service, and the experience of employees.

The main conclusions of this study refer to:

- The importance of the customer as the basis for all decisions and direction of actions in all links of the chain,
- Convenience over time' as the great driving force behind the delivery of perceived value,
- Accurate communication guarantees business development,
- Training actions and data integration is a key factor to reduce costs.

In summary, by committing to digital transformation, businesses can improve performance and results and maintain a competitive edge in the agribusiness sector.

Keywords: Digital Transformation, Costumer Experience, Process Automation, Data Driven Decision, Employee Empowerment, Supply Chain, Agribusiness.

Foreword

My name is Elder Bruno, the only son of a Brazilian couple raised in the rural area of a small town in the state of São Paulo. Whenever possible, I have lived through experiences on family farms, listening to the challenges, the bad weather and, of course, the celebrations of achievements that were of great value to family members. With this foundation, I became an agricultural engineer at a large public university in Brazil and had the opportunity to have fantastic technical learning experiences.

However, the biggest breakthrough was the opportunity to go abroad to get an extremely wide and diverse view of the world. Seeing how social and environmental differences are reflected in business and culture – and the technology that is developed and adopted was beyond my expectation. I had experienced life in Brazil, the USA, New Zealand and Italy before Nuffield, and now I have exposure to United Kingdom, Singapore, Australia, Netherlands and Norway, as well as a deeper experience in USA and Brazil.

Figure 1: Travel Itinerary Map.

Travel date	Location/Tipe of Visit
Week 1 **Pré-CSC**	**United Kingdom**
Week 2 **CSC**	**United Kingdom** Norwich, London
Week 3	**United Kingdom** London (UPL and EIWA)
Week 4 - 8 **GFP**	**Singapore**, **Australia** (Darwin/Kununurra), **USA** (Delaware), **Netherlands** and **Norway**.
Week 9	**Brazil** Ambev World Agri-Tech Summit (SP)
Week 10	**USA** Maryland, 6-Grain USA
Week 11	**USA** IOWA
Week 12	**USA** Texas
Week 13	**Brazil** Agtech Meeting PWC - Piracicaba
Week 14 **Report**	**Brazil**

Acknowledgments

I would like to express my heartfelt gratitude to my sponsors for their invaluable support and belief in my journey through the Nuffield Program.

Firstly, I extend my deepest appreciation to Renato Guimarães and Carlos Pellicer for your unwavering encouragement and mentorship. Your insights and guidance have been instrumental in shaping my goals and aspirations.

I would also like to thank UPL for providing the resources and opportunities that have enabled me to participate in this prestigious program. Your commitment to fostering innovation and knowledge-sharing in the agricultural sector is inspiring.

Figure 2. Elder Bruno, Carlos Pellicer and Jodie Redcliffe at UPL Head Quarter in London.

I am grateful to Sinova for their generous support and belief in the potential of the Nuffield Program. Your dedication to developing people like me, enhancing agricultural practices and promoting sustainable solutions is deeply commendable. This journey would not have been possible without your support.

Finally, I would like to extend my sincere gratitude to the Nuffield network and all the visitors and colleagues I had the pleasure of meeting during the Nuffield Program across various countries. Your diverse perspectives, shared experiences, and collaborative spirit have challenged and enriched my understanding and inspired me throughout this journey. The knowledge exchanged and the relationships formed during our time together have been invaluable, and I truly appreciate the insights I have gained. Thank you all for being an integral part of this transformative experience. I look forward to staying connected and continuing our collective pursuit of excellence and innovation in our respective fields.

Figure 3. Elder Bruno and Jhones Sarturi at Texas Tech in Lubbock -

Figure 4. Elder Bruno and his GFP group.

Abbreviations

AI - Artificial Intelligence

AR - Augmented Reality

COA – Operations Center of Agriculture

FAQs - Frequently Asked Questions

GIS – Geographic Information System

GPS – Global Positioning System

IOT – Internet of Things

LMS - Learning Management Systems

NPP – Natural Plant Protection

RFID - Radio Frequency Identification

UPL - United Phosphorus Limited

USA – United States of America

VR - Virtual Reality

Objectives

Fully digitizing the agricultural supply chain is a complex challenge, both in Brazil and around the world. This study aims to highlight some important focus areas that can help guide the creation of a practical plan for further development. These areas were identified as the most relevant throughout the different stages of this research.

The goal of this study on digital transformation in agribusiness is to offer useful ideas that encourage progress and support sustainable growth. By looking at successful examples from different countries, we can learn best practices and valuable lessons that may be adapted to fit different needs and situations. The study is organized around the following key objectives:

Objective 1: Improve Operational Efficiency

Look at how digital technologies—such as sensors, precision farming tools, and automation—can help increase productivity, reduce waste, and make better use of resources in farming and agribusiness.

Objective 2: Increase Transparency in the Supply Chain

Explore how tools like blockchain and data analysis can improve the traceability and transparency of agricultural products, helping ensure better quality and reduce the chances of fraud.

Objective 3: Support Sustainable Agriculture

Understand how digital technologies can help farmers adopt more sustainable practices, such as conserving water, protecting soil health, and reducing emissions, all while dealing with the impacts of climate change.

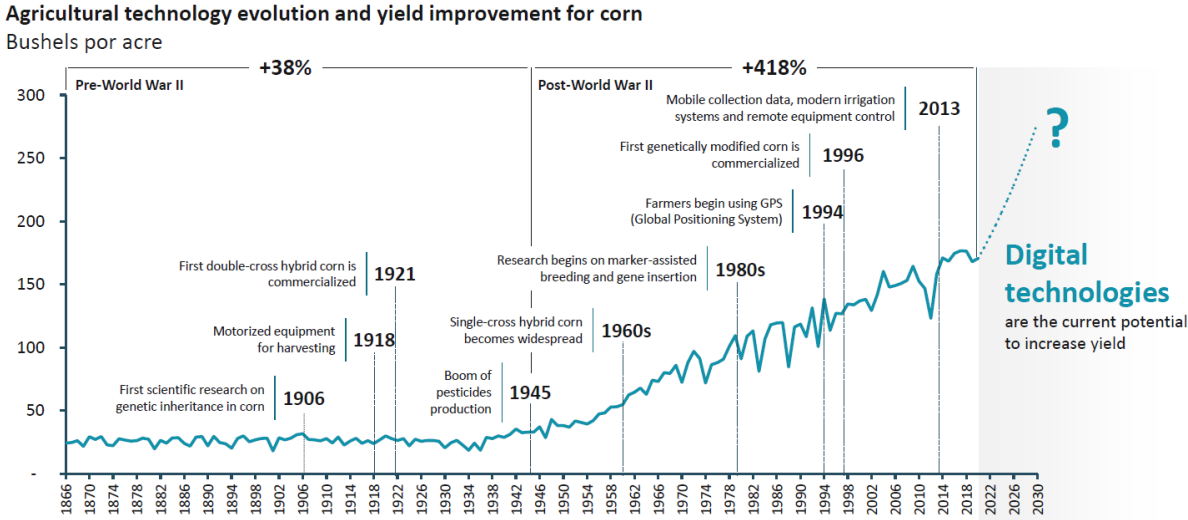
Objective 4: Encourage Innovation and Knowledge Sharing

See how digital platforms can support innovation and make it easier for people working in agribusiness to share knowledge and best practices, helping others learn and grow across different regions.

Objective 5: Improve Customer Engagement and Market Access

Examine how online marketing, e-commerce, and direct-to-consumer sales can help farmers connect more closely with customers, reach new markets, and improve how products are distributed.

Figure 5. Agricultural technology and the yield of crops.



