New strategies to accelerate the digitalization of small agricultural businesses in SUDOE AgriTech

Acronym: «**AgriTech**»

Deliverable: «**E 1.1 Diagnosis of the level of digitalization of small agricultural holdings**»

Version: 1.0

Responsible of the deliverable: CONETIC

Date: «31/01/2026»

INDEX

1. INTRODUCTION

This document constitutes Deliverable **E.1.1.1, Diagnosis of the level of digitalization of small enterprises** (hereinafter referred to as the Diagnosis) of the AGRITECH project (S2/1.4/E0222). Its objective is to describe the level of digitalization of small agricultural holdings in the six SUDOE territories where the pilot projects will be implemented to test the AgriDemoLab methodology, which is the basis of the personalized strategy developed by the project.

1. Andalusia, Spain
2. Extremadura, Spain
3. Navarre, Spain
4. Western Portugal
5. Nouvelle-Aquitaine, France
6. Occitania, France

The document will identify the specific needs and barriers faced by small agricultural holdings, highlighting the differences observed as well as the variables that influence them. It will also seek to highlight strengths that may act as levers to accelerate digitalization.

This analysis includes examining the technologies and practices currently in use, as well as the digital skills and capacities of farmers, in order to obtain an accurate picture of the starting point from which the project will intervene. This evidence-based foundation also helps to identify the most appropriate digital solutions and support mechanisms for the agricultural sector in each region.

The diagnosis will provide highly valuable, in-depth knowledge to enable the implementation of the AgriDemoLab methodology in the pilot projects and, therefore, will contribute to the development of the Strategy for accelerating the digitalization of small agricultural holdings in the SUDOE area.

All partners have contributed to the preparation of this deliverable, with CONETIC being responsible for its final drafting based on all the information and documentation collected.

It is important to highlight that the vast majority of partners have extensive knowledge and experience in the agricultural sector, and that partners contributing digitalization expertise work jointly with them, together providing a very valuable perspective for this analysis. Partners operating in a specific territory have also worked together to collect information from their respective regions.

Ultimately, the purpose of this deliverable is to guide the design of tailored digitalization pathways that will steer the implementation of the pilot actions. By grounding the methodology in precise and context-specific knowledge, the project ensures that its interventions are truly effective and aligned with the real needs and priorities of local small agricultural holdings.

1.1 EXECUTIVE SUMMARY

In the six regions covered by this Diagnosis, the agricultural sector is one of the main economic drivers, ranking second or third in terms of contribution to regional GDP and employment. In all cases, these indicators are above the national average of the respective countries. **This confirms that agriculture is a priority sector for the development of these regions and their rural environments**. Therefore, it is crucial to address its needs and difficulties in undertaking modernization, supported by digital transformation as a fundamental component, thus contributing to its economic, social, and environmental sustainability, promoting generational renewal, and preventing rural depopulation.

In Nouvelle-Aquitaine and Occitania, although the relative weight of the agricultural sector in regional GDP is lower than in the Spanish regions analyzed, its strategic relevance is very high due to its productive specialization, especially in viticulture, and its strong orientation towards quality markets and exports. In Western Portugal, the agricultural sector has a very significant impact on regional employment, reinforcing its role as a structuring element of the territory.

In all regions, **the typical holding is small in size, with family-run farms generally being predominant**. This characteristic is particularly pronounced in Nouvelle-Aquitaine and Occitania, where most viticultural and agricultural holdings are managed by family units with very small workforces, as well as in Western Portugal, where small holdings are characteristic of fruit growing, horticulture, and organic farming.

The table below includes data on the weight of the sector in each region.

SUDOE REGION	CONTRIBUTION TO REGIONAL GDP	CONTRIBUTION TO REGIONAL EMPLOYMENT	TYPE OF HOLDING
ANDALUSIA	7%	9%	60%–70% are small holdings with a medium–low level of digitalization
EXTREMADURA	7.7%	9.5%	Small holdings have a low level of digitalization (percentage missing)
NAVARRE	7.5%	4.79% (to be confirmed)	The sector is represented by small holdings with a low level of digitalization

NOUVELLE-AQUITAINE	4.5% (to be confirmed)	5.6% (to be confirmed)	The viticulture sector targeted by the pilot is 90% made up of holdings with fewer than 10 employees and a low level of digitalization
OCCITANIA	4% (to be confirmed)	3% (to be confirmed)	Most agricultural holdings are family-run with a medium and heterogeneous level of digital maturity
WESTERN PORTUGAL	4%–5% (to be confirmed)	11% (to be confirmed)	Small holdings are characteristic of several dominant crops such as arable, horticultural, and organic farming. The level of digitalization is considered incipient to medium, with uneven and fragmented adoption

Digitalization disparities are notable between small holdings and medium and large ones, making size one of the factors influencing the level of digitalization. In Nouvelle-Aquitaine and Occitania, this pattern translates into a "two-speed" model, where a small group of highly digitalized holdings, often linked to collective projects, cooperatives, or regional programs, coexists with a majority of small holdings with basic or incipient levels of digitalization. In Western Portugal, the gap is also evident between holdings integrated into producer organizations and those operating independently.

