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Digitalization of the agricultural sector in Spain and the Netherlands: Recommendations, gaps, and synergies

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Executive Summary

This report analyzes the digitalization strategies and key initiatives of the agri-food sectors of Spain and the Netherlands, exploring synergies and opportunities for cooperation and collaboration in the development and implementation of agricultural digitalization agendas for the two countries. We present results from a desk-based review of key policies, action plans, and scientific literature, and key insights from experts across the sector. This report examines policy approaches adopted by both countries to enhance strategic autonomy and security in the agricultural sector, improve rural digital connectivity, and overcome barriers to the uptake of digitalization. We identify areas of potential bilateral cooperation, and provide strategic insights for the evolution of agricultural digitalization in the context of wider European policy processes and digital agendas. We end with recommendations on key focus areas for policy-making, investment, and collaboration to advance the use of digital technologies and solutions for improved efficiency and sustainability of the agri-food sector:

- **Strengthen collaborations and Public-Private-Partnerships between and within Spain and the Netherlands**: Specifically, we see a great opportunity for Dutch companies and research institutes to test the latest digital technology across the Spanish territory and its variety of climates, landscapes and territories, collaborating with its producers and research organizations.
- **Sharing knowledge and innovation**: Our desk-based research and interview data collection highlights Spain's leading role in precision irrigation and water management. In this aspect, northern European countries, including the Netherlands, should increase collaboration and knowledge sharing in the face of increasing unpredictability of weather patterns, and increasing drought events which will affect agricultural productivity. Likewise, the research and interview results highlight the leading role of the Netherlands in developing digital technologies, and exporting this knowledge, while partnering through test and demonstration sites, such as through "Living Labs", which could be of mutual benefit for both countries.
- **Understand the local context**: We encourage the consideration and representation of national and regional characteristics in European policy development and implementation: geographic, social and political differences must be understood and considered when developing and implementing digitalization agendas. This includes analysis of the different socio-economic sectors most affected - digital transformation must be ethical, just, and sustainable - leaving nobody behind.
- **Strengthen and represent farmers' voices in the digitalization agenda**: We must ensure technology and digital transformation works for and with farmers, not against them. Traditional and cultural knowledge in the agricultural community must also be considered and included together with technological and innovation advances. Digital software companies and other private sector actors should increase collaboration with farming cooperatives and representatives to understand the needs and complexities of the agricultural sector, so that technology is developed in a way which supports real farming processes and is compatible with European policy frameworks.
- **Data ethics:** A key finding from this work is lack of clarity, transparency and appropriate processes for the ethical collection, sharing, and use of agricultural data. It is imperative that protocols or agreements are put in place if digitalization in the sector is to be adopted by the farming community.

1. Introduction

In this report, we understand digitalization in the agri-food sector as the integration of advanced digital technologies —such as artificial intelligence (AI), the Internet of Things (IoT), blockchain, big data, and robotics— into agricultural production, supply chains, and rural development.

Digital transformation in the agricultural sector aims to integrate digital technologies into all aspects of agricultural production and supply-chains, increasing efficiency, sustainability, and resilience by enabling processes such as precision farming, smart irrigation, real-time data analysis, and automated decision-making. Used well, it also supports resource optimization, reduces environmental impact, and strengthens economic viability in rural areas, ensuring a more competitive and sustainable agricultural sector. The European Commission and the OECD define digitalization as “processes which offer the potential to help address the productivity, sustainability and resilience challenges facing agriculture”[1] and “Digital technologies in agriculture can increase farm performance by enhancing sustainability, productivity, and resilience, especially through Internet of Things (IoT) technologies, sensors, data analytics (e.g. based on Artificial Intelligence), and decision support systems, leading to more tailored and precise farming operations.”[2] In the current European, and global context of complex and converging economic, environmental, and social challenges, digitalization is more important than ever, offering the potential to create a more efficient, resilient, and sustainable food production system.

This report analyzes and compares the current digitalization strategies for the agricultural sectors in Spain and the Netherlands. It summarises key advances, the current state of development of digital technology, and identifies potential areas for bilateral collaboration in policy development, trade, and sectoral cooperation. We provide actionable recommendations and key focus areas to enhance cooperation, support policy development, and promote sustainable growth in both nations' agricultural sectors.

2. Methodology

2.1. Objectives and Research Questions

Six overarching research questions were chosen to guide this study, identified in alignment with the interests of the Netherlands´ Ministry of Environment and the Netherlands Embassy

[1]https://www.oecd.org/en/publications/the-digitalisation-of-agriculture_285cc27d-en.html
[2]https://digital-strategy.ec.europa.eu/en/policies/digitalisation-agriculture

in Spain. To address the similarities, differences, and opportunities for collaboration between both countries - drawing also conclusions at the European level - we structure this research into six guiding questions:

1. What are the opportunities for collaboration and co-operation in the development of Dutch and Spanish digitalization action programmes and strategies?
2. What are the opportunities for bilateral cooperation in the development of policies and European regulations linked to digitization of the agricultural sector?
3. What are the key opportunities for cooperation in the agri-food sector?
4. How does digitalization support strategic autonomy and security in the agricultural sector?
5. What lessons can be drawn from Spain regarding the use of digitalization to address societal challenges?
6. How can the digitalization of the agricultural sector support the Dutch 'Goals Steering Approach' (doelsturing) and its application to agriculture?

A mixed methodology was adopted to address the research questions posed. A desk-based study and literature review were conducted to analyze the digitalization strategies of the agricultural sector in Spain and the Netherlands, as well as their related policies and regulatory frameworks[3]. Subsequently, a key actor mapping was conducted to identify relevant experts with the direct support and guidance from the Embassy. Questions were developed for Key Stakeholder Interviews (KSIs) based on the six Research Questions and initial findings of desk-based review, which were then used to provide additional information and fill knowledge gaps. Finally, the collected data were analyzed. Thus, this report synthesizes the results and offers recommendations for bilateral cooperation, collaboration and learning in the field of digitalization and digital transformation of the agri-food sector.

2.2. Desk-based study

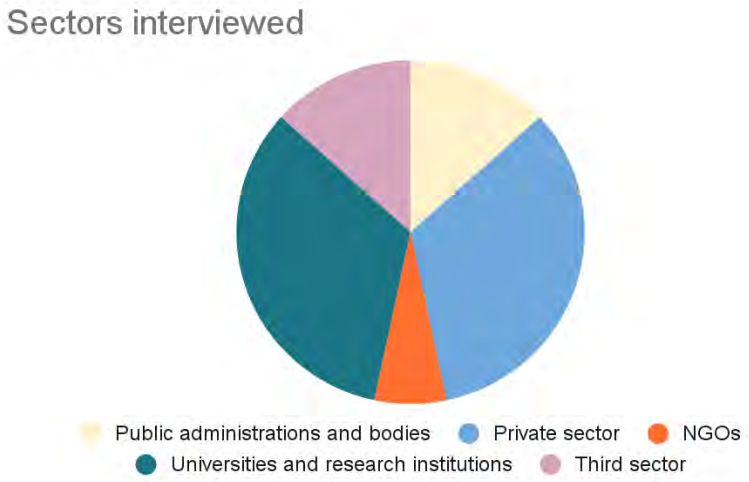
2.3. Interviews

43 actors were contacted for interview between February and April 2025, from which we interviewed 15 key actors (34.8% response rate) from 5 sectors, summarised here:

- Public administrations and bodies (N = 2)
- Private sector (including banks) (N = 5)
- NGOs (N = 1)
- Universities and research institutes (N = 5)

[3]Consulted policy-related documents are detailed in the References section.

- Third sector: farmers and farmer cooperative representatives; irrigation organizations (N = 2)



All interviews were conducted via online meetings except one which was conducted in person. Participants were sent prior information and consent forms to guarantee data and information will be shared anonymously, in compliance with European GDPR regulations and participant ethical consent procedures.

3. Results and key findings

3.1. Opportunities for collaboration and co-operation in the development of Dutch and Spanish digitalization action programmes and strategies

In recent years, both Spain and the Netherlands have launched ambitious digitalization strategies for their agri-food sectors. While their approaches reflect their unique agricultural, economic, and geographic contexts, their objectives often converge around key areas such fast digital infrastructure, innovation support, data governance, and sustainable agriculture. These efforts align with broader EU frameworks, including the European Digital Strategy, the Digital Decade 2030, the Common Agricultural Policy (CAP 2021–2027), and Horizon Europe. In this first section, we answer the question: *What similarities does the Dutch digitalization action program have with the Spanish digitalization strategy?* and we explore areas for collaboration in the development of these strategies, between the two countries and more widely across Europe.

According to the Digital Economy and Society Index, or DESI, which has four key areas: connectivity, human capital, integration of digital technology and digital public services (European Commission, 2022); in 2022 the Netherlands was ranked third in the EU, i.e. one of the most digitally advanced EU member states, while Spain was ranked 7th, especially focused on expanding rural connectivity and public digital services (Figures 1 and 2). Spain's strategy is more closely aligned with national policy priorities and EU funding mechanisms like NextGenerationEU, whereas the Netherlands benefits from a well-developed private innovation ecosystem.

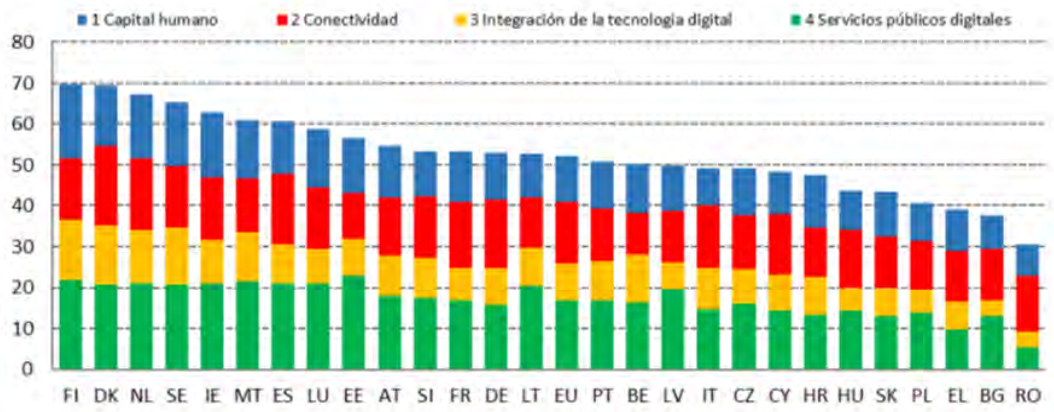


Figure 1. Digital Economy and Society Index (DESI) 2022 ranking (source: European Commission, 2022). Bars show ranking according to four key categories: Human capital (blue); connectivity (red); digital technology integration (yellow); and digital public services (green).