The agricultural stand of point the objective is to show if the technology is accessible, scalable and delivers real benefits to farmers, digital transformation could indeed be the next great agricultural revolution. The future of agriculture will depend on the intelligent integration of these technologies with sustainable farming practices.

Introduction

Innovation as a base for Digital Transformation

Main Concepts

Innovation and digital transformation are closely intertwined concepts that play a crucial role in the advancement of businesses and society.

Innovation refers to the process of developing new ideas, products, services, or processes that improve efficiency, effectiveness, and competitiveness. It can take various forms, including incremental innovations (small improvements) and radical innovations (major breakthroughs). (P. Waengertner, 2020)

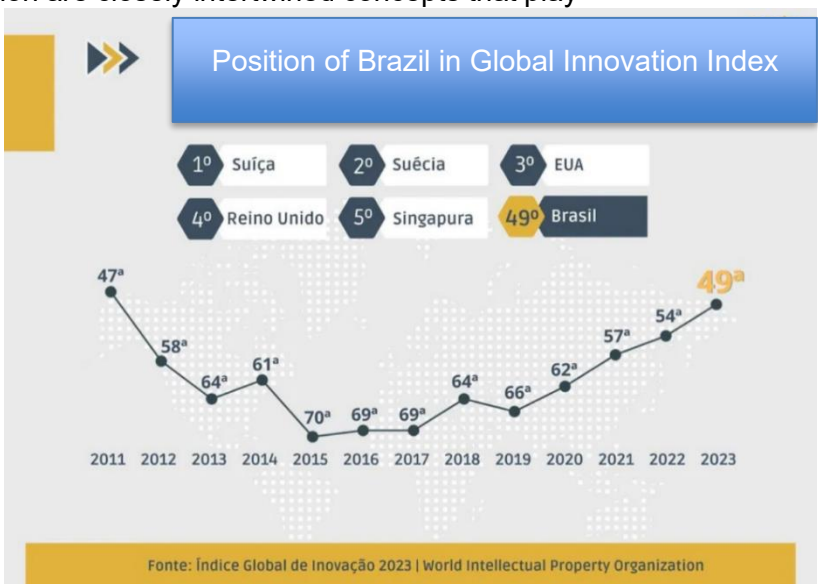


Figure 6: Position of Brazil on innovation index.

Digital Transformation, on the other hand, is the integration of digital technology into all areas of a business or organization, fundamentally changing how they operate and deliver value to customers. It often involves:

- Using digital tools and platforms to streamline operations.
- Enhancing customer experience through digital channels.
- Leveraging data analytics for better decision-making.
- Adopting new business models that capitalize on digital advancements.

But what is “digital”? Digital transformations can be characterized by activating at least one of four key value levers: business models (new ways of operating and new economic models); connectivity (real-time engagement); processes (focusing on customer experience, automation and agility) and analytics (better decision-making and data culture). However, to capture the value created by these levers, it is necessary to associate them with a set of best management practices that cover four fundamental dimensions: Strategy, Capabilities, Organization and Culture.

The biggest challenge identified for driving digital transformation in agribusiness is the need to establish digitalization as a structured process (67%), even more so than in other sectors. In addition, 30% of agribusiness companies point out the need to know the technological trends in the market, close to the general average of 31%, which indicates a difficulty in keeping up with technological innovations and integrating them effectively. Compared to different industries and sectors, B2B-first companies have faced significant challenges in bringing value to the customer journey. (cf. Becker & Jaakkola, 2020).

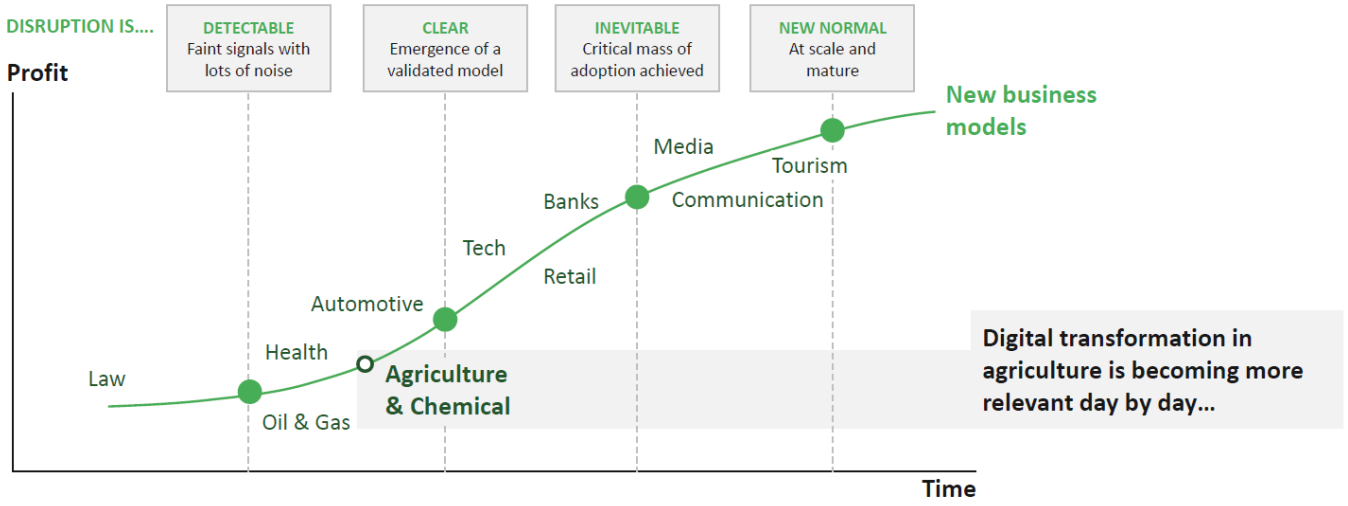
Since its inception, agriculture has undergone several phases of modernization. In Agriculture 1.0, the workforce came from families, using manual instruments and relying on animal traction. Agriculture 2.0 witnessed the green revolution, introducing innovations aimed at increasing productivity through genetic modification of seeds, new soil fertilization techniques, and the incorporation of agricultural products and machinery. In Agriculture 3.0, there was an intensification of agricultural mechanization with the advent of precision agriculture from the 1990s, resulting in significant productivity gains and optimization of the use of agricultural inputs. (Dias, Cleidson Nogueira, 2023).

Digital transformation in Brazil can revolutionize Brazilian agribusiness, but it requires investments in infrastructure, connectivity, training and security. Overcoming these challenges is essential to maintain Brazil's competitiveness as a global agricultural powerhouse. Going deep on the slowing the evolution of digital transformation in the agricultural supply chain can occur due to several factors:

1. **High Implementation Costs**: The initial investment in digital technologies can be substantial, including costs related to hardware, software, and infrastructure development. Smaller farms may struggle to afford these expenses.
2. **Infrastructure Limitations**: In many rural areas, inadequate internet connectivity and lack of access to reliable electricity can hinder the adoption of digital tools, making it difficult for farmers to utilize technology effectively.
3. **Resistance to Change**: Farmers accustomed to traditional farming methods may be hesitant to adopt new technologies. Psychological comfort with existing practices can slow down the transition to digital solutions.
4. **Complexity of Technology**: The perceived complexity of new technologies can discourage farmers from adopting them. If digital tools are not user-friendly or require extensive training, farmers may be reluctant to engage.
5. **Data Privacy Concerns**: Concerns over data ownership, security, and privacy can deter farmers from using digital platforms that collect and analyze sensitive information about their operations.
6. **Regulatory Barriers**: Regulations and compliance requirements can slow the adoption of new technologies. If laws do not adapt quickly to accommodate digital innovations, this can create obstacles.
7. **Limited Technical Support**: A lack of access to technical support and training resources can prevent farmers from effectively integrating and utilizing digital technologies in their operations.