While the study explores the specific details of each region, in general terms there are common barriers to digitalization across the six territories, such as the high average age of workers and their limited digital skills. These factors result in resistance to change or an inability to assess cost–benefit ratios.

This generational factor is particularly relevant in Western Portugal and in certain rural areas of Occitania, while in Nouvelle-Aquitaine greater heterogeneity is observed, with young and well-trained profiles coexisting alongside holdings managed by older farmers.

Another barrier is limited financial capacity to undertake the investments associated with incorporating advanced digital devices and solutions.

Infrastructure-related barriers to digitalization are also identified, such as poor connectivity in the most rural areas. This issue is notable in Andalusia and Extremadura and is also evident in Nouvelle-Aquitaine, Occitania, Navarre, and Western Portugal. Although most holdings have minimum levels of connectivity, farmers consider lack of connectivity to be a major barrier or obstacle to implementing digital transformation.

There are also barriers linked to the supply of digital solutions, stemming from a lack of interoperability between systems and equipment, highlighted particularly by Nouvelle-Aquitaine and Navarre. This complicates farm operations and increases costs.

Finally, at a general level, the cost of technological solutions is a common barrier, even more so in crops requiring specialized and customized solutions, such as wine production. In some cases, mistrust of technology providers also emerges, driven by reluctance to share data for fear of misappropriation, as observed in Occitania.

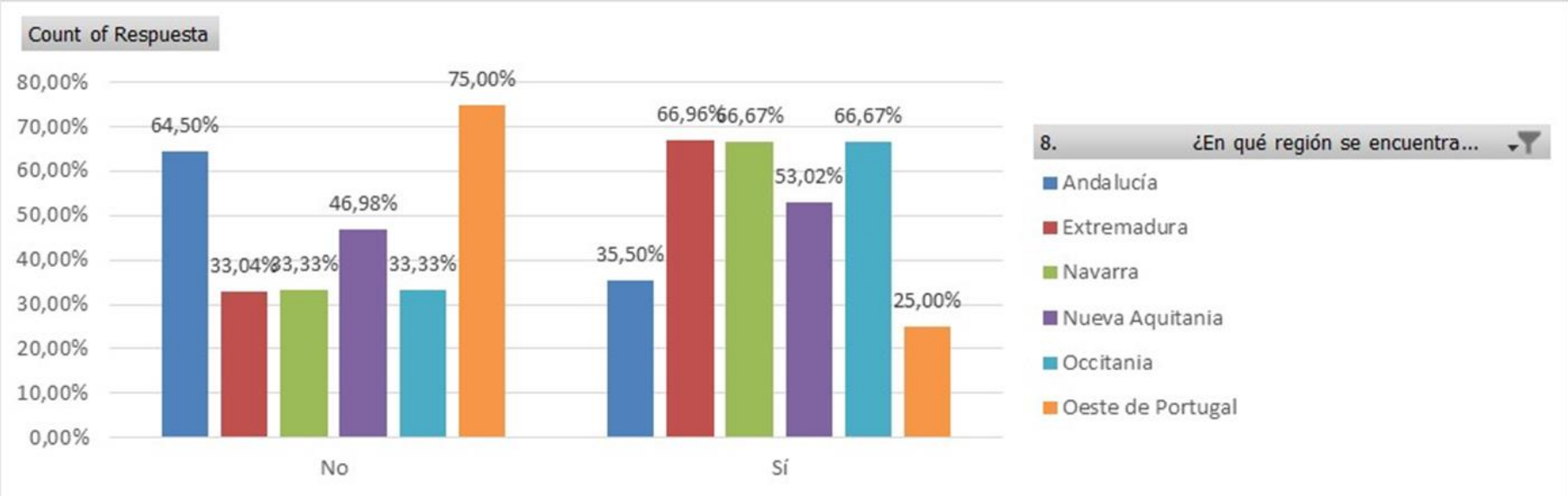
The type of crop is not, in itself, a factor that creates barriers to digitalization. However, it is observed that in crops with a strong market position and export orientation, farm size ceases to be a barrier to digitalization. This phenomenon is evident in viticulture in Nouvelle-Aquitaine and Occitania, and in export-oriented fruit farming in Western Portugal, where requirements for quality, traceability, and sustainability drive the adoption of digital solutions even in smaller holdings.