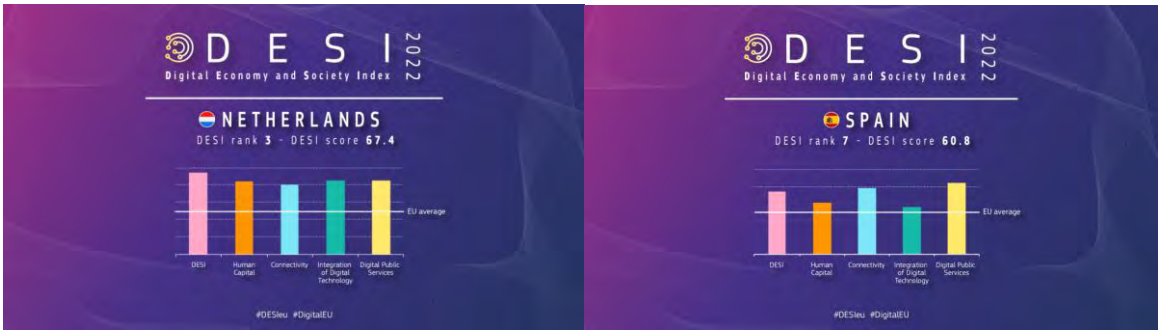


Figure 2. The Digital Economy and Society Index-DESI in four key areas. (source: https://digital-strategy.ec.europa.eu/en/policies/desi)

Here we summarise key areas of similarities, and differences, between the digital transformation of the agricultural and agri-food sectors in both countries, (Figure 3) focusing on 9 key areas of digital transformation as highlighted in key strategies (The Dutch Digitalisation Strategy 2021; Dutch Digitalisation Strategy: Getting the Netherlands 2019; Estrategia de Digitalización del Sector Agroalimentario y Forestal y del Medio Rural 2021; and Observatorio para la Digitalización del Sector Agroalimentario 2024):

1. Integration of Advanced Technologies like AI, IoT or Robotics
2. Data-Driven Agriculture
3. Sustainability and Climate-Resilient Agriculture
4. Cybersecurity and Ethical Considerations
5. Infrastructure Development
6. Support for Innovation and Entrepreneurship
7. Smart Villages and Rural Digital Inclusion
8. Blockchain and Supply Chain Optimization
9. Investmen and Funding

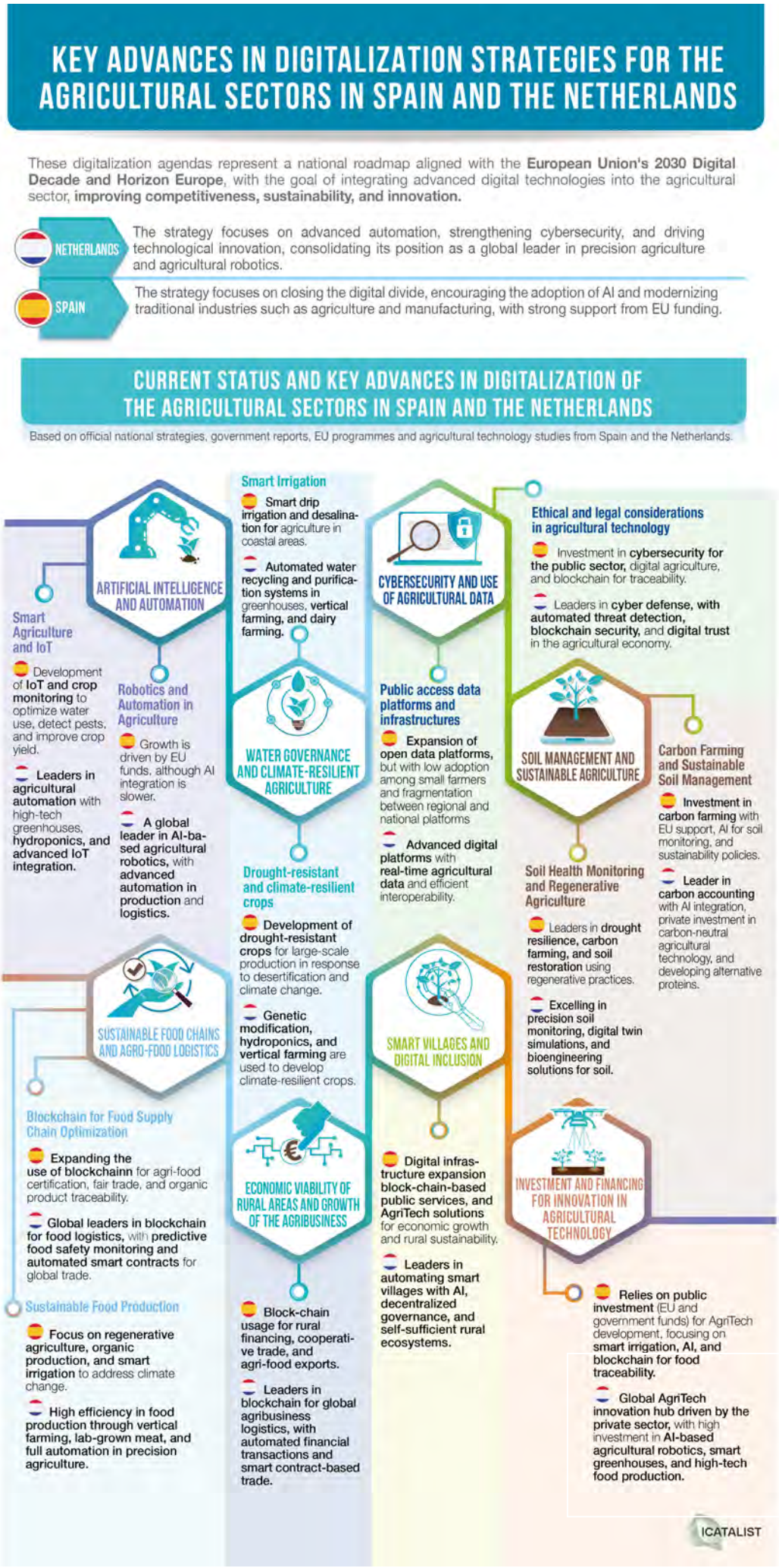


Figure 3. Key Advances in digitalization strategies for the agricultural sectors in Spain and the Netherlands

- **Integration of Advanced Technologies like AI, IoT or Robotics**

Both countries emphasize the integration of AI, IoT, and robotics into precision farming. Spain is implementing these technologies under its National Strategy for the Digitalization of the Agri-Food, Forestry, and Rural Environment (2021–2027) (Ministerio de Agricultura, Pesca y Alimentación, 2021; Ministry of Agriculture, Fisheries, and Food (MAPA)), while the Netherlands includes these in its Dutch Digitalisation Strategy (Ministerie van Economische Zaken en Klimaat, 2021).

Spain is deploying smart irrigation systems, robotic harvesters, and AI-powered pest control solutions through programs like the **PERTE Agroalimentario**[4] (a Spanish government initiative aimed at modernising and digitising the agri-food sector, fostering innovation, sustainability, and competitiveness, with 1 bill EUR in funding), with strong participation from startups such as *Hispatec, Agrosingularity,* and *BrioAgro*[5]*.* In the Netherlands, innovations such as automated greenhouses, automatization in livestock / dairy farming (Lely), and vertical farming are supported by Wageningen University & Research (WUR).

- **Data-Driven Agriculture**

Both strategies prioritize real-time data for decision-making in agriculture. **Spain is creating open agricultural data platforms and digital farm record systems (e.g., the "Cuaderno Digital" or Digital Farm Book (see Box 1))**, while the Netherlands has deployed tools like Sensoterra and uses remote sensing platforms to monitor crops and soil moisture.

According to the Observatorio de Transformación Digital (Digital Transformation Observatory) (Ministerio de Agricultura, Pesca y Alimentación, 2023), **almost 90% of Spanish agri-food professionals are willing to share data generated on their farms, though concerns about confidentiality remain.** Both countries aim to ensure interoperability of platforms, protect user privacy, and enhance ethical data governance (Ministerio de Agricultura, Pesca y Alimentación, 2024).

[4] More information: https://planderecuperacion.gob.es/como-acceder-a-los-fondos/pertes/perte-agroalimentario
[5] https://www.intelectium.com/en/post/11-startups-del-sector-agtech

Box 1. Cuaderno Digital de Explotación Agrícola (CUE) (Spain 's Digital Farm Book).

Cuaderno Digital de Explotación Agrícola (CUE)

This Digital Farm Book aims to transition from traditional paper-based agricultural records (previously known as Cuaderno de Campo) to an electronic format for agricultural holdings. It aims to improve data management, facilitate communication with authorities, and promote efficient and environmentally friendly practices.

It is accessed through management systems offered by the agricultural authorities of each Autonomous Community. A digital certificate or electronic ID and the farm's identification is necessary.

Implementation:

- Initially, it was scheduled to be mandatory in stages starting September 2024, but it has been changed to voluntary until the next programming period of the Common Agricultural Policy (PAC) from 2027 (in part due to socio-political push back highlighted by the farming protests of 2024).
- It will be progressively implemented based on farm size and type, with smaller farms initially being exempt.

Key Features:

- Records of pesticide and fertilizer applications.
- Aims to improve data-driven decision-making for farmers.
- Integrates with other digital tools like fertilization and weather applications.
- Facilitates compliance checks by authorities.

Voluntary Adoption: Farmers can voluntarily adopt the digital book and may receive benefits like priority in aid programs, reduced controls, and exemptions related to fertilization measures. Voluntary use is encouraged to familiarize farmers with the technology.

NOTE: The **SIEX** (Sistema de Información de Explotaciones Agrarias) is a digital management platform that connects various administrative and agricultural holding records, including the **Cuaderno Digital de Explotación Agrícola (CUE),** to improve the management and compliance with the **Common Agricultural Policy (CAP).**

More information here: https://www.plataformatierra.es/actualidad/cuaderno-explotacion-digital-obligacion-oportunidad-gestion-sostenible

- **Sustainability and Climate-Resilient Agriculture**

Spain and the Netherlands are both committed to climate-resilient farming practices. Spain emphasizes regenerative agriculture, carbon farming, and AI-supported water efficiency in drought-prone regions. Spain specifically has a long history of investment and development of precision irrigation due to the low rainfall rates in large parts of the country, and the large

size of its agricultural sector, and much higher productivity of irrigated agriculture compared to dryland farming: 23% of Spain's agricultural land is cultivated with irrigation, but contributes 65% of the total production value (Ministerio de Agricultura, Pesca y Alimentación 2023). The Netherlands focuses on climate-neutral farming, blockchain-supported food traceability, and circular economy initiatives such as precision fermentation and lab-grown meat (Ministerie van Economische Zaken en Klimaat, 2021).

- **Cybersecurity and Ethical Considerations**

Both strategies include dedicated efforts to ensure cybersecurity and ethical data use. Spain addresses these through its Cybersecurity Plan 2021–2025 and national strategies on AI and digitalization, while the Netherlands outlines broader values in its AI ethics framework, which prioritizes human rights and responsible innovation.

- **Infrastructure Development**

Both countries prioritize expanding 5G and IoT infrastructure in rural areas. Spain's "Digital Spain 2025 Agenda" aims for 100% of rural households to have broadband access above 100 Mbps by 2025. The Netherlands also advances 5G and IoT connectivity in agricultural regions to facilitate smart farming (Ministerio de Asuntos Económicos y Transformación Digital, 2020).

- **Support for Innovation and Entrepreneurship**

Public-private partnerships are central in both countries. Spain supports agri-tech startups and SMEs through public funds and digital transformation platforms, like the Platform Tierra from Cajamar, while the Netherlands offers innovation financing through Rabobank, Invest-NL, and the National Growth Fund.

- **Smart Villages and Rural Digital Inclusion**

Spain has launched platforms to support digital entrepreneurship in rural areas and improve access to digital services, while also investing in public-private partnerships for high-speed internet expansion. These initiatives work at both national (e.g.: UNICO Demanda Rural) and regional levels (e.g.: PEBA Basque Country, CTIC Rural Tech Asturias). In parallel, the Netherlands promotes smart village development with digital hubs, training programs, and digital inclusion efforts in rural communities (Ministerie van Economische Zaken en Klimaat, 2021).