8. **Market Readiness**: The availability of compatible digital tools and solutions that meet specific agricultural needs may be limited, slowing the overall transformation process.

Figure 7. Position of Agriculture in the disruption curve. (Markestrat Group 2020)

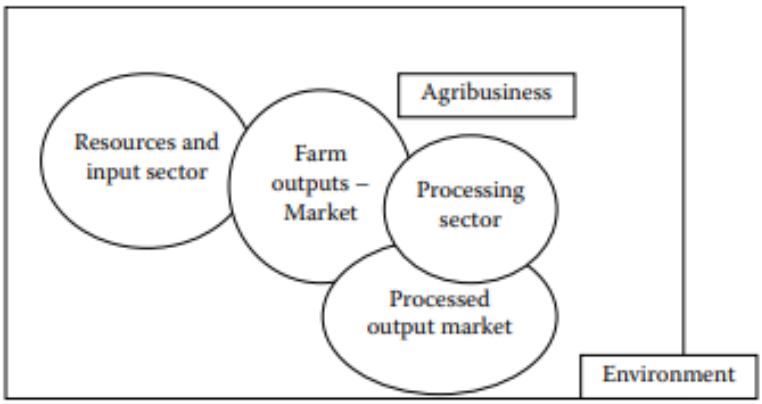


To mitigate these challenges, stakeholders can work together to provide support, resources, and education that facilitate the integration of digital technologies into the agricultural supply chain.

Still with the aim of clarifying the vision of supply chain in agriculture, it is important to understand that the processes occur mainly **inside and outside the farm gate**. They all have their importance and main objectives; however, it is worth highlighting that the great **value of crops** can only be extracted with great efforts in all senses.

Looking for supply chain characterization, the supply chain focuses on managing a network of organizations and their activities to fulfil the demands of the ultimate customers of a focal firm in a dynamic environment. The full picture of the Agri Supply Chain will be described below:

Figure 8. Summary of Agribusiness Supply Chain.



In a Global perspective which has a large geographical spread, with varying climatic conditions, developing infrastructure, and a large and variable population to be served, resource management is a challenge. Hence, resources, role agents, and activities in the agribusiness supply chain must be synchronized to establish successful supply chains.

Companies that want to be successful in their digital transformation and aim to achieve higher levels of digital maturity in the Brazilian context need to be aware of specific actions that are directly related to the digital dimensions investigated in the study: execute digital initiatives inside or outside the company, develop new capabilities in the company, ensure accountability for transformation and culture with promoting new ways of work and communicate the purpose frequently. (Mackinsey 2019).

For example, when a European buys a grape from Brazil in a supermarket in rural France and uses a QR code to trace its journey, it shows how much digital technology is involved—from farming through logistics to sales and consumption. This highlights the need for efficiency in our operations.

Some topics such as logistics, which permeate all areas of the supply chain, have always been worked on and have a very large competitive advantage in some countries, and concepts such as uberization have appeared in a more connected way with digital transformations.

For the next sections we will define and show some cases for all the big objectives that we have driven through.

Enhance Operational Efficiency

The Impact of Technology

Efficiency and Cost Reduction

Digital transformation can significantly enhance operational efficiency in several ways like automation of processes by automating routine tasks, organizations can reduce manual errors, speed up processes, and free up employees to focus on higher-value work. Workflow automation tools streamline operations and improve consistency. Data Analytics implementing digital tools allows for the collection and analysis of data in real-time. This helps organizations make informed decisions, identify inefficiencies, and proactively solve problems. Collaboration tools like digital platforms facilitate better communication and collaboration among teams, regardless of location. This improves project management and allows for quicker responses to issues. Supply Chain Optimization with digital solutions can enhance supply chain visibility, enabling better inventory management, demand forecasting, and supplier collaboration, thus streamlining the entire supply chain. Enhanced flexibility with Digital systems allows organizations to adapt quickly to market changes and customer demands, making them more agile and responsive. Cost reduction by improving efficiency and processes, companies can significantly reduce operational costs associated with labor errors, and inefficiency.

The digital transformation can significantly reduce agricultural production costs by increasing efficiency and minimizing waste. The impact varies depending on the technology adopted, farm size, and crop type, but some estimates suggest **operational cost reductions of 20% to 50%**. A study by Embrapa indicated that **precision agriculture could reduce input costs by up to 25%** and increase productivity by **up to 67%**.

To successfully implement digital transformation, organizations should assess their current processes, identify areas for improvement, and choose the right technologies that align with their operational goals.

Some technologies that can be used through digital transformation in agribusiness involve leveraging technology to optimize farming practices, supply chain management, and data analysis. Here are some effective strategies to consider:

1. **Precision Agriculture**: Utilize technology such as GPS, drones, remote sense and IoT sensors to monitor crop health, soil conditions, and weather patterns. This allows for targeted interventions, optimizing resource use (like water, fertilizers, and pesticides) and improving yields.

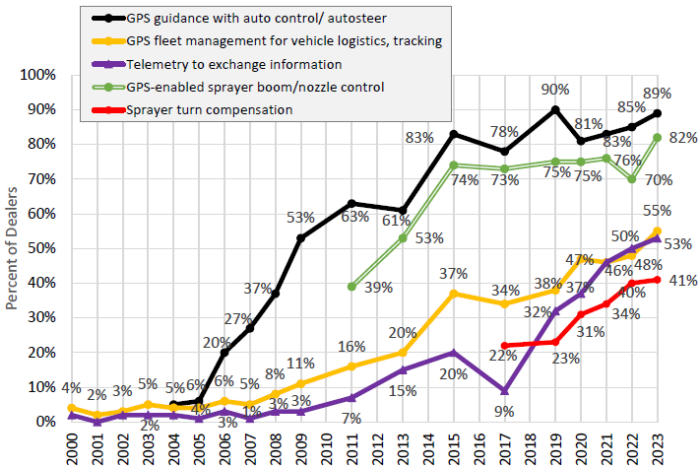


Figure 9. A survey of mainly dealers in the USA about the use of some Precision Agriculture.

Precision Agriculture Dealership Survey.

Numbers got from the field study are showing that the reduction in input usage can be around 30%, savings on fuel and labor around 40%, reduction in production losses up to 20% and 30% higher profits coming from productivity increases.

2. **Data Analytics**: Implement data analytics platforms to analyze historical and real-time data for better decision-making. By analyzing trends and patterns, agribusinesses can improve planning and forecasting.
3. **Farm Management Software**: Use comprehensive farm management software to streamline operations, from planting to harvest. These platforms can manage schedules, crop rotation plans, and equipment maintenance, enhancing overall productivity.
4. **E-commerce Platforms**: Establish online platforms for direct sales to consumers, reducing dependency on intermediaries. Digital marketplaces can broaden customer reach and improve profit margins.
5. **Mobile Applications**: Develop mobile applications for farmers that provide access to market prices, weather forecasts, pest management resources, and farming best practices. This enables informed decision-making in real time.
6. **Remote Monitoring and Automation**: Implement IoT devices for remote monitoring of fields and automation technologies in planting, watering, and harvesting. Automated systems can reduce labor costs and enhance efficiency.

Also, remote sensing can help to evaluate fields without being in all farms and create a sense of prioritizing management.

7. **Training and Education**: Provide digital training resources for farmers to improve their digital literacy. Workshops and online courses can help them utilize technology effectively in their operations.
8. **Collaboration Tools**: Use digital collaboration tools to enhance communication among stakeholders, including farmers, suppliers, and distributors. Streamlining communication can lead to quicker decision-making and responsiveness.
9. **Sustainability Initiatives**: Leverage digital tools to track sustainability metrics, such as water use and carbon footprint. Being more efficient in resource usage can not only improve profitability but also enhance brand reputation among environmentally conscious consumers. (Loy R., 2024)

By focusing on these digital transformation strategies, agribusinesses can enhance their operational efficiency, leading to increased productivity, improved resource management, and greater responsiveness to market demands.