Common challenges are identified, varying by crop and region. In Andalusia, where the main respondents are farmers growing mangoes, avocados, and other subtropical crops, the need to optimize irrigation stands out, a challenge exacerbated by climate change. In Extremadura, given the diversity of crops among the surveyed holdings, needs are more heterogeneous. These include irrigation control, also influenced by climate, fertilizer management, pest control, and optimization of other production processes.

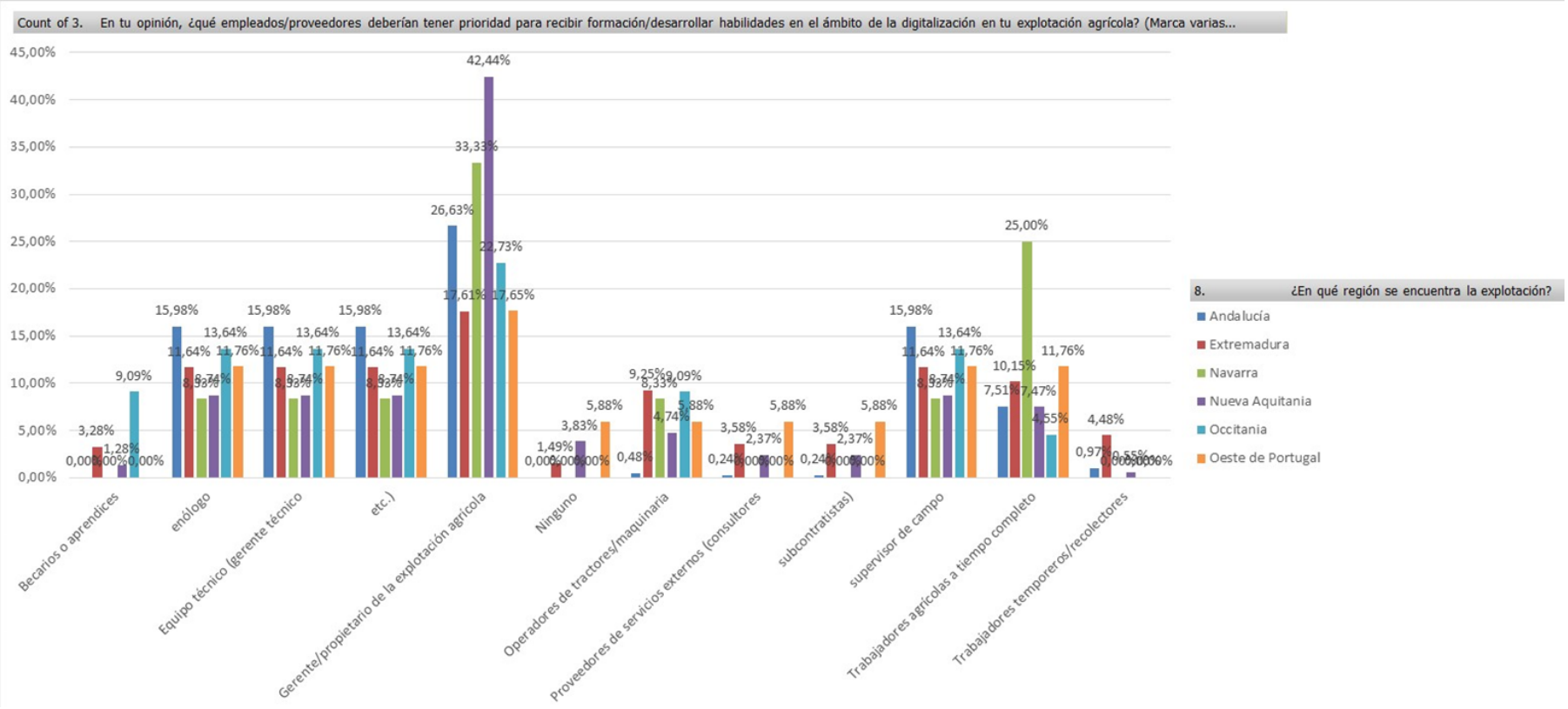
Given the importance of the agricultural sector in these six regions, there is a large number of territorial stakeholders promoting digital transformation within their respective areas of competence. These stakeholders range from public administrations, professional agricultural organizations, research and training centers, and sectoral platforms, to numerous companies developing digital and technological solutions, both public and private. However, despite this coverage, there is broad agreement on the need to develop personalized strategies that can reach small holdings and deploy actions tailored to their needs. Such approaches would enable higher levels of digitalization and prevent the gap between small and large agricultural holdings from continuing to widen.