- **Blockchain and Supply Chain Optimization**

Spain is expanding the use of blockchain to improve traceability in olive oil, wine, and organic

produce supply chains, supported by retailers like Carrefour. The Netherlands is integrating blockchain into its food logistics infrastructure through initiatives like IBM Food Trust and the Port of Rotterdam, improving customs procedures and enhancing trade transparency.

- **Investment and Funding**

Currently, Spain utilizes EU recovery and modernization funds, and national funding, via programmes such as the "PERTE Agroalimentario" and "Digital Spain Agenda," alongside private sector involvement. The Netherlands leverages private capital and national investment frameworks such as the "National Growth Fund" to drive agricultural innovation and AI deployment.

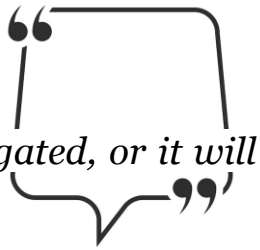
Spain and the Netherlands share a common strategic vision for the digital transformation of agriculture, with different country characteristics leading to different levels of focus and development. Their alignment in key areas such as AI integration, data governance, rural digital inclusion, and climate adaptation lays the foundation for fruitful bilateral cooperation. Spain offers diverse agricultural environments and experience in collaboration and multi-stakeholder governance across diverse government ministries, regional governments, universities and private sector, while the Netherlands provides technological expertise and innovation capacity. Together, they are well-positioned to lead Europe toward a more sustainable, data-driven, and resilient agri-food system.

Results from interviews - what do the experts say?

Experts have identified common priorities in the Dutch and Spanish digitalisation strategies, including data-driven agriculture, sustainability, AI and blockchain. While the Netherlands is leading on implementation (especially in arable and dairy farming) (for example via IoF2020 the project coordinated by Wageningen University[6]), Spain is moving quickly focusing on government-led or partnership programmes, at the national and also at the regional scale (and its 17 regions or autonomous communities as they are named in Spain). Spain is also viewed as an expert in water management and irrigation, and organizations are focusing on the application of technology to achieve environmental goals within the framework of EU policy, such as the CAP (for example via the Zitrus project[7]). Spain will continue to invest in efficient management and protection of its natural resources, with the current focus being on the development of

[6]https://www.smartagrihubs.eu/iof2020
[7]https://www.wwf.es/nuestro_trabajo/alimentos/proyecto_zitrus

technologies to ensure the sustainability of irrigation agriculture.



QUOTE: "The future of agriculture in Spain will be irrigated, or it will not be."

Several interviewees emphasised the necessity for clearer and more detailed comparisons to better assess the similarities between the two strategies. However, they also stressed the importance of knowledge transfer, practical implementation and alignment with environmental and policy objectives.

3.2. Policy developments and European regulations linked to digitalization of the agricultural sector: Opportunities for cooperation

Spain and the Netherlands are actively involved in shaping European policy regarding the digitalization of the agricultural sector. Both nations align their strategies with overarching EU frameworks, including the European Digital Strategy, the Data Act, Horizon Europe, and the Common Agricultural Policy (CAP). These alignments, combined with their distinct national strategies and focus areas, offer significant opportunities for bilateral cooperation.

A critical area for collaboration is the update of the **European-level Code of Conduct for Agricultural Data Sharing by Contractual Agreement (EUCC)**. The Netherlands has already released its own **Dutch Agrifood Code of Conduct for Data Use** (see Box 2), tailoring the European-level code to its specific national circumstances. This provides a potential model and basis for collaboration with Spain, which could also develop its own Code of Conduct with Dutch assistance (as well as other European countries). Such cooperation ensures that data sharing practices are harmonized, protect farmers' interests, and align with broader EU data regulations, including the EU Data Act.

Box 2. Dutch Agrifood Code of Conduct for Data Use

Dutch Agrifood Code of Conduct for Data Use

Purpose: It aims to foster data-driven agriculture and horticulture by establishing clear rules and promoting trust in smart data use in the Netherlands. It applies to suppliers of digital tools and smart machines, agricultural businesses (farms), and supply and processing chain partners.[8]

Key Aspects:

- It is a set of rules that parties voluntarily commit to, it is not mandated bylaw or statutory regulation.
- It focuses on rules about data use between data users (*agricultural enterprises*), data holders *(suppliers of digital tools*), and data recipients (*companies receiving data via data holders*).
- **BO Akkerbouw:** This organization is the administrator responsible for the Code of Conduct, maintaining a public list of participants who have signed a self-declaration letter committing to the code.
- **List of Participants:** A list of participating parties was published on BO Akkerbouw's website in early 2025. Agricultural businesses can select suppliers who have committed to the code.
- **Data Space/Farm Data Space:** The code aims to strengthen the data position of agricultural enterprises, with the goal of every farm having control over its data.
- **Alignment with Legislation:** The code is aligned with current legislation, like the General Data Protection Regulation (GDPR), the Data Act, and the Artificial Intelligence Act, with legislation taking precedence.

Core Principles:

- **Control/Data Sovereignty:** User data is only collected, used, and shared if necessary for the agreement or with the user's permission.
- **Transparency:** Clear information must be provided about the data generated by connected products/digital tools (type, format, volume).
- **Purpose Limitation:** Data can only be used for purposes agreed upon with the user.
- **Interoperability:** Efforts should be made to comply with data standards for smooth data sharing.
- **Data Portability:** Users are entitled to receive their data back in a machine-readable format when the cooperation ends.
- **Confidentiality/Privacy/Security:** Data is treated confidentially and securely, with measures against unauthorized access.

Both Spain and the Netherlands utilize **Public Private Partnerships (PPPs)** as a central strategy for advancing digitalization in the agri-food sector (See Box 3). These PPP efforts are aligned with broader EU frameworks. Collaboration opportunities include co-developing digital agricultural solutions, establishing shared R&D centers, and piloting smart village technologies in rural regions.

[8]Code of Conduct for the Use of Agri-Food Data logo by BO Arable Farming, 2025, https://www.bo-akkerbouw.nl/gedragscode-datagebruik-agrifood.

Box 3. Public Private Partnerships (PPP) for Digitalization in Agriculture

Public Private Partnerships (PPP) for Digitalization in Agriculture

- **Spain** and **the Netherlands** utilize Public Private Partnerships as a central strategy for advancing digitalization in the agri-food sector.
- **Spain** supports agri-tech startups and SMEs through public funds and digital transformation platforms. The country also utilizes EU recovery and modernization funds, such as the “PERTE Agroalimentario” and the “Digital Spain Agenda”
- **The Netherlands** fosters innovation financing through entities like banks Rabobank, or **public investment** vehicles like Invest-NL, and the National Growth Fund. It also benefits from a well-developed private innovation ecosystem.

Collaboration Potential: Both countries can leverage PPPs to co-develop digital agricultural solutions, establish shared R&D centers, and pilot smart village technologies in rural regions.

Importance:

- PPPs are crucial for driving innovation, securing funding, and ensuring the successful implementation of digital technologies in the agricultural sector.
- By combining public resources with private sector expertise, both Spain and the Netherlands can accelerate their digital transformation and enhance their competitive edge in the global agri-food market.

Regarding **universal software for agriculture, challenges arise from significant differences in regulations across countries and the characteristics of soil, water, and crop type.** Despite these challenges, the International Organization for Standardization (ISO) has established the "ISO Strategic Advisory Group on Smart Farming" (ISO SAAG Smart Farming) to develop the first roadmap for international standardization in smart farming. This international effort underscores the potential for collaboration between Spain and the Netherlands in contributing to and adopting global standards that facilitate interoperability and data sharing (See Box 4).

Box 4. How to achieve universal software for agriculture?

Universal software for agriculture?

During the interviews with key stakeholders, the critical role of software developers in agricultural digitalization was highlighted. Interviewees emphasized the need for globally usable, harmonized systems that facilitate data sharing, support precision agriculture, and are user-friendly for farmers. Experts stressed that software must adapt to varying regulations and farming practices across different countries.

Creating a universal software for agriculture is difficult due to the significant differences in regulations across countries, covering areas like soil, water, and crop protection. Concerns about data ownership and sharing, varying technical skills of farmers, costs, trust in new systems, and existing outdated systems also pose challenges.

Additionally, the need for harmonization of standards, language and cultural differences, data privacy issues, and resistance to change further complicate the development of a universally applicable software solution.

Note. To address the complexities and challenges of digital standardization in agriculture, the International Organization for Standardization (ISO) has established the "ISO Strategic Advisory Group on Smart Farming" (ISO SAAG Smart Farming). This initiative, prompted by the German Institute for Standardization (DIN), aims to develop the first roadmap for international standardization in smart farming, focusing on the application of modern information and communications technology in agriculture. By fostering global standards, ISO seeks to enhance interoperability, data sharing, and overall efficiency in digital agricultural practices.

Smart Farming relevant standards (interactive visualization)
Updated: 2025-03-27

Results from interviews - what do the experts say?

As mentioned above, several participants shared the same conclusion around the importance of working towards an **updated European-level Code of Conduct for Agricultural Data Sharing by Contractual Agreement (EUCC)**. During interviews, experts mentioned the lack of trust and understanding in the data usage and sharing process as one of the main barriers to farmer uptake of digital technologies. As well as clear codes of conduct, and capacity building from public administrations and farmers cooperatives, the development of a ***European strategy for data spaces with control over data usage and destination*** is highlighted as a necessary step to improve digitalization update. The idea of **digital contracts** ensuring ethical data use and the creation of data spaces for universities and companies through legally binding contracts is proposed. Administrations are also encouraged to make data available

and be clear on the ownership, rights and use of farmers' data. This aligns with the need for legal clarity at the European level and also ensures farmer data is not misused, as mentioned before.

Both countries could collaborate to ensure farmers' data is protected and not used against them, advocating for clarity and process at the European level. Interviewees suggested that governments should ensure that data use benefits farmers and avoids penalizing them for not meeting sustainability metrics, which is a crucial consideration for both the "Code of Conduct" and any data sharing agreements. The Netherlands is already engaged with Brussels on this matter, and Spain's input and collaborative efforts would add substantial value and ensure alignment with the practical needs of both countries' agricultural sectors.

Participants, especially those discussing the Spanish context, highlight a strong emphasis on aligning the ***Common Agricultural Policy (CAP)*** to better support the competitiveness of the European agricultural sector through digitalization. Some interviewees suggest shifting the PAC's focus from social aid to agricultural aid, targeting sector competitiveness, while others were clear that environmental outcomes and monitoring should be a priority. Joint efforts to influence EU regulations, support digital technologies, and ensure data protection are essential for keeping European companies competitive globally. For example, WWF Spain emphasized the importance of advocating for sustainable practices like grazing, addressing the environmental impacts of intensive farming, and promoting policies that reduce protein dependence, support plant-based proteins, and minimize food loss and waste. It highlights the necessity for **strategies tailored to each country's specific geopolitical and biogeographical contexts**, encouraging a dynamic and adaptable approach to policy development. Importantly, Spain, with its extensive experience in highly technical irrigated agriculture, but also important traditional and extensive grazing practices (e.g. the Dehesa agro-ecological ecosystem), can significantly contribute to EU policies regarding said topic.