Examples of Operational efficiency that we could see on the visits.

1- Visit to the port in the UK where inputs are received from various locations around the world and feed is produced to be distributed to some farms in the country. This service brings more efficency and cost savings.

2- Visit to the ethanol plant, a great example of grain processing that would otherwise be sent out of state, resulting in greater financial returns for producers, with a high processing rate, adequate price conditions where the transformation of traditional processes yielded high results. Use of technology to monitor each valve within the industry, resulting in a reduction in the number of people. The process of the corn in the region brings back 5% in reduction of freight.

3- Robots in a beverage factory make it possible for general monitoring to be carried out by just 2 people. Of course, this type of operation requires more qualifications, in this case, engineers.

4- Automated production of mini vegetables in a greenhouse with little human intervention. End-to-end technology in products with extremely high added value in production. Sales and consumption in different regions and reaching restaurants spread across several continents. Good example of better use of inputs and a big value of products.

Strengthening Supply Chain Transparency

Real-Time Data

Consumer Transparency

Digital transformation is important for supply chain management to enhance traceability, reduce waste, and predict demand more accurately. This can include several technologies to track product origins and quality.

We know that in the traditional supply chain, if a step fails, deadlines and customers can be affected and lost. In the case of the Digital Supply Chain, the focus changes and the customer becomes the center, with the goal of serving them at three levels of excellence: meeting demand, speed and personalization.

The revealed secret of the digitalization of the supply chain lies in the integration of internal and external data, using technologies such as the Internet of Things, sensors, Machine Learning predictive models, among others.

It is worth noting that moving from the Supply Chain to the digital is a transition. And, like any transition, it requires time, effort, commitment and involvement from all participants to make it happen and establish itself in a genuine and organic way.

An entire structure must be rethought so that a new culture can be implemented. In view of this, management and operations must embrace the cause and be open to digital transformation, because resisting innovation is not smart these days.

Digital transformation can significantly enhance supply chain transparency by leveraging technology to improve data collection, sharing, and analysis. Here are several ways in which digital transformation can strengthen supply chain transparency:

1. **Real-Time Data Tracking**: Utilizing IoT devices (sensors, RFID tags) allows for real-time tracking of products throughout the supply chain. This visibility helps stakeholders monitor conditions such as temperature and humidity, ensuring product quality and safety. And enhanced Data Analytics with Advanced analytics and data visualization tools that can process large volumes of data from various sources, enabling stakeholders to gain insights into supply chain performance, trends, and risks. This informed decision-making fosters transparency.
2. **Blockchain Technology**: Integrating blockchain creates a secure, decentralized record of transactions. Each participant in the supply chain can access and verify records, ensuring authenticity and traceability of products from origin to end consumer. This technology is still complex in the minds of the producer and has many links in the chain.
3. **Digital Platforms for Collaboration**: Cloud-based platforms enable stakeholders (farmers, suppliers, processors, retailers) to share data and collaborate efficiently. This fosters communication and can lead to more coordinated supply chain efforts. A good example on this topic is the Agroplataform of 6-Grain were:

    - The financial team can see fields with problems for yield impacting on the payment.
    - Commercial teams can see how to help the farmers to improve their yield.
    - Farmers can fix problems, optimize the use of inputs and produce more.

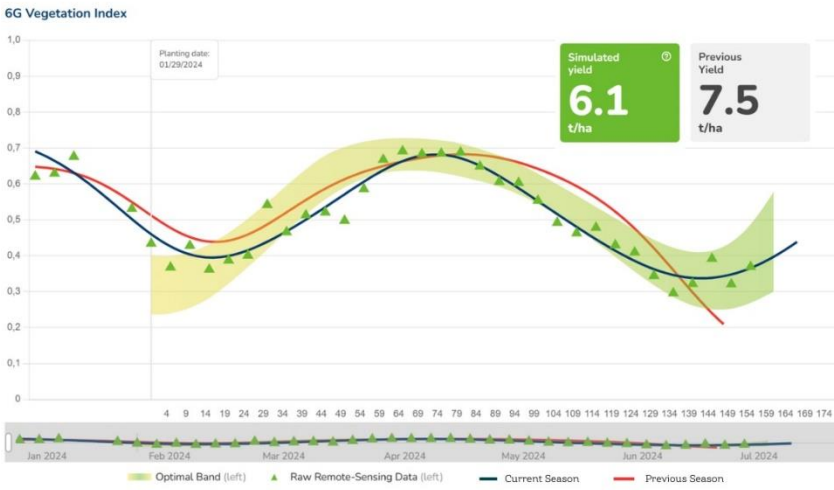
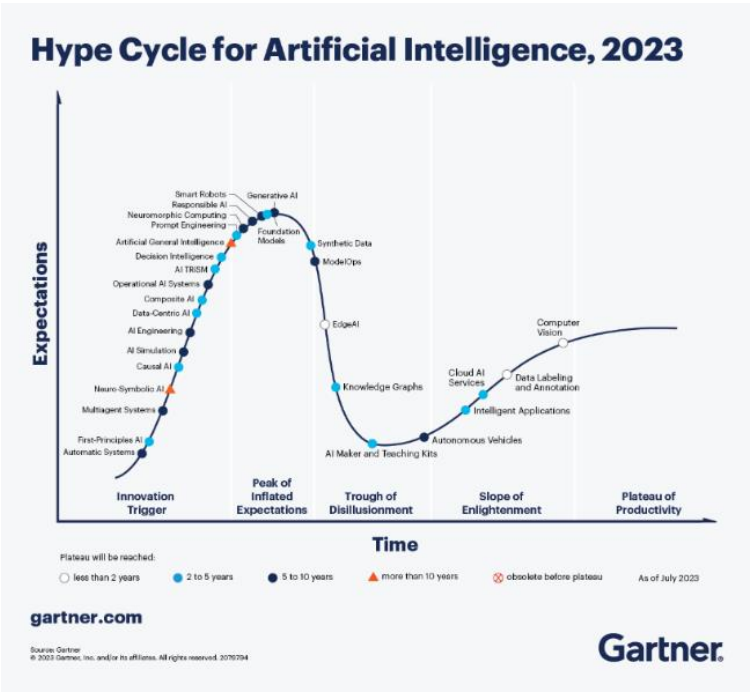
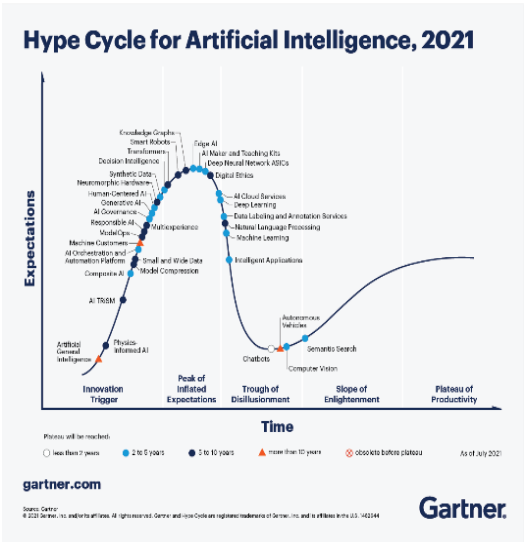


Figure 10. Curve of production of 6Grain Agroplataform and Predicted Yield.

4. **Automated Reporting Systems**: Automation tools can generate reports on supply chain activities, providing real-time updates and audits. These reports enhance accountability and make it easier to track and prove compliance with regulations.