Finally, there is a recurring theme regarding the **practical aspects of policies.** Interviewees consistently mentioned the need for policies to focus on the operational aspects of theoretical solutions. Involving end-users, particularly farmers, in the development and operation of digital solutions is crucial for successful implementation. A user-centric approach is necessary in shaping digitalization policies, ensuring that they are not only legally sound but also practically applicable and beneficial for those who will be using them on the ground.

3.3. Bilateral Cooperation opportunities in the agri-food sector

Spain and the Netherlands are in a unique position to become strategic partners in leading

the digital transformation of agriculture across Europe. Both nations have implemented robust national strategies aligned with EU initiatives such as the Digital Agenda, the Common Agricultural Policy (CAP 2021–2027), and Horizon Europe. Spain's strategy, outlined in the "Estrategia de digitalización del sector agro-alimentario, forestal y del medio rural" (Ministerio de Agricultura, Pesca y Alimentación, 2021), focuses on reducing the rural digital divide and modernizing its agricultural sector through technologies like AI, blockchain, and IoT. The Netherlands, through its "Dutch Digitalisation Strategy", stands out as a global leader in precision agriculture, smart greenhouses, and AgTech innovation (Ministry of Economic Affairs and Climate Policy, 2019).

The following section outlines key areas where collaboration between the two countries could yield impactful results, leveraging their complementary strengths and shared priorities.

- **Cybersecurity and Agricultural Data Access**

Spain is expanding its open agricultural data platforms but faces challenges by SME adoption, data fragmentation, and cybersecurity (Ministerio de Agricultura, Pesca y Alimentación, 2023). In contrast, the Netherlands has mature digital platforms supported by advanced cybersecurity infrastructure and blockchain-based data verification (WUR, 2022).

Joint initiatives could focus on developing interoperable and secure data platforms that support real-time decision-making. Spain can benefit from Dutch expertise in cybersecurity frameworks tailored for smart farming, while both countries could cooperate on EU-level data governance and ethical standards, as promoted by the European Commission’s Digital Europe Programme.

- **Technological Safety and Dependency**

Both countries recognize the risk of overdependence on technology in agriculture. Spain is in the early phases of deploying large-scale AI (Ministerio de Asuntos Económicos y Transformación Digital, 2020), while the Netherlands is advancing toward fully automated farming models, such as those tested at Wageningen University & Research (WUR, 2022).

There is significant potential for collaboration in researching the ethical implications of AI in agriculture, developing risk mitigation strategies, and creating hybrid models that combine human oversight with automation.

- **Water Governance and Scarcity**

Spain's leadership in smart irrigation, water re-use, aquifer recharge, and desalination technologies is critical given its exposure to drought and water scarcity (Martínez, Victoriano & Maestre, 2022). The Netherlands is globally recognized for advanced water reuse and flood control systems (Cavalcanti et al., 2024).

Co-innovation opportunities include developing AI-powered irrigation and water reuse systems, combining Dutch water management expertise with Spanish precision irrigation systems. These projects align with EU climate resilience programs under Horizon Europe and Copernicus.

- **Soil Management and Regenerative Agriculture**

Spain is advancing in regenerative agriculture and AI-based carbon farming, supported by EU subsidies and national funding through PERTE Agroalimentario (Ministerio de Industria y Turismo, 2022). The Netherlands is at the forefront of digital soil mapping, bioengineering, and digital twins (WUR, 2021).

Partnerships could focus on the co-development of soil health monitoring platforms and AI-based predictive models suitable for diverse European climates.

- **Sustainable Food Chains**

Spain is using blockchain to enhance traceability in organic agriculture and traditional products like olive oil and wine (Carrefour Spain, 2022)m and other high value crops like e,g, avocadoes. The Netherlands leads in integrating blockchain into international food logistics (Supply Chain, 2018 & Chapman, 2020).

Collaboration can include harmonizing blockchain protocols for cross-border food trade and co-developing smart contracts to streamline sustainable supply chains. These efforts support the EU Farm to Fork Strategy.

- **Economically Viable Rural Areas**

Opportunities include piloting Dutch smart village technologies in Spanish rural regions, forming shared innovation hubs, and co-developing rural business models eligible for EU funding under Horizon Europe and Digital Europe, or the current initiatives under the EU Rural Pact like e.g. rural proofing.

In Figure 4 we present an estimated degree of development or maturity that each country (Spain and the Netherlands) demonstrates in key thematic areas related to digital agriculture. These levels are represented on a scale from 1 to 5 in Figure 4, where:

1 = Initial or emerging stage
2 = Early-stage development or partial adoption
3 = Moderate development or partial implementation
4 = Advanced development or strong adoption
5 = High-level maturity, leadership, or full integration

For instance, the Netherlands scored higher in areas like cybersecurity, data platforms, and logistics blockchain integration, due to its established digital infrastructure and advanced smart farming practices. Spain, while also active and highly relevant in sectors like water management and regenerative agriculture, is still in the early phases of large-scale AI.

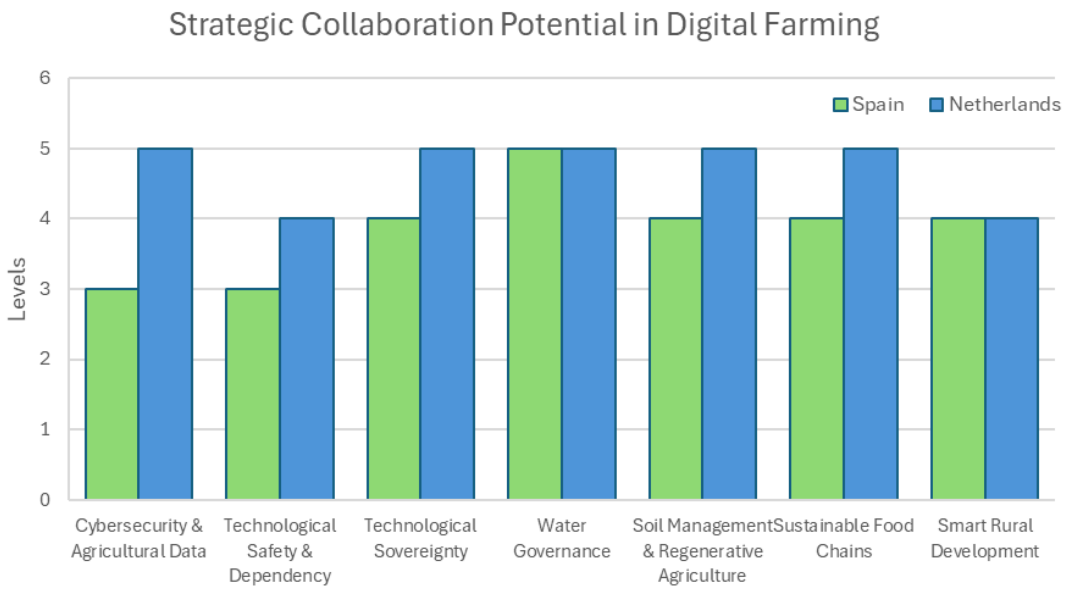


Figure 4. Indicative comparative assessment of collaboration potential between Spain and the Netherlands. Columns indicate the level of development of digital technologies under each theme, ranked from 1-5 based on literature and desk-based review. The themes on the X axis are organised according to areas of interest for the Netherlands Embassy and Netherlands Ministry of Agriculture. Source: Icatalist. (*NOTE: this analysis is qualitative from a theoretical perspective based on our own conceptual analysis and evidence found in policy documents, national strategies, and publicly available information, not on quantitative metrics*)

Results from interviews - what do the experts say?

The interviewees identified significant potential for Spain-Netherlands cooperation in the digitalisation of the food and drink industry, particularly through knowledge exchange, smart technologies and sustainability efforts. The areas mentioned most frequently include smart irrigation, robotics, data platforms and climate change adaptation. Artificial intelligence (AI) and blockchain were highlighted as key elements for improving traceability, automation and farm management. The experts also emphasised the need to improve communication and to convert innovation into practical, farmer-friendly solutions.

The ***Horizon Europe*** ***program*** was identified as a pivotal platform for international collaboration, especially between universities. Wageningen University, for instance, led the ***IoF2020 project*** aimed to accelerate the adoption of IoT in 5 different agrifood sectors (meat, dairy, vegetables, fruits and arable farming). It brought together over 70 partners from 16 countries, including farmers, technology providers, research institutions, and policymakers.

Spain's diverse biogeographical conditions offer an ideal environment for testing Dutch technologies, allowing for real-world validation and adaptation. This is exemplified by the EU-funded ***ROBS4CROPS project***, coordinated by Wageningen University, and aimed to accelerate the adoption of high-tech robotics and automated technologies in the European food and farm industry. Trials were conducted in partnership with commercial farms and business leaders from France, Greece, Spain, and the Netherlands to test and implement these advanced solutions. However, the success of such collaborative projects highlights a **pressing need for clarification at the European level concerning data sharing** and privacy, particularly in relation to GDPR regulations. These clarifications would facilitate smoother collaboration and prevent misunderstandings or regulatory conflicts, as well as having due consideration to potential cybersecurity threats, or current geopolitical trends. This is important, especially since **software systems that work across countries despite varying regulations** are needed in the sector.

3.4. Strategic autonomy and security in the agricultural sector - lessons learned from Spain

3.4.1. Setting the scene

Politically, the post-Covid 19 years are a critical time for the EU, with recent developments across the Atlantic really accelerating the importance and adoption of the concept of (open) strategic autonomy which is particularly important in the context of agriculture. According to

the European Commission "Open Strategic Autonomy (OSA) means cooperating multilaterally wherever we can, acting autonomously wherever we must", meanwhile the Council of the European Union defines it as the "capacity to act autonomously when and where necessary and with partners wherever possible" (Council of Europe 2016). See Box 5 for terminology and definitions.

Box 5 . Terminology and definitions

Terminology and definitions[9]

We define the following concepts and definitions for the purposes of this document:

- **Resilience:** the ability not only to withstand and cope with challenges but also to undergo transitions in a sustainable, fair, and democratic manner. Resilience is necessary in all policy areas, also to undergo the green and digital transitions, while maintaining the EU's core purpose and integrity in a dynamic and at times turbulent environment;
- **Open Strategic Autonomy:** the ability to shape the new system of global economic governance and develop mutually beneficial bilateral relations, while protecting the EU from unfair and abusive practices, including to diversify and solidify global supply chains to enhance resilience to future crises;
- **Strategic capacity:** a certain level of capabilities held within the EU allowing to produce, provide or rely on strategic goods, services, data, infrastructures, skills, industrial know-how and technologies ;
- **Dependencies:** reliance on a limited number of actors for the supply of goods, services, data, infrastructures, skills and technologies combined with a limited capacity for internal production to substitute imports ;
- **Strategic dependencies**: dependencies that are considered of critical importance to the EU and its Member States' strategic interests such as security, safety, health and the green and digital transformation.

Strategic autonomy is particularly pertinent in agriculture since it is crucial for food security, economic, political and social stability, and overall resilience. It allows a country- or the EU- to control its food supply, reduce reliance on imports, and protect its domestic agricultural sector from global disruptions. It means being able to make independent choices about food production and distribution, reflecting European and national interests and values.

In relation to digitalisation a number of factors have to be considered:

- first, how digital technologies can help strategic autonomy in the agri-food sector in terms of production,
- second, how digital technologies can enhance governance and strengthen social networks and benefits for farmers and farming communities, and the wider agrifood sector.
- third, how digital technologies raise issues related to cybersecurity and digital

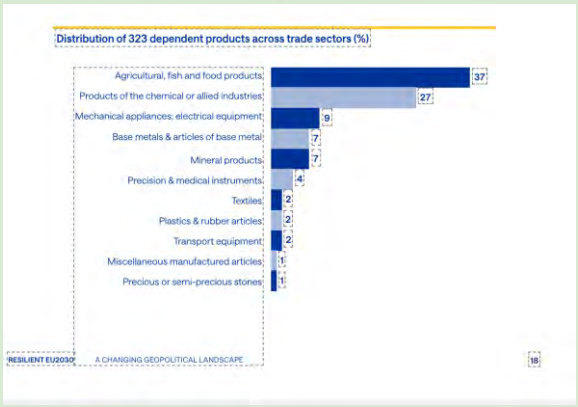
[9] Commission Staff Working Document. Strategic dependencies and capacities. SWD(2021) 352 final, 5 May 2021, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021SC0352

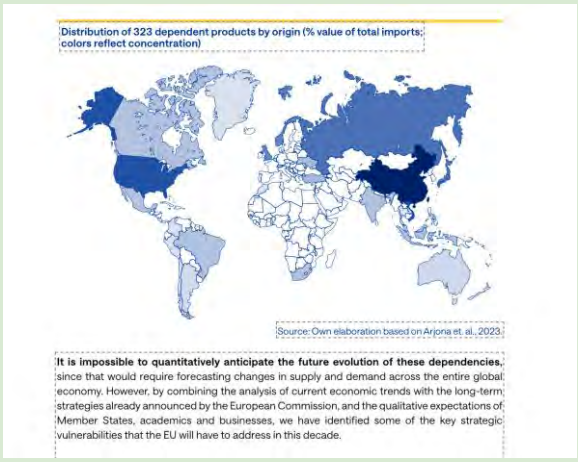
dependencies that can harm or hamper our strategic autonomy in relation to the agri-food sector.

In this section we adopt a multilevel approach; first we analyse recent documents at EU level that help set the common framework for Spain and the Netherlands which offers many opportunities for collaboration based on common principles and constraints. Second, we look in more depth at the Spanish case. Finally, we step out of Europe briefly to look at emerging trends and hegemons that are particularly interesting for our shared sought strategic autonomy in the agrifood sector. In all cases we look at the three key elements outlined above (agri-food, social networks and security aspects).

Box 6. EUROPE 2030 - EU DEPENDENCIES ON THE AGRI-FOOD SECTOR (2024)

EUROPE 2030 - EU DEPENDENCIES ON THE AGRI-FOOD SECTOR (2024)





Source; Moncloa (2023) ResilientEU2030

3.4.2. **Strategic autonomy, agriculture and digitalisation in Europe, and beyond**

Box 7. Big Numbers on EU Agriculture

Big Numbers on EU Agriculture

- Generates 15% of total EU employment.
- Largest agri-food exporter in the world- €230 bn (9% of total exports).
- EU trade imports of €160 bn (6% of total imports in 2024).
- EU trade surplus: EUR 70 billion in 2024.
- EU is highly reliant on imports for the supply of fishery and aquaculture products, oilseeds and protein crops.
- Rural areas are home to 25% of the EU population.
- Rural areas cover 75% of its territory.
- Rural areas are an integral part of Europe's identity and values.

(Source: EU Vision for Agriculture and Food)

In September 2024 a *Strategic Dialogue on the Future of EU Agriculture: A shared prospect for farming and food in Europe* (EC 2024) was published to help set the scene for the *EU Vision for Agriculture and Food* (EC 2025). The Vision was published helpsn to set the framework for the revision of the CAP and the new MFF (from 2028).

Strategic autonomy and digitalization were identified in both documents and are interconnected in the context of the EU's agricultural and food systems since digital tools and technologies play a critical role in enhancing the EU's ability to independently manage its food production, supply chains, and sustainability goals, thereby strengthening its strategic autonomy.

The EU Vision for Agriculture and Food, published within the first 100 days of the new Commission - with new geopolitical winds already apparent, makes explicit reference to strategic autonomy when it states:

> *"But we should never take our food sovereignty for granted. The agri-food sector has withstood the shocks of the pandemic and high input costs, showcasing its incredible resilience. However, the pressure of geopolitical tensions, legacy effects of recent crises, devastating impacts of extreme weather events and environmental degradation as well as the consequences of structural trends are* ***threatening the viability of this important sector and EU strategic autonomy"*** *(...). The European agri-food sector has many strengths and is a leader when it comes to health, safety, quality, sustainability and innovation in food production. We must build on these strengths. But in the current geopolitical context, the Union must sharpen its response to the challenges farmers, fishers, other rural actors and the agrifood sector are facing and* ***prepare for the future with a more assertive policy response in favour of our strategic autonomy and food sovereignty****, while pursuing its objectives of nature protection and decarbonisation.*

In particular special emphasis is placed on dependencies on imports from a small number of countries, therefore putting in focus on how to derisk agrifood supply chains.

> *Diversifying supply chains and promoting transformative resilience In a world marked by geopolitical and geoeconomic tensions, "dependencies are becoming vulnerabilities" in Draghi's words. Today, the EU's food sovereignty depends to a large extent on imported inputs, such as fertilisers, feed and energy, and this usually from geographically concentrated regions.* ***Reducing these strategic dependencies and derisking supply chains is therefore crucial, while supporting a transition to a***

clean and increasingly resource-efficient low-carbon economy.

In relation to how open strategic autonomy can support EU (and thus Dutch and Spanish) food security, there are a number of important aspects to take into account::

1. **Resilience to External Shocks**: By enhancing the resilience of the agri-food systems, the EU can better withstand global disruptions such as geopolitical conflicts, trade restrictions, and supply chain disruptions. This ensures a stable and continuous supply of food within the EU.
2. **Sustainable Agricultural Practices**: Promoting sustainable farming practices helps maintain the long-term viability of food production. This includes reducing dependency on non-renewable inputs, improving soil health, and managing water resources effectively, which are crucial for consistent food production.
3. **Trade Policy Alignment**: Ensuring that trade policies are coherent with sustainability goals and that imports meet EU standards protects domestic producers and maintains high-quality production standards. This reduces the risk of food shortages due to import dependencies.
4. **Innovation and Technology**: Leveraging technological advancements and innovation in agriculture enhances productivity and sustainability. This includes precision farming, biocontrol, and new breeding techniques, which can increase food production efficiency and reduce reliance on external inputs. Working together, the two countries can co-develop digital agricultural solutions to reduce reliance on non-European technologies. For example, joint R&D centers focused on AI, blockchain, and remote sensing would enhance the EU's food sovereignty and support goals set by the EU Open Strategic Autonomy.
5. **Support for Farmers**: Providing targeted support to farmers, especially those most in need, ensures they can maintain a decent income and continue contributing to food security. This includes financial aid, access to technology, and training programs.
6. **Policy Coherence**: Ensuring that agricultural, environmental, and trade policies are coherent and mutually reinforcing creates a stable and enabling environment for sustainable agricultural practices. This helps maintain a reliable food supply.

Thus the overall food security of the European Union can be strengthened by focusing on these areas, ensuring that Europe can produce sufficient food to meet its needs while maintaining high standards of sustainability and resilience.

In relation to agri-food systems we have identified 10 concrete examples (Box 10) and 5 key areas (Box 9) in the the interface between strategic autonomy, digitalisation and agriculture in

the Strategic Dialogue document and the follow up vision:

Box 8. 10 CONCRETE ACTION POINTS FOR FOR DIGITALISATION OF AGRICULTURE IN THE EU

Strategic Dialogue on the Future of EU Agriculture: A shared prospect for farming and food in Europe **10 CONCRETE ACTION POINTS FOR FOR DIGITALISATION OF AGRICULTURE IN THE EU**
Cooperation initiatives between farmers and other supply chain actors in line with **art. 210 a CMO Regulation to reward farmers for their efforts and investments in sustainability.** For example, a sustainability agreement pilot initiative to test the application of art. 210a CMO.
Development of **collaborative structures** in order to disclose the relevant data to the relevant authorities and to the public based e.g. on technologies such as gravimetric measures for groundwater monitoring and **digital tools to monitor the quantitative and qualitative status** of water and soils. Medium term support programmes through an agri-food transition fund to incentivise the **sustainable digital transformation of the agricultural sector,** with better qualified job opportunities, higher pay levels, more attractive career perspectives, safer working environments, higher competitiveness for business undertakings and more environmentally friendly operations. These measures must ensure the inclusion of all farm types in Europe.
An agricultural benchmarking system to better leverage the potential of sustainability certification schemes.Data utilization can offer significant benefits to support the benchmarking system
Digitalization of food business operators including additional **digital labelling**, satellite and drone imagery, artificial intelligence and process automation, and biotechnology.
Creation and scaling up **living labs in specific markets** to implement concrete measures, backed by public investment, to improve critical and sustainable infrastructure for the agri-food sector as well as support and strengthening of **innovation hubs** and experimental settings (such as testbeds, field/living labs, landscaping initiatives and demo farms)
Unified digital portal for all EU and national regulatory and reporting requirements, ensuring a one-stop-shop for farmers and agri-food actors.
Develop a transparent **data governance model** with clear rules on data ownership, interoperability and ethical use, aiming at fair and secure use of data for the benefit of all, taking into account legal and ethical aspects development and application of data acquisition, interpretation and development of relevant algorithms and AI tools
Promote in the international trade context the widespread adoption of digital tools and platforms to simplify administrative tasks. **Digitalization** can improve the management of **sourcing and trade flows**

Improving the development of digital infrastructures and **high capacity digital networks all across the EU for the benefit of rural areas** as a whole, including access to social services, education, training, healthcare, and culture; while being **aware of the so-called digital divide**. that can entail socio-economic risks and challenges such as changes in the public sphere, job losses, new skills requirements,
Invest in agriculture-related digital education and food literacy to increase public and professional awareness of sustainable food systems, highlighting the benefits, risks, and trade-offs associated with different approaches, to be included in the design, governance and functioning of **farming extension and advisory service**s, aimed at providing farmers and food producers – in an inclusive way – with access to free and independent expert guidance, technical assistance, and training programs.

Box 9. EU VISION ON AGRICULTURE: 5 PILLARS FOR DIGITALISATION

EU VISION ON AGRICULTURE: 5 PILLARS FOR DIGITALISATION
EU Digital Strategy for Agriculture: The Commission plans to launch a digital strategy to enable a future-oriented farming and food sector. This includes integrating digital systems, harmonizing data collection, and reducing reporting burdens for farmers under the "collect once, use multiple times" principle.
Digital Tools for Simplification: Technologies like earth observation satellites (e.g., Copernicus and Galileo) can reduce on-the-spot controls and reporting obligations, improving resource use and sustainability.
Digital Transition in Agriculture: Advanced digital technologies, such as artificial intelligence (AI), Internet of Things (IoT), and data-driven solutions, can enhance farm performance, sustainability, and resilience. However, adoption remains slow due to high costs, lack of digital skills, trust issues, and connectivity challenges.
Common European Agricultural Data Space: This initiative aims to create a unified framework for data sharing, fostering innovation and reducing administrative burdens.
Lifelong Digital Skills Training: Investments in digital skills training and advisory services are essential to encourage adoption and innovation in the sector.

Lastly, we present an overview and short analysis in relation to the external aspects of strategic autonomy, digitalisation and agriculture in relation to the US, China and the rest of the world.