5. **Supply Chain Mapping**: Digital tools can create detailed maps of the supply chain, identifying key partners and processes. This visualization helps in recognizing vulnerabilities and areas for improvement.
6. **Predictive Analytics and AI**: Leveraging AI can help anticipate disruptions, optimize inventory, and forecast demand. This proactive approach enhances resilience and allows for quicker responses to issues that may affect supply chain transparency. Gartner has been comparing the advancement of artificial intelligence technologies, and the speed of these advances has been very high, opening new fronts of study as described below in the figures.





And perhaps the most important point of attention for this topic is the reduction in the expectation of implementation of the technologies, which has been reduced very significantly. In other words, it is a Formula 1 race where everyone will arrive, some earlier and others later.

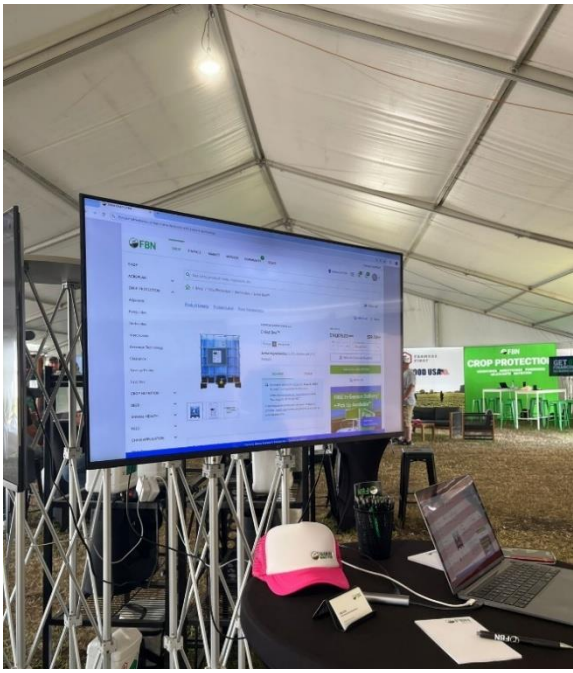
Figure 11 and 12. The Gartner Chart of expectations and time to AI have been developed. (Gartner, 2023)

7. **Digital Contracts and E-signatures**: Utilizing e-contracts and digital signatures streamline agreements between parties, making transactions more efficient and traceable. This minimizes disputes and keeps an accurate record of commitments.
8. **Training and Development Platforms**: Digital training resources can upskill the workforce stakeholders on the importance of transparency and the technologies available to enhance it. Educated participants are more likely to adhere to transparency practices.

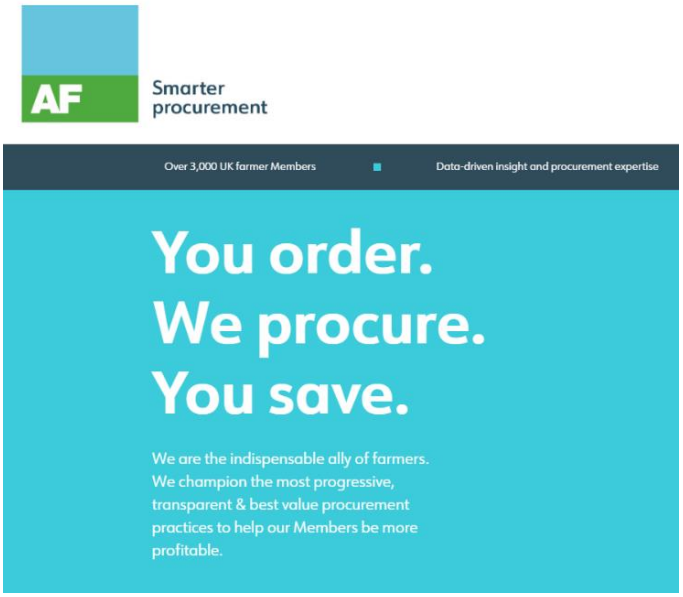
By embracing digital transformation, agriculture and other industries can facilitate better visibility across the entire supply chain, leading to improved accountability, efficiency, and trust among stakeholders.

Examples of Operational efficiency that we could see on the visits:

1- FBN (Farmers Business Network) was founded in 2014 by a group of farmers looking for an independent, unbiased and objective source of information for their crops. By sharing agronomic data between members, the team knew that farmers could make better decisions and choose the most appropriate inputs for each region. The members wanted transparency and a level playing field. This is One of the great examples of the use of technology in the agricultural inputs market, which has been bringing transparency to the supply chain in a very consistent way. It has a structure of warehouses distributed in some of the main American producing regions. In addition to the use of e-commerce, it is possible to obtain various benefits, including financial resources. In addition to inputs, the company recently launched a community on the market that has been offering second-hand machinery among its members.



2- AF Smarter Procurement provides a range of services to producers related to crop inputs, fertilizers, livestock inputs, fuels, seeds, telecoms, energy, machinery, farm supplies, construction materials and business services. A specialized financial team with technology that displays total monthly expenses.



3- Digital transformation is also present in more specific markets, such as equines. Almost 60% of all breeding and clinical work in the United States is handled by a company with Brazilian DNA. In addition to the day-to-day work of the clinics, control of the departure and stock of products that will be sent to different parts of the world begins with this technology. Clients from all over the world will have access to cutting-edge genetics for equine improvement and selection.

Promote Sustainable Practices

Optimizing the Resources Uses

Regenerative agriculture

The use of sustainable practices throughout the supply chain requires a broader view of the process. It essentially involves a better energy balance in production and transportation, rational use of inputs, traceability of processes and greater care for the soil and agricultural products. It is also worth highlighting the importance of a financial system that supports these initiatives by promoting incentives for such practices and, above all, a major communication movement so that consumers understand what is being done and the commoditization of products and management practices does not occur.

There are several innovative technologies that can promote sustainable practices in agriculture. Here are some key examples:

1. **Precision Agriculture**: Global Positioning Systems (GPS) and Geographic Information Systems (GIS) enable farmers to analyze and manage field variability, optimize inputs, and improve yield. Drones can be used for aerial surveys, drones can assess crop health, monitor irrigation, and apply pesticides efficiently.
2. **Soil Health Monitoring**: Soil Sensors can measure moisture levels, nutrient content, and pH, helping farmers make informed decisions about fertilization and irrigation. Biological Soil Amendments: Introducing beneficial microorganisms to improve soil fertility and health.
3. **Water Management Technologies**: Drip Irrigation is an efficient irrigation technique and delivers water directly to the roots of plants, reducing water waste. Rainwater harvesting rainwater for irrigation, promoting better water management.
4. **Crop Management Systems**: Integrated Pest Management (IPM) can combine biological, cultural, and chemical practices to manage pests

sustainably and reduce chemical pesticide use. Crop Rotation and Diversification is made by utilizing technology to plan and implement crop rotations that can improve soil health and reduce pest infestations.

5. **Data Analytics and Farming Software**: Farm Management Software are a tool that help farmers manage crop planning, labor, and resources more efficiently. Predictive Analytics utilizing historical data and machine learning to predict yields and optimize farming practices.
6. **Biotechnology**: Genetic Engineering developing crops that are resistant to diseases, pests, and harsh environmental conditions. CRISPR Technology Editing genes to enhance crop resilience and improve nutritional content.
7. **Sustainable Livestock Management**: Use of Livestock Tracking Systems using RFID technology to monitor livestock health and optimize feeding regimes. Manure Management Systems that convert animal waste into energy or compost, reducing environmental impact, circular agriculture and making more money on the system.
8. **Carbon market**: There are several digital tools and platforms designed to facilitate carbon markets, helping businesses, governments, and individuals measure, trade, and offset carbon emissions. Here are some key categories: carbon accounting and management platforms, carbon credit trading platforms, blockchain and tokenized carbon credits, PDD and MRV (measurement, reporting and verification) tools and Nature-Based carbon offset marketplaces.