In relation to the US, it is important to note that according to Nobles et al. (2022)[10] "*The food and agriculture sectors are considered critical infrastructure. The U.S. Cybersecurity and Infrastructure Security Agency (CISA, 2022a) classifies critical structure sectors as the domains whose resources, structures, and networks, both physical and virtual, are essential to the U.S".* This is important because it coincides with the current approach adopted by the EU, with two marked differences; first, in the case of the EU there is now a focused effort first, to understand external dependencies in relation to food, but also and second, combined with the idea of "open" strategic dependency which still gives a role to trade and multilateral relations. This balancing act will be a key aspect in the coming years with changing geopolitical conditions.

3.4.3. **Strategic autonomy at the national scale**

In 2023 during the EU Spanish presidency, Spain prepared a substantive paper on strategic autonomy which included aspects related to both agriculture and digitalisation (Spain's National Office of Foresight and Strategy, 2023). This paper served as the basis for the strategic documents outlined earlier on the strategic dialogue and EU Vision. In particular it identified agriculture, fish and food products as the main sector where the EU is externally dependent, with some of these dependencies heavily concentrated on a number of small non EU countries (See Box 6).

In Valencia, recently hit by a very serious extreme DANA event in November 2024, Spain launched its "National Food Strategy" (Estrategia Nacional de Alimentación or ENA (MAPA 2024) at the same time that the EU launched its EU Vision for Agriculture and Food, . A few months later the official presentation of the document took place in February 2025, led by the President of the Government, Pedro Sánchez, and the Minister of Agriculture, Fisheries, and Food, Luis Planas. The very purpose of the Spanish National Food Strategy states how it is central to improve strategic autonomy: "*The purpose of the ENA is to build a sustainable food system in Spain and Europe to achieve Open Strategic Autonomy";* thus ensuring food supply under a sustainable model while strengthening the role of food chain operators. The aim was to generate fairer economic returns, and create new business opportunities. Six key challenges were identified in the strategy as shown in Box 10:

[10]Nobles, Calvin & Burrell, Darrell & Waller, Tyrone & Cusak, Austin. (2022). Food Sustainability, Cyber-Biosecurity, Emerging Technologies, and Cybersecurity Risks in the Agriculture and Food Industries. International Journal of Environmental Sustainability and Green Technologies. 13. 1-17. 10.4018/IJESGT.309744.

Box 10. Challenges found in the Spanish National Food Strategy (2024)

Challenge 1: Strategic Supply

1. Promote the availability and stability of food supplies.
2. Implement trade policies that guarantee the competitiveness of the Spanish agri-food and fishing sector.
3. Optimize efficiency in the value chain.
4. Define response protocols for crisis situations.

Challenge 2. Sustainable Food Systems

5. Incorporate sustainability criteria in public procurement.
6. Promote the proper management of packaging and packaging waste, preventing environmental waste and the overuse of unjustified packaging, and boosting the market for secondary raw materials for reintroduction into new products.
7. Promote policies and projects that work towards circularity and integrate the bioeconomy to utilize and valorize agri-food by-products and waste, thus improving the profitability and efficiency of the agri-food value chain.
8. Continue to promote and effectively implement environmentally sustainable practices in food production.
9. Promote the sale of local, fresh, and seasonal products and encourage short marketing channels.
10. Promote actions that help reduce food waste.
11. Provide training and advice to all stakeholders in the transition to a more sustainable and resilient food system.

Challenge 3. Rural and coastal areas highly dependent on fishing

12. Ensure adequate training for the sector to improve its competitiveness.
13. Enhance and strengthen rural areas through financial support and the implementation of rural policies aimed at building a sustainable, efficient, and resilient sector.
14. Promote generational renewal to ensure the future of rural and coastal areas.

Challenge 4. Healthy eating.

15. Defend a healthy diet
16. Accessibility to the Spanish diet.
17. Educate and inform about the Spanish diet.

Challenge 5. Innovation and Technology in Food

18. Promote innovation in the Spanish agri-food and fisheries sector.
19. Digitize the production models of the agri-food and fisheries system.
20. Stimulate the generation and transfer of knowledge among the various stakeholders in the agri-food and fisheries chain.
21. Promote investment in technological and digital innovation and promote regulations that foster innovation to achieve modernization of the sector in our country.

Challenge 6. Food information for consumers

22. Food information available through labeling.
23. Food information available through purchasing channels and points of sale.
24. Food information available through communication campaigns.
25. Ensure that food information is accurate.

It is relevant for relations with other member states like the Netherlands, that Spain also identified the importance of Common Market Organization (COM)[11] and CAP regulations, instruments that clearly can help to develop and improve the Open Strategic Autonomy for the whole European agri-food system.

In this context the Spanish Food strategy states: *"the European Commission should establish a classification of agri-food and fisheries sectors according to their degree of risk of self-sufficiency. Based on this assessment of the risk of shortages, measures should be established to promote subsectors, in parallel with the establishment of trade measures that facilitate access to these agri-food and fisheries raw materials.The aim of this initiative is to improve the degree of food self-sufficiency for all Member States".*

In the Netherlands, the political and economic context of the past 5 years, including the difficulties in trade and supply chain operations stemming from the COVID19 pandemic and the Russian invasion of Ukraine in 2023, have also heightened calls for a greater integration between national agriculture, food and strategic autonomy agendas. For example, IDH submitted a paper in January 2025 for the Round table discussion on Food Security held in February 2025 by the Committee on Foreign Trade and Development Cooperation (Commissie Buitenlandse Handel en Ontwikkelingshulp) of the Dutch House of Representatives (Tweede Kamer)[12]. The paper addresses the need for sustainable supply chains for food and agriculture products, as key parts of national food security.

Results from interviews - what do the experts say?

Experts highlighted several crucial aspects of strategic autonomy in agriculture. They emphasized the significance of data sharing for benchmarking and sustainability but stressed the need to guarantee benefits for farmers who contribute their data, and clear ethical guidelines of data sharing and use. This led to discussions about "Cooperativa de Datos," or data cooperatives (see Box 11), operating under GDPR (General Data Protection Regulation) to ensure data ownership and control for farmers. However, concerns were raised regarding the lack of clarity in EU-level regulations concerning data ownership and usage, with calls for more regulatory expertise in the agricultural sector, particularly concerning AI (Artificial Intelligence) and data governance. Additionally, there's a

[11]https://www.europarl.europa.eu/factsheets/en/sheet/293655/the-common-organisation-of-the-markets-cmo-regulation
[12]https://idh.org/news/food-security-and-global-value-chains-of-food-and-agricultural-products-towards-an-action-plan-in-the-netherlands

perception that Europe's stringent data protection regulations, while crucial for privacy, could create a competitive disadvantage compared to global players with fewer restrictions. This has led to suggestions for implementing external limits on non-European companies to level the playing field.

Furthermore, there were diverse perspectives on defining strategic autonomy. Some argued that "open" strategic autonomy might be contradictory in practice, advocating instead for prioritizing sustainable agriculture and livestock farming that restores ecosystem services. There was a notable reluctance to share data due to competitive concerns, except when legally required, highlighting the sensitive nature of data control and privacy, especially for data related to phytosanitary products, fertilization, and water use. Experts also pointed out "vendor locking," which means farmers becoming overly reliant on specific technology providers. Lastly, the interviews stressed the need for training and education in areas like biosecurity, cybersecurity, and new technologies to address farmer concerns and build trust in data sharing.

Box 11. Data Cooperation by “Cooperativas Agro-alimentarias”

Data Cooperation

by “Cooperativas Agro-alimentarias”

The report includes a wealth of socioeconomic data regarding agri-food cooperatives in Spain, such as the number of cooperatives totaling 3,669 and the membership which currently exceeds 1 million individuals. The total turnover of these cooperatives is reported at 43,207 million euros in 2018, and they provided direct employment to 122,615 people for the same year. The document also details the geographical distribution of these cooperatives, including their economic weight within each Autonomous Community, notably highlighting the significance of Andalusian cooperatives which represent 22,4% of the total. Furthermore, the report compares the turnover of the cooperative sector compared to the broader Spanish Food Industry in relation to the value of the Final Agricultural Production and the Net Sales. This provides a valuable baseline for the sector's economic relevance. The document outlines key agri-food cooperative sectors and subsectors, such as olive oil, supplies, animal feed, cereal crops, dairy, wine, fruits, and vegetables.

Additionally, the report analyzes the internationalization of cooperatives by examining export turnover, the number of exporting cooperatives, and their primary export destinations. The document also notes the increase in the production and commercialization of ecological products from 2011 to 2022. Finally, the report includes data on participation, focusing on the involvement of women and young people as members and in management positions. Specifically, women represent 28.3% of the social base, 10.1% of the composition of the governing councils, 4.8% hold the presidency, and 14.3% hold management positions.

Additionally, young people represent 9.8% of the social base, 7.9% of the composition of the governing councils, 4.1% hold the presidency, and 7.1% hold management positions.

NOTE: A formal request is being submitted to the European Commission to address and clarify ambiguities found within existing European regulations regarding the classification of certain data types (such as personal data), which are subject to interpretation due to identified legal loopholes. This ambiguity creates challenges in ensuring compliance and effective data management within the agricultural sector. A formal request for legislative clarification has been made to the European Commission to resolve these issues and provide a more definitive framework. Further details are not available at time of writing.

Source: Informe Cooperativas Agro-alimentarias 2023

3.5. Overcoming societal challenges through digitalization of agriculture: Lessons drawn from Spain

Spain, with its diverse geography and strong agricultural tradition, has faced numerous societal challenges within the agricultural sector — from rural depopulation, lack of workforce continuity, to water scarcity and extreme weather events due to climate change. The digital transformation of its agricultural sector offers an important opportunity for the sector to support the sector in adapting to this changing world, and for countries like Spain and the Netherlands to learn from each other and mutually benefit when confronting similar pressures. Here we summarise some of the key challenges, with examples of programmes and collaborative initiatives (at different stages of development) to combat them:

- **Water Efficiency and precision agriculture in a Water-Stressed nation:** As mentioned previously, Spain is both highly vulnerable and highly advanced in development precision technology to combat droughts and water scarcity. Digital tools like smart irrigation systems, satellite imagery, and AI-powered weather forecasting have enabled Spanish farmers to optimize water use. This approach not only supports environmental sustainability but also contributes to economic resilience in the face of climate variability.
- **Social Inclusion through Digital Training:** The Spanish government and regional initiatives have invested in digital skills training for farmers, including women and older workers. These programmes are supported by the government, as well as farming cooperatives, who recognize the possibility of digital transformation for attracting and retaining skilled workers in the sector, of all ages. Examples include the “Rural Digital Challenge” programmes, which offers digital training and support in rural areas[13] and

[13] https://www.miteco.gob.es/es/prensa/ultimas-noticias/2023/12/miteco-convoca-ayudas-21-millones-proyectos-capacitacion-digital-medio-rural.html

supported by the Spanish Ministry of Ecological Transition and Demographic Challenge (MITECO) with 21 million Euros; and the Digitalizacion Strategy for the Agrifood, Forestry sectors and Rural environment [14] which states Objective 1 as "reducing the digital divide".

- **Strong collaboration between government, academia, and the private sector**. Innovation hubs, agri-tech think tanks and research centres, and Living Labs have fostered the development of scalable digital solutions tailored to local contexts. Notable examples are the Cátedra Internacional de Inteligencia Artificial y Agricultura at the University of Córdoba[15] and AgroBank Tech Digital INNOvation[16] (driven by CaixaBank and AgroBank).