Implementing these technologies can lead to increased productivity, reduced environmental impact, and enhanced resilience in agricultural systems.

Examples of Sustainable Practices that we could see at the visits.

1- Visit to Corteva's Head Quarter where the main American corn hybrids are developed. It has been almost 10 years of development until the material becomes commercial. Large laboratory of changes in genes and materials being tested to compose with different characteristics, including a dwarf corn with adaptability to local conditions and resistance mainly to winds and bad weather.
Every year Corteva invests many millions of dollars in research and development of new materials. Modern equipment makes genetic mapping operations more accurate and faster.

2- Development of studies at the University of IOWA with nitrogen balance, use of direct planting in straw, use of remote sensing to identify productivity limitations and monitoring of crops. breaking paradigms of traditional corn agriculture in the American Midwest. The usage of remote sensing and software to stimate the results on yield for each soyben variety was presented also.

3- Drones could be used for local applications, reducing use of inputs. Reducing water use for spraying and demand of fossil fuel. Some cases reduction of 30% in inputs used with localized spraying.

4- Use of technology for production and research into practices that result in lower greenhouse gas emissions. Use of RFID at the animals, calculated individual consumption, and the search for increased efficiency. Technology captured in real time capable of individualizing and generating important information within the university that can be used by producers in a region or even an industry. The university assumes a leading role in the search for sustainable production practices that must be presented to producers as soon as they are validated, as an independent party capable of minimizing the commercial effects of products, solutions, and management.

Foster Innovation and Knowledge Sharing

Collaborative and Communicative

Open for Innovation

We live in an increasingly digital society. And this digitalization and innovation has provided benefits for consumers – and transformed industries. At the same time, digitally transforming a company or institution implies facing several challenges, including the fact that the disruption caused by digital is accelerating and, in some cases, leading to market dynamics in which a few leaders end up concentrating the largest share of the market. When it comes to “digital”, however, trying to follow the main trends quickly does not seem to be enough. Proof of this is the finding that, even in highly digitalized sectors, digital maturity can vary significantly in such a way as to impact companies’ results – leaders in digital maturity in the world present superior performance with an EBITA growth rate up to 5 times higher compared to other companies.

Fostering innovation and knowledge sharing within organizations and communities can be greatly enhanced through various technologies. Here are some key technologies that can facilitate this process:

1. **Collaborative Platforms**: Project management tools made by software can help teams collaborate on projects, manage tasks, and share progress, enhancing transparency and communication. Online collaboration tools and platforms allow for real-time communication, file sharing, and collaborative workspaces.

2. **Knowledge Management Systems**: Wikis and Intranets serve as centralized repositories for documents, best practices, and organizational knowledge that are easily accessible to all team members. Document management systems that allow for the storage, organization, and sharing of documents, while also enabling version control and access permissions.
3. **Open Innovation Platforms**: Crowdsourcing Platforms allow organizations to engage outside talent or communities to generate ideas and solutions for specific challenges. Hackathons and Innovation Contests facilitate competitions for developing innovative solutions, often bringing together diverse skill sets.
4. **Learning Management Systems (LMS)**: Online Training Platforms that support employee training and continuous learning, providing courses and resources to enhance skills and knowledge. Microlearning Tools and Applications that deliver bite-sized learning modules to encourage ongoing education and knowledge sharing.
5. **Social Networks and Community Platforms**: Enterprise Social Networks that encourage social interaction among employees, fostering a culture of innovation and knowledge sharing. Discussion Forums for employees or community members to ask questions, share ideas, and collaborate on problem-solving. Also, virtual forums allow companies to host knowledge-sharing sessions, workshops, and discussions with experts and thought leaders.
6. **Virtual Reality (VR) and Augmented Reality (AR)**: VR Training Programs Immersive environments that allow employees to practice skills or explore new concepts in a safe setting. AR Applications like augmentations that provide real-time information or visual aids, enhancing knowledge sharing during collaborative tasks.
7. **Data Analytics and Business Intelligence**: Analytics Platforms that analyze data and generate insights, fostering informed decision-making and innovation. Trend Analysis Tools, software that tracks industry trends and customer feedback, provide crucial information for innovative strategies.
8. **Artificial Intelligence (AI) and Machine Learning**: Intelligent Knowledge Bases with AI-enabled platforms that learn from user interactions to improve knowledge retrieval and sharing. Chatbots AI-driveled provide instant answers and facilitate knowledge sharing among employees or customers.

Implementing these technologies can create an environment where innovation thrives and knowledge flows freely, ultimately leading to enhanced performance, creativity, and collaboration within organizations and communities.

Examples of knowledge sharing that we could see on the visits.

1- Simulator use in UK port for operator training resulting in over 20% improvement in performance, reduction of accidents and time to evolution. Cutting-edge technology for workforce training and development.

3- A strong case using several technologies to bring transparency, efficiency, knowledge and good results, with automation and IOT used in different industries and sectors.

2-Iowa Beef Center is one of the most traditional research and extension centers for beef cattle in the United States. In addition to applied research, it has a technical team capable of providing large-scale extension services for the state of Iowa. In this context, technology becomes essential to ensure that dissemination between research and extension services reaches producers. This is still one of the major problems faced by traditional knowledge sharing models.

Enhance Customer Engagement and Market Access

Customer needs and behaviors

Matter of creating value on sales

Enhance Customer Engagement is conceptualizing value-based sales as a distinct approach for companies to implement their value strategy across various levels. This unique construction influences how salespeople work in business-to-business industries. The authors identified three fundamental pillars in well-executed value-based sales. The first involves understanding the customer's business model, followed by crafting a value proposition, and third, effectively communicating the created value to the customer.

Now, there is a better understanding value-based selling. Subsequently, it´s important to explore the opportunities for implementing this sales approach in agribusiness and why the approach, despite it not being new, is of growing importance in today's reality.

In the first pillar, the importance of understanding the customer's business model is related to assertion that value emerges from the "customer's engine," where staff and other customers' resources interact with products or services provided by suppliers. Understanding the "customer's value generation machine," is crucial for the supplier to position the solution where value will be created. Some components of the customer business model contribute to a clearer understanding of its nature and importance. The customer's profit formula is one such component. Understanding how the customer makes money (main cost components and revenues) what drives the value creation gives clues as to where value may be created. For instance, there might be opportunities to increase the price of customers' output and still be highly regarded by the customers.

The second component is crafting the value proposition. Simply defined, a value proposition is the reason why a customer should choose a supplier over the second-best alternative. First, a good value proposition from a value-based strategy's perspective must involve the customer's reality somehow. It may be with the use of customer data or direct customer engagement in a co-creation exercise. Chances are, if a value proposition disregards the customer's reality and does not have customer data somehow built-in from the start, it is more of a product-centric sales approach. Also, the value created must be relevant and impactful for the customer, as well as visible. Importantly, the value proposition should include tangible numbers that make clear the financial benefits potentially generated for the customer by the offer. More than precise numbers, the exercise of how a value proposition may create additional revenues or help the company cut down on costs will allow the customer to build its own scenarios and assess how much that offer is indeed valuable.

Finally, communicating the value created is what will sell the offer. Translating all these potential benefits to different stakeholders, recognizing that different stakeholders have different ways to read benefits, is a great starting point. To establish credibility, it is fundamental to help the customer evaluate alternatives paths. This involves transparently and sincerely comparing competitors' offers and recognizing

their advantages and disadvantages against those of the suppliers. A good recommendation is to enhance the credibility of the offer through risk-sharing, especially when the offer involves an important and potentially risky change for the customer. (Lundin L. 2024)

Enhancing customer engagement and market access is vital for businesses, and various technologies can help achieve these goals. Here are some key technologies used in this ecosystem:

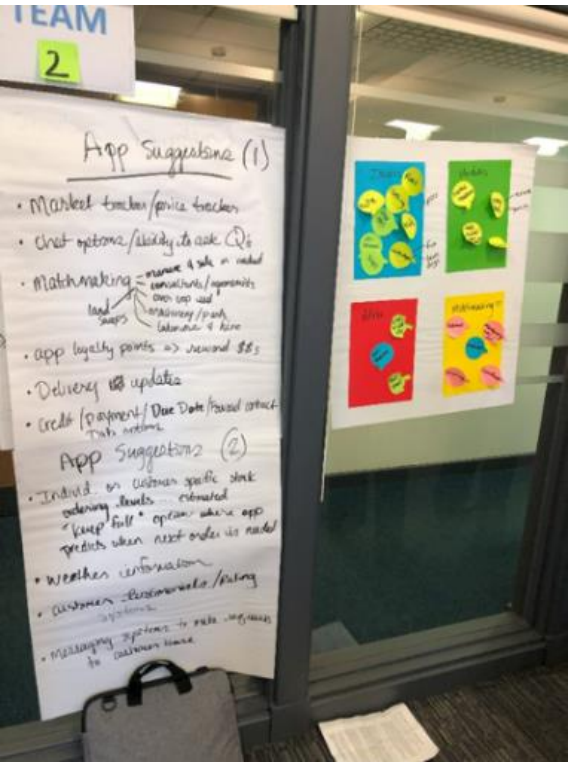
1. **Customer Relationship Management (CRM) Software** helps businesses manage interactions with customers, track leads, and analyzes customer data to improve relationships and retention. Digital transformation helps in utilizing CRM systems to better understand customer needs and behaviors, allowing for more efficient service delivery and improved customer satisfaction.
2. **Consumer Transparency Tools**: Apps and websites can provide consumers with detailed information about product origins, production practices, and supply chain sustainability. This engagement builds trust and encourages informed purchasing decisions. AI-Powered Chatbots tools can provide 24/7 customer support, answer FAQs, and guide customers through the sales process, enhancing user experience.
3. **E-commerce Platforms**: Online Marketplaces enable businesses to reach a broader audience through online sales. Mobile Commerce (m-commerce) optimized websites and apps that facilitate shopping directly from mobile devices.
4. **Personalization Technologies**: Recommendation Engines used by e-commerce websites to suggest products based on user behavior and preferences, enhancing the shopping experience. Dynamic Content are Websites that adapt content based on user data to create a more personalized customer experience.
5. **Mobile Applications**: Branded Apps are developing mobile apps for direct engagement with customers, offering exclusive deals, and providing a platform for feedback and interaction. Loyalty Programs using mobile apps that integrate loyalty rewards for purchases and engagement.

By leveraging these technologies, businesses can create more meaningful interactions with customers, enhance their marketing efforts, and improve overall market access.

The traditional way we do business still has a lot of value in the agricultural sector, where face-to-face contact still has a lot of weight in decision-making, since the planning basis is not yet something that is strongly developed and used by most producers.

Examples of Enhance Customer Engagement and Market Access that we could see on the visits:

1- Digitalization of the analogy sales process at the Amsterdam flower market, where the entire flow takes place using technology. The entire auction, separation and logistics process takes place virtually. After Covid, this process has become even more efficient.



2- Development of an App mockup for customer relations for AF Farm Procurement in UK. This Job got a prize for the consistency and good ideas that your Nuffield group made during the real activities at the CSC program.

3- Equipment for collecting information about products on supermarket shelves, providing transparency to products and adding value and quality to the consumer and improving the shopping experience.

4- Retail distribution models for products and supplies are still present in many regions of the United States. Large physical stores with different types of products, segments, from tools to agricultural and farm supplies, clothing and in some cases even food.

Conclusions

The agricultural value chain is made up of inputs, agricultural production, processing and distribution, marketing and consumers. In short, a complex chain with many opportunities.

If you ask a farmer what they need and want on the farm, the answer will probably come in many forms due to the complexity of their operations. What is important in this case is that they need to increase efficiency and clearly visualize what is stealing their productivity.

A comprehensive **understanding** of digital transformation in agricultural supply chains requires a more nuanced perspective that considers various stakeholders and their specific needs. (J. Burguin, 2018)

A major concern within the concept of digitalization is linked to the fact that offers are **commoditized**, leading to many solutions for the same problem or demand, and this has created a major barrier in the market for producers and companies that should benefit from the services.

Many businesses may disappear in the future because they have a very strong link with the people who run them, such as consulting services and supporting operations. Although it may seem harsh, the only way for certain types of services to stay alive and grow is by **entering the digital world**.

In Brazil, according to the digital maturity index carried out by PWC in partnership with FDC, agribusiness has the lowest digital maturity index among all industries evaluated, which seriously threatens the competitiveness of the business. The greatest impact was seen in **digital processes** and **data-driven decisions**. Another point for this is the low rural connectivity and reduced incentives for technological innovation coming from the government.

The digital transformation process in the supply chain involves **many business areas**, many opportunities and many challenges. This transformation essentially involves people and processes. Technology is the middle ground and an important three-pronged consolidation tool. In summary, our conclusions on the subject lead us to reflect on three major blocks:

The customer is at the center of decisions.

Customer relationships and perception of value are key elements during the sales and business development process. Whether before the acquisition, after the acquisition or for repurchase, the customer must always come first. It is important to map out very well what the customer needs and with that make a good recommendation and develop more appropriate solutions.

It is important to remember within this concept that often the customer cannot know what they need due to aspects already discussed previously of conservatism in the sector, but tests and new developments must always be on the agenda within companies.

The convenience that generates the value.

Analysis, better results, ROI, many things are said about what really generates value for producers, suppliers and agents in the agricultural supply chain; however, convenience becomes the greatest agent that adds value within the business. technology, transparency that bring greater agility, reduction of stocks and costs, better utilization, sustainability with better use of resources, reduction of labor and even help in the qualification of this labor force begin to play a fundamental role in the greater adherence of solutions.

Analytical data linked to results that effectively generate some actions are a great source of search for innovative solutions linked to the digitalization of processes and people. Practical solutions that have led to disintermediation have gained a great advantage over normally used sales solutions.

Communication is the greatest tool in the business world.

Communication and transparency are certainly the major success factors of new digital technologies, as they bring greater effects in terms of cost reduction and economies of scale. Transparency is followed by social proof, which is usually the major driving force behind sales, engagement and the development of great solutions. Again, communication in the sales environment is very important because everyone sells, all areas of the company must know their customers, and using data,

technologies and all available tools will strengthen the main bond that exists between companies and all solutions that are part of a vast innovative ecosystem around the world.

Supply Chain integration as a base of reducing costs.

With the integration of the supply chain, it is possible to reduce impacts arising from seasonality, which is inherent to agribusiness, and which can strongly impact the decisions and results of production processes in all links.

Concluding everything that was worked on throughout this report, there are 2 major points that cannot be ignored:

There are many work fronts, and they must be directed and connected to the business base of each company. Digital, because it is digital, does not bring the expected result and kills the project and the results and benefits of the entire process.

It's all about people and this cannot be ignored because people buy, people sell, people operate, people do more in less time, people are largely responsible for all the actions and approaches that digitalization can bring.

However, there are **high risks and barriers** to implementing the long-awaited digital transformation.

Within the production environment, we can highlight risk points such as data security, reduced economic power due to labor reallocation, overdependence on technology, exclusion of small producers, and even environmental risks from implementing certain technologies. Furthermore, speaking of barriers within the production process, infrastructure limitations, high initial costs, the sector's low digital heritage, data fragmentation, and lack of clear regulation, in addition to cultural and language aspects, can lead to limitations in usability.