  The **Proyectos Estratégicos para la Recuperación y Transformación Económica (PERTES)** exemplify this collaboration. These strategic projects for economic recovery and transformation involve public-private partnerships aimed at modernizing the agricultural and agri-food sectors. The **PERTE de digitalización del regadío** (digitalization of irrigation), launched in 2023, received 137 projects covering 1.3 million hectares with €100 million in funding, focusing on electronic processing, GIS inventories, and technological water volume control improvements. The **PERTE Agroalimentario** (agri-food industry), approved in 2022, aims to enhance sector competitiveness, sustainability, and traceability with a €3 billion projected economic impact and investments in industry support, digital adaptation, and research.
- **Boosting Agricultural Competitiveness and Traceability:** This is an area of potential growth for the Spanish sector, which heavily depends on exports of produce to other European countries where traceability and environmental and water standards are increasingly important to consumers. Digitalization allows Spanish producers to better compete in international markets, with the development of technologies for blockchain-based traceability, supply chain transparency, and farm-to-fork tracking. These innovations will also help meet EU regulatory standards and differentiate Spanish products globally.

[14] https://www.mapa.gob.es/es/ministerio/planes-estrategias/estrategia-digitalizacion-sector-agroalimentario/
[15] https://i-sml.mtrbio.com/public/smartlink/CatedraENIAgri
[16] https://www.caixabank.com/en/headlines/insights/the-companies-revolutionising-the-spanish-agricultural-sector

Results from interviews - what do the experts say?

Responses related to socio-economic challenges in Spain reveal significant concerns about the aging farming population and the challenge of attracting young people to rural areas. Interviewees note a general resistance to adopting new technologies due to cost, perceived risks, and a reluctance to change, especially in a sector often characterized by traditional practices, and ageing workforce. The complexity of technologies like AI and blockchain makes them difficult for many farmers to understand and accept. Participants also mentioned that often, technological development and private investment into different digital technologies does not match the real needs of the sector. There were calls for technology and software companies to actively engage with the farming community to develop tools which are useful, and work within the existing regulatory framework.

QUOTE: "The data should serve the farmer, not the other way around"

Rural exodus is another major problem, leading to a lack of farmer replacement and threatening the sustainability of agricultural communities. This depopulation, combined with Spain's highly diverse agricultural landscape, makes it challenging to concentrate efforts on technological advancements and support compared to countries with more homogeneous agricultural systems.

Moreover, the historical experience with past information systems (like SIEX) has resulted in skepticism towards new digital initiatives. There's also the challenge of ensuring digital solutions are tailored to meet diverse farmer needs rather than being imposed as one-size-fits-all solutions. Overall, addressing these socio-economic challenges requires not only technological advancements but also educational programs, support structures, and policies that encourage the younger generation to engage in agriculture and that overcome the hesitancy towards new technologies within existing farming communities. These efforts are crucial for ensuring the long-term viability and modernization of the Spanish rural agri sector.

3.6. The dutch ‘Goals Steering Approach’ (doelsturing): opportunities for application to the digitalization of the agricultural sector

"Doelsturing" is a Dutch policy approach, often translated as "Goal Steering Approach" or "Management by Objectives". In the context of agriculture, the current Dutch government is interested in implementing this approach in the agricultural sector as a way to to tackle environmental problems via outcomes-based rewards and monitoring, and incentivise approaches which lead to positive outcomes for nature[17]. Following this approach, instead of the government dictating specific methods farmers must use (means-based regulation), “Doelsturing” focuses on setting clear environmental and sustainability goals.

This approach aims to empower farmers, recognize the diversity of agricultural practices, and prioritize achieving desired outcomes over strict adherence to prescribed methods. Farmers are then given the flexibility and autonomy to choose the methods and technologies that best suit their specific situations to achieve those goals, by both the Dutch government as agri-food companies. It contrasts with a more rigid, rule-based policy approach, such as that currently in place in the Netherlands. This rule-based policy approach is still the current approach for laws and regulations in The Netherlands. Examples of this are the 7th “Actieprogramma Nitraatrichtlijn” (Action Programme Nitrates Directive) (LNV Ministry, 2021), which links to the EU Water Framework Directive (EC, 2000).

“Doelsturing” is yet only applied in pilot projects, and the focus of policy-makers and scientists is currently on the development of appropriate Key Performance Indicators (KPIs) which can support the monitoring and reporting of this approach.

For example, Wageningen Environmental Research (WEnR, part of WUR, commissioned by the Dutch Ministry of Agriculture) is currently researching which set of KPIs (key performance indicators) can be used by the implementation of Doelsturing. The next steps should be for the government to make choices about the target values per KPI, and create a legal basis for the implementation, while ensuring integrality on all relevant environmental and sustainability goals. Digitalization can support this process, especially in relation to easy and accessible monitoring and data collection that will support the reporting based on these KPIs.
If you look at the (research) projects which have been done on “Doelsturing” in The Netherlands, a few focus areas for future work are identified:

1. In the creation of KPIs, we must ensure integrality on all relevant environmental and sustainability goals. In other words, make sure that you first create an overview of all

[17]https://www.nieuweoogst.nl/nieuws/2024/09/18/hoe-kan-doelsturing-vorm-krijgen

parameters needed (Reijs & Van Doorn, 2023), and do not start with only a part of these parameters, because it could jeopardize the integrality (Boerennatuur, 2024).

2. There should also be a clear legal basis for implementation, which is technically feasible to execute (and considers farmer skill sets and training needs).
3. Implementation of “Doelsturing” does not mean that all regulations could or should be abolished. Regulations which proved to have a positive effect on (a) certain parameter(s), should be retained (Ros et al., 2024).

Results from interviews - what do the experts say?

There were mixed responses in terms of the role or potential for *Doelsturing* to be integrated in the digitalization agenda. The most clear response was that digitalization and data can support collecting and monitoring indicators in a standardized way which would facilitate the reporting for farmers, and thus facilitate following a Doelsturing approach. Interviewees considered that digitalization is a powerful method to transparently show your farming method. The easier it is made by tech providers and the government, the more transparent the systems will be. The responses and discussion around Doelsturing were also linked to the creation and monitoring of Key Performance Indicators, KPIs. For example, one participant mentioned that making the calculations of the KPIs easier and giving more control to the farmer is the priority. Overall, the prevailing theme is general support for goal-setting in sustainability, rather than specific discussions on a defined "goal-steering" framework (this was also due to a lack of knowledge on the concept by many participants). Some participants also expressed interest in seeing the lessons learned from the Netherlands be shared and applied to European policies, such as the CAP.

3.7. Deep dives - learning from Spain

One key characteristic of the digital transformation of the agricultural sector in Spain, and indeed of the agricultural sector in general, is the regional differences stemming from Spain’s political system which grants regional autonomy to its 17 Autonomous Communities. In addition to this de-centralized political system, Spain’s geography and biogeography are highly diverse, resulting in varied landscapes, climates, and agricultural practices. To highlight these regional differences and highlight key advances and digitalization, we explore three case studies, identified due to their novel approaches, examples of cooperation across sectors, and recommendations from interviewed experts.

1. Cartagena municipality (Murcia Autonomous Community):

- Murcia's significant water scarcity challenges have driven the adoption of advanced irrigation technologies and water management systems over the past decades.
- The company ***FutureWater*** highlighted Cartagena is ahead in digitalization, citing the **"Comunidad de Regantes de Campos de Cartagena"** and their advanced water resource planning, like the computerized platform for sustainable fertigation management developed in collaboration with the **Polytechnic University of Cartagena (UPCT),** which integrates soil-plant-atmosphere data through sensors, drones, and satellites. This indicates a pioneering role in adopting digital solutions.
- The **Observatorio para la Digitalización del Sector Agroalimentario** highlights Murcia's interest in robotizing plant protection product application. This indicates a precision agriculture approach and specialized crop needs, which shows a targeted approach to technological solutions.
- **The association "Asociación Española de Riegos y Drenajes (AERYD)"** emphasizes the high efficiency of water use in the "Comunidad de Regantes de Campos de Cartagena," highlighting its leadership in water-related technologies and digitalization like for example the implementation of fertigation platforms, the use of multispectral indices from satellite and drone imagery, and continuous data monitoring from soil and environmental sensors.
- Murcia is highly willing to share data (94.8%), crucial for advancing digitalization and innovation, as shown by data in the Observatorio para la Digitalización del Sector Agroalimentario.
- Murcia prioritizes the collection and sharing of fertilization data for input optimization and sustainability.
- Murcia and Valencia prioritize irrigation technologies according to the Observatorio para la Digitalización del Sector Agroalimentario.

Figure 5. Fields of Cartagena, 2022, Ayuntamiento de Cartagena (https://urbanismo.cartagena.es/medionatural/areas.asp?CodMenu=001&Ficha=120).

2. Almería province (Andalucía Autonomous Community):

- Almería's extensive greenhouse operations and intensive agricultural practices heavily rely on technology for climate control, irrigation, and pest management. This technological dependence drives innovation and digitalization, making it an excellent example of how technology is integrated into high-yield, resource-intensive farming.
- Interviews with **Cajamar** highlight Almería's experimental center (**Estación Experimental Cajamar;** see also **Tecnova**) and advanced irrigation/fertilization sensor companies like **Ikostech**, establishing the region as a hub for agricultural technology development and adoption. This signifies a proactive approach to technological advancement.
- **The company FutureWater** emphasizes Almería's focus on water management, crucial in its arid environment. This aligns with the need for water-related technologies and sustainable practices, making it a valuable case study for water-scarce regions. For example, the upcoming Unica Agribusiness Centre features greenhouses, AI, sensorics, big data zones, and experimental farms integrated into the **Parque Cientifico Tecnológico de Almería (PITA).**
- Almería's significant economic contribution to Spain (roughly 1.2 percent of Spain's GDP) and its role in retaining rural populations through intensive agriculture underscore the broad impact of digitalization efforts. Almería occupies 1.73% of Spain's surface area, a percentage slightly higher than that observed in terms of population (1.43%). Almería experienced a population increase of over 100,000 people between 2001 and 2007 (growth rate of 3.27%), more than double the national average. Its youth population (under 15) remains above the national average (16.7% vs. 14.3%), while older population levels are lower (12.7% vs. 16.7%), highlighting demographic vitality supported by agricultural employment (Fundación BBVA, 2007).
- As part of Andalusia, Almería shows a strong interest in robotizing harvesting, as noted in the Observatorio para la Digitalización del Sector Agroalimentario, reflecting its large-scale agricultural operations and the need for automation in labor-intensive tasks.
- Inferred Data Needs: Although not explicitly mentioned in the Observatorio para la Digitalización del Sector Agroalimentario, Almería's intensive agriculture implies a high need for data related to irrigation, climate, and crop management, critical for precision agriculture in its greenhouse operations.

Figure 6. Intensive agriculture in Almeria, 2016, Grupo Cajamar (https://www.plataformatierra.es/innovacion/contribuciones-economicas-sociales-y-medioambientales-de-la-agricultura-intensiva-de-almeria-1).