Complementing and with a view to the entire supply chain, it is important to list as main risks: cyber vulnerabilities, the challenges of the lack of connection between solutions, data governance and local protection laws, the dependence on open field functionalities and connectivity, in addition to the concentration and dominance of markets in some regions. As all transformations bring barriers to implementation, in this case the fragmentation of stakeholders, infrastructure deficiencies, dependence on high investments, the lack of clear regulations, in addition to cultural and behavioral aspects bringing resistance should be listed.

Recommendations

The main recommendation is that we cannot look at digital transformation in agribusiness in the same way that we would buy a farm or an industry. It is a long and important journey that involves people and many, many processes. This mostly causes destabilization in business and demands people who truly understand the importance of doing the same thing, but in a different way. This movement requires resilience from decision-makers.

Some approaches and **GENERAL RECOMENDATIONS** we have on these different topics:

- Focus on efficiency, logistics, and data-driven decision-making would prove the potential of digital technologies to streamline agricultural supply chains. We must work and advocate for increased automation, AI-powered predictive analytics for optimizing yields and resource allocation, and robust e-commerce platforms connecting farmers directly with suppliers and consumers. An emphasis would be on scalability and consumer reach.
- This digital approach might prioritize domestic production and job creation. Might see digital transformation as a tool to bolster Agriculture, making it more competitive globally. However, there is a good balance between technological innovation itself and economics. A global market comes with important topics to concerns about foreign technology dependency in some cases and some countries.

- Another focus on user experience could translate to a vision of intuitive, user-friendly digital tools for farmers. All tools might emphasize the importance of creating accessible technology that empowers farmers and simplify complex agricultural processes. The perspective would likely prioritize ease of use of the technology itself.
- A big emphasis on innovation, sustainability, and automation could lead a leader to advocate for the integration of cutting-edge technologies like robotics, AI, and other disruptive. Looking to envision a future of highly automated, sustainable agriculture with minimal human intervention, focusing on efficiency and resource optimization, potentially using technology for precision agriculture and environmental monitoring.
- People, people and people: they are the driving force behind the creation, use and consumption of any technology and we strongly encourage the promotion of digital transformation as a source of information and development.

Looking at agribusiness and some phases of the supply chain, the targeted recommendations are as follows and based on a suggested digital transformation **ROADMAP** with different available technologies:

Industries and resellers are indispensable for the efficiency of the agricultural supply chain. While industries ensure innovation and the production of high-quality inputs, resellers make these products accessible to farmers, offering technical support and financial solutions, thus boosting the productivity and sustainability of the agricultural sector.

INDUSTRY / DEALER

- Integration with usage and demand planning data.
- Knowledge of the potential use of products in each region and culture.
- Mapping of production and credit risks in each region and ways to mitigate them.
- Team training.
- CRM and relationship automation.
- On line sales app.

Agriculture and livestock farms are the foundation of the agricultural supply chain, ensuring the production of essential food and raw materials for society. Their role extends beyond production, influencing the economy, labor market, and environmental sustainability, making them fundamental to global development.

FARMERS AND RANCHERS

Digitalization

• Remote processing and analysis of crop development

• Regional climate and disease risk

Precision Agriculture

• Pest and disease monitoring

• Area systematization

• Variable rate nutrient correction and application

Agriculture 4.0

• Use of drones to spraying

• Machine automation and telemetry

• Local weather stations

Management

• Administrative and operational management platforms

• Team training

Trading and processors are vital for the agricultural and livestock supply chain, ensuring efficient commercialization, logistics, and transformation of raw materials. They enhance market access, add value to agricultural products, and improve overall food security and economic stability, benefiting both producers and consumers worldwide.

The digitalization of the agricultural supply chain is not just a trend, but a necessity to make the sector more resilient, competitive and sustainable. Solutions such as blockchain, artificial intelligence, automation and big data analysis will be essential to integrate all links in the chain, improve predictability and reduce waste.

Innovation must be accompanied by a collective effort by governments, companies and producers to ensure that no one is left behind in this technological revolution, enabling the agriculture and livestock of the future to be increasingly efficient and intelligent.

As a final point of the work and thinking about reducing risks and barriers to implementation, here is a summary of possible actions:

Policy Development: Establish clear legal frameworks for data ownership, digital transactions, and interoperability standards. Also, inclusive policy to protect smallholders and ensure fair access to technology.

Infrastructure Investment: Expand digital connectivity and power infrastructure in underserved agricultural regions.

Capacity Building: Implement targeted digital literacy and training programs for all supply chain actors including farmers and extension workers.

Inclusive Platform Design: Develop accessible, modular, and interoperable platforms that cater to diverse user capabilities and open data initiatives that promote collaboration and transparency.

Public-Private Collaboration: Foster partnerships to share the cost and risk of digital infrastructure development and ensure inclusive access to technology. Important focus on infrastructure and affordability.

References

Gartner Hype Cycle (2023). What's New in Artificial Intelligence from the 2023 Gartner Hype Cycle: https://www.gartner.com/en/articles/what-s-new-in-artificial-intelligence-from-the-2023-gartner-hype-cycle

P. Waengertner, S. Santiago, Victor Navarrete, **Transformação Radical**, Editora Gente, São Paulo-Brasil.

DIAS, Cleidson Nogueira; JARDIM, Francisco; SAKUDA, Luiz Ojima (Orgs.) **Radar Agtech Brasil 2023**: Mapeamento das Startups do Setor Agro Brasileiro. Embrapa, SP Ventures e Homo Ludens: Brasília e São Paulo, 2023. Disponível em: <www.radaragtech.com.br>. Acesso em 04 de novembro de 2023.

B. Erickson, J. Lowenberg-DeBoer: 2023 **Precision Agriculture Dealership Survey**, Purdue University.

Markestrat Group: **Digital Transformation in Agribusiness: Challenges and Opportunities within the Value Chain.** Public Access Document, September 2020.

Lucie Douma (2022) Nuffield New Zealand Report: **Data Sharing to Achieve data interoperability**. New Zealand.

H. Martins, Y. Dias, P. Castilho, D. Leite: **Transformações digitais no Brasil: insights sobre o nível de maturidade digital das empresas no país.** São Paulo, Brasil, 2019.

J. Burghin, T. Catlin, M. Hirt, P. Willmot: **Why digital strategies fail.** McKinsey Quarterly, January 2018.

Lundin, L., Kindström, D. (2024). **Managing digitalized touchpoints in B2B customer journeys**. *Industrial Marketing Management Journal*, *121*, 88-99. https://doi.org/10.1016/j.indmarman.2024.07.004

Loy, R., Britton, L. L., & Malone, T. (2024). **Software solutions in agri-food supply chains: a current view for sustainability reporting**. *International Food and Agribusiness Management Review*, *27*(4), 729-744. https://doi.org/10.22434/ifam.1085

L. Becker, E. Jaakkola: **Customer experience: Fundamental premises and implications for research**. Journal of the Academy of Marketing Science, 48 (4) (2020), pp. 630-648, 10.1007/s11747-019-00718-x

ITDBr: Índice Transformação Digital Brasil 2024. PWC & FDC. https://www.pwc.com.br/pt/estudos/servicos/consultoria-negocios/indice-transformacao-digital-brasil-2024.html

N. Chandrasekaran, G. Raghuram, **Agribusiness Supply Chain Management**, 2014, by Taylor & Francis Group, LLC.

Makinsey & Company (2019), Transformações digitais no Brasil: insights sobre o nível de maturidade digital das empresas no país. https://www.mckinsey.com/br/our-insights/transformacoes-digitais-no-brasil.