3. The Valencian Autonomous Community:

- The region's history of irrigated agriculture makes irrigation management a critical issue, driving the adoption of digitalization solutions for water efficiency. The Observatorio para la Digitalización del Sector Agroalimentario notes the community's significant interest in the robotization of irrigation, reinforcing this focus.
- The Valencian Community's diverse agricultural production (across its three provinces, Valencia, Castellón and Alicante), including citrus fruits and vegetables, necessitates a variety of digital solutions like remote sensing, smart traps, and AI-powered pest detection systems. This makes it a valuable case study for exploring different digitalization approaches and adaptability, such as the adoption of satellite monitoring, hyperspectral drone imagery, and electronic noses for pest detection in the **Sensoplag project**.
- The Valencian region's location, with its coast and ports, makes it very important for agricultural trade. Digital tools can improve how they handle shipping and the movement of goods, making digitalization even more important for the region and the whole country.
- Industries in the Valencian Community also focus on the water-food-energy nexus, looking at energy consumption data, indicating a concern for efficiency and sustainability in the broader agri-food industry.

Figure 7. Valencian fields, 2025, FruitToday. (https://fruittoday.com/el-peor-ano-de-la-historia-reciente-para-la-agricultura-valenciana/)

The **"Observatorio para la Digitalización del Sector Agroalimentario"** developed by the Spanish Ministerio de Agricultura, Pesca y Alimentación (MAPA) in collaboration with Grupo Cajamar, is a key resource for understanding the current state and future trends of digitalization in Spain's agri-food sector, and differences between Spain's 17 Autonomous Communities (See Box 12). It is also an example of effective public-private sector collaboration, and has led to the creation of initiatives such as **DigiMapa** (Box 13). This observatory provides comprehensive analyses, data, and reports on the adoption of digital technologies across different regions and agricultural sub-sectors in Spain. It was utilized to identify case studies as it offers insights into regional variations, technological adoption rates, and strategic priorities, allowing for the selection of areas that exemplify innovative practices and challenges in agricultural digitalization.

Box 12. Differing perceptions of digitalization strategies among sectors (agriculture, livestock farming, and agri-food industry) and Autonomous Communities in Spain.

Differing perceptions of digitalization strategies among sectors (agriculture, livestock farming, and agri-food industry) and Autonomous Communities in Spain

Sectoral differences:

- **Agriculture:** Focuses on *irrigation efficiency, input management (fertilizers, pesticides), and pest/disease detection*, driven by sustainability and regulatory requirements
- **Livestock:** Prioritizes *animal welfare monitoring technologies, farm condition control, and automated feeding systems the need to monitor animal well-being.*
- **Agri-food Industry:** Emphasizes *automation of production processes, quality control systems*, with less immediate focus on emerging technologies like AI or blockchain (although their potential is recognized) the optimization of production efficiency.

Regional differences:

- **Andalusia, Aragon, Castilla-La Mancha,** and the **Community of Madrid** show a high percentage of respondents interested in *robotizing harvesting*, reflecting their large-scale agricultural operations.
- **The region of Murcia** stands out for its interest in *robotizing the application of plant protection products*, likely due to specialized crops and intensive farming practices.
- **The Valencian Community** shows significant interest in the *robotization of irrigatio*n, aligning with its focus on irrigated agriculture.
- **Canary Islands, Aragon, Extremadura**, and **Murcia** show the highest willingness to share agricultural data, whereas **Asturias, Madrid,** and **La Rioja** demonstrate lower percentages. This disparity suggests differing regional views on data ownership and privacy.

Source: Observatorio de la Digitalización del Sector Agroalimentario 2024.

Box 13. DigiMapa

DigiMAPA

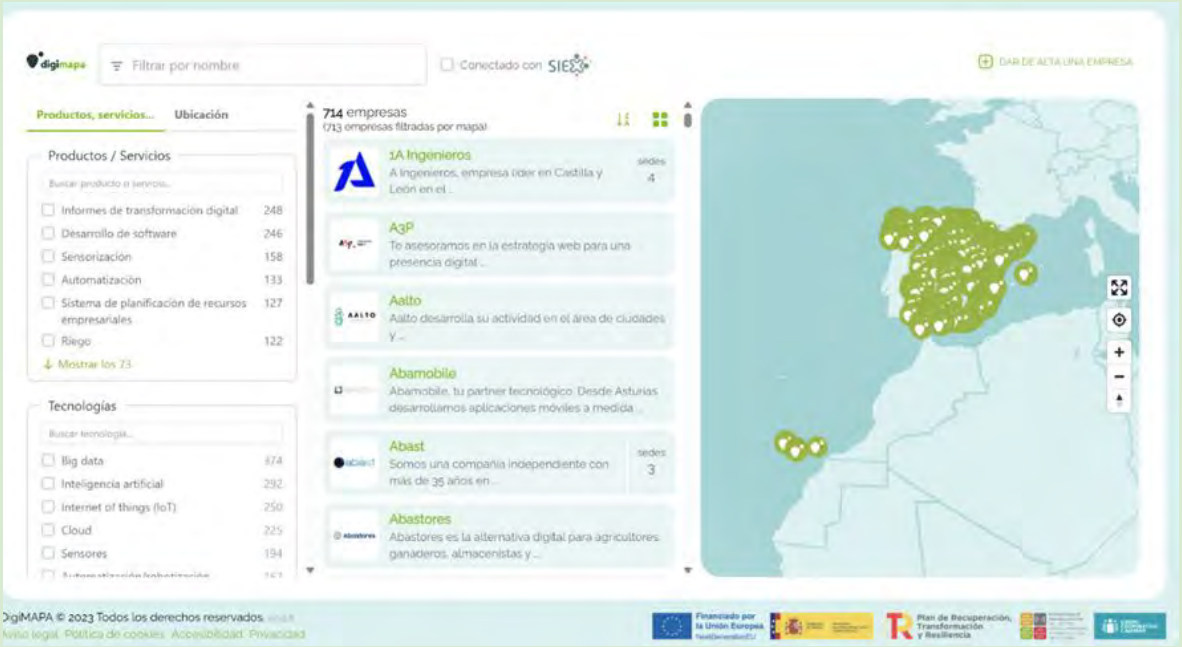
DigiMAPA is a free digital platform developed by the Observatorio para Digitalización del Sector Agroalimentario Español, as a joint initiative of the Ministerio de Agricultura, Pesca y Alimentación (MAPA) and Grupo Cajamar. It is a search portal designed to connect

technology providers with end-users in the Spanish agri-food industry.

Key Features:

- It aims to bridge the gap between companies offering digital technologies (agritech) and agri-food operators seeking these solutions.
- The platform contains information on over 660 companies specializing in ICT, automation, and robotics for the agri-food value chain.
- Geolocalisation of company headquarters, mapping over 1,200 different locations.
- Each company has a detailed profile that includes a description of activities, website access, contact information, and detailed classifications of their offerings.

Its purpose is to facilitate the digital transformation of the Spanish agri-food sector by providing easy access to technology providers and fostering communication between stakeholders.



4. Recommendations

- **Strengthen collaborations and PPPs between and within Spain and the Netherlands:** Specifically, we see a great opportunity for Dutch companies and research instituted to test the latest digital technology in the Spanish territory, collaborating with its producers and utilizing the variety of climates, landscapes and territories Spain offers.
- **Sharing knowledge and innovation:** Our desk-based research and interview data collection highlights Spain's leading role in precision irrigation and water management. In this aspect, northern European countries, including the Netherlands, should increase collaboration and knowledge sharing in the face of increasing unpredictability of weather patterns, and increasing drought events which will affect agricultural productivity. Likewise, the research and interview results highlight the leading role of the Netherlands in developing digital technologies, and exporting this knowledge, while partnering through test and demonstration sites, such as through "Living Labs", could benefit both countries.
- **Understand the local context**: We encourage the continuation of national and regional contexts to be represented in policy-making, since the realities of both study countries remain different, and social and political differences must be understood and considered when developing and implementing digitalization agendas. The digital transformation must be ethical, just, and sustainable - leaving nobody behind.
- **Strengthen the role and voice of farmers:** We must ensure technology and digital transformation works for and with farmers, not against them. Moving away from binary views, sustainable and regenerative agriculture are not incompatible with modern technologies, rather they should work with them to maximise their potential. Traditional and cultural knowledge in the agricultural community must be considered and included together with technological and innovation advances.
- **Data ethics:** An underlying message across the interviewed experts, from all sectors, is that there is a lack of clarity and process for the ethical and transparent collection, sharing, and use of agricultural data. It is imperative that protocols or agreements are put in place if digitalization in the sector is to be adopted by the farming community.

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Annex

Annex I. List of interviewed participants

Interviewed experts and their identity are kept anonymous. We summarise here the number of interviews conducted for each sector and organization:

Sector	Organization name	N Interviews
Public Administrations	Ministry of The Netherlands	1
	Tragsa/ AERYD	1
Banks	Cajamar	1
	Rabobank	1
Private sector	ACCIONA	1
	BO Akkerbouw	1
	FutureWater	1
Associations/Organizations	Cooperativas Agro-Alimentarias	1
	Coordinadora de Organizaciones de Agricultores y Ganaderos (COAG)	1
	WWF España, Agriculture Department	1
Universities and Institutes	Wageningen University and Research (WUR)	1
	University of Valencia (UV)	1
	University of Cordoba (UCO)	3
TOTAL		**15**

Annex II. Companies working in the Netherlands (non-exhaustive)

We have compiled a list of companies in the Netherlands which are leading in the space of digitalization and agricultural digital transformation:

- Crop monitoring with drones and sensors: **CropX** offers platforms that integrate data from various sources (satellites, drones, sensors) to provide farmers with real-time insights into crop health, soil conditions, and weather patterns. This allows for optimized irrigation, fertilization, and pest control, leading to increased yields and reduced environmental impact. They operate internationally.
- **Priva** develops automated greenhouse control systems that optimize climate, irrigation, and lighting based on real-time data and AI algorithms. This leads to higher yields, improved quality, and reduced resource consumption. They operate

internationally.

- **Wasteless** is developing AI-powered pricing systems that dynamically adjust prices for food products nearing their expiration date, incentivizing consumers to purchase them and reducing waste. They operate internationally.
- Start-up incubators and accelerators: Organizations like **StartLife** and **Foodvalley NL** provide support and resources to agri-food tech start-ups, fostering innovation and entrepreneurship in the sector. They operate internationally.

Annex III. Companies and organizations Spain (non-exhaustive)

- **HEMAV** created **LAYERS**, an AI-driven platform that forecasts crop yields (in tons per hectare) and supports smarter, more efficient farm operations. Their technology helps agricultural businesses—from growers to food producers—make informed decisions, cut down on waste, and boost productivity. It also provides valuable insights for financial stakeholders involved in trading, lending, and insurance. HEMAV operates on a global scale.
- **VisualNACert** offers a cloud-based farm management solution that blends geospatial technology with advanced data analytics. It empowers farmers to make better decisions, improve crop performance, and adopt more sustainable practices. Their services are primarily focused within Spain.
- **Agroptima** delivers a user-friendly mobile app and cloud platform that simplifies farm management. It allows farmers to track and analyze their fieldwork in real time, helping them work more efficiently and sustainably. Agroptima mainly serves the Spanish market.
- **Odins** is a Spanish tech company offering IoT-based solutions for precision farming, livestock management, and aquaculture. Their Smart Agro platform integrates real-time data from soil, climate, and plant sensors, satellite imagery, and automated systems. This enables producers to fine-tune irrigation, monitor pests, manage livestock feeding, and optimize fish farming environments. Odins works with clients both in Spain and internationally.