There is consensus that the lack of digital training and skills constitutes an additional barrier for small agricultural holdings, preventing them from assessing the impact and return that digitalization could generate for their operations. At the same time, it represents the greatest threat to their continuity, followed by financial difficulties in assuming the necessary investments.

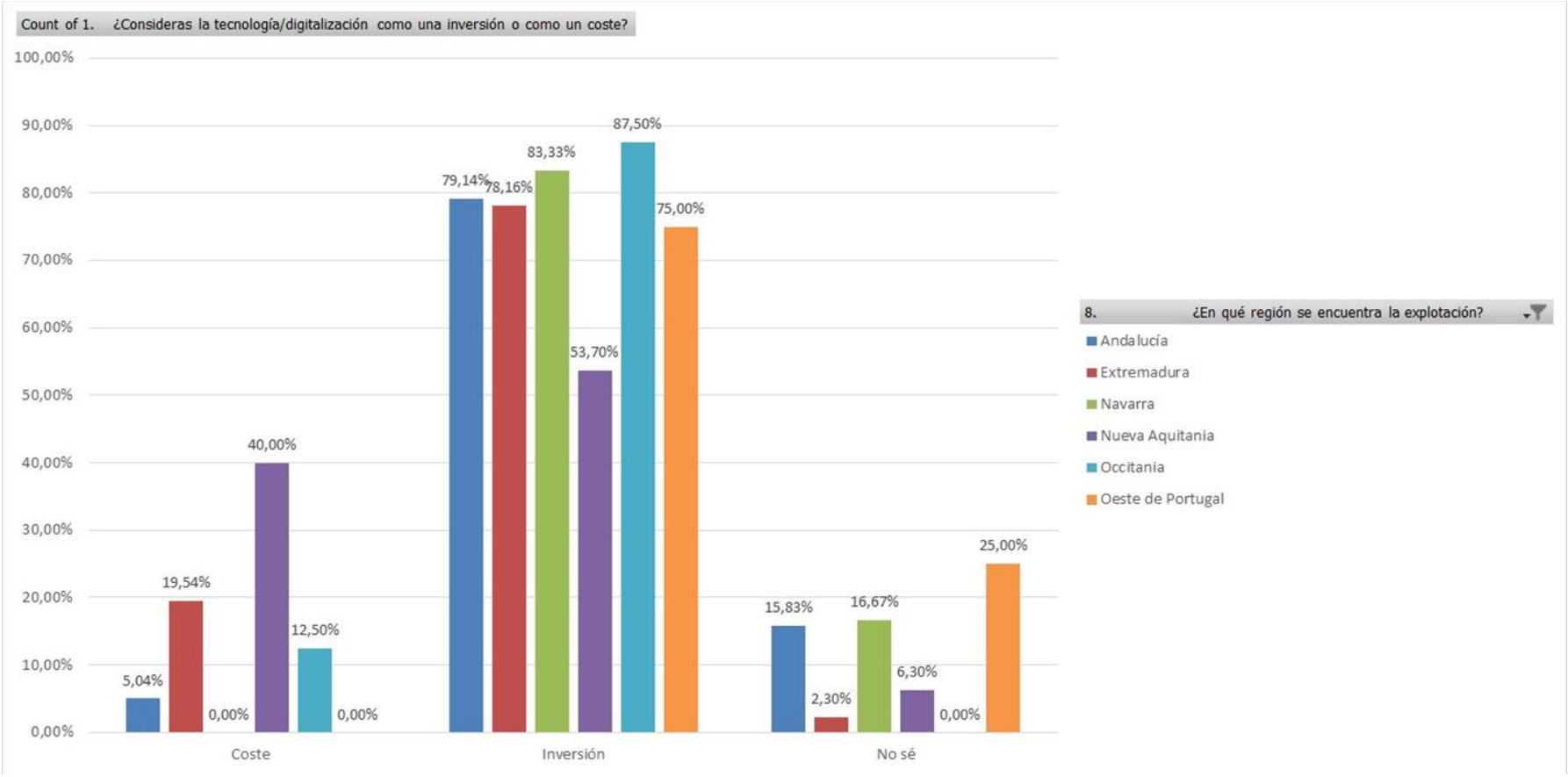
Limited digital training contrasts with a willingness to participate in training on topics such as technology and agricultural practices. The following chart shows whether the surveyed farmers have received any type of digital training, however limited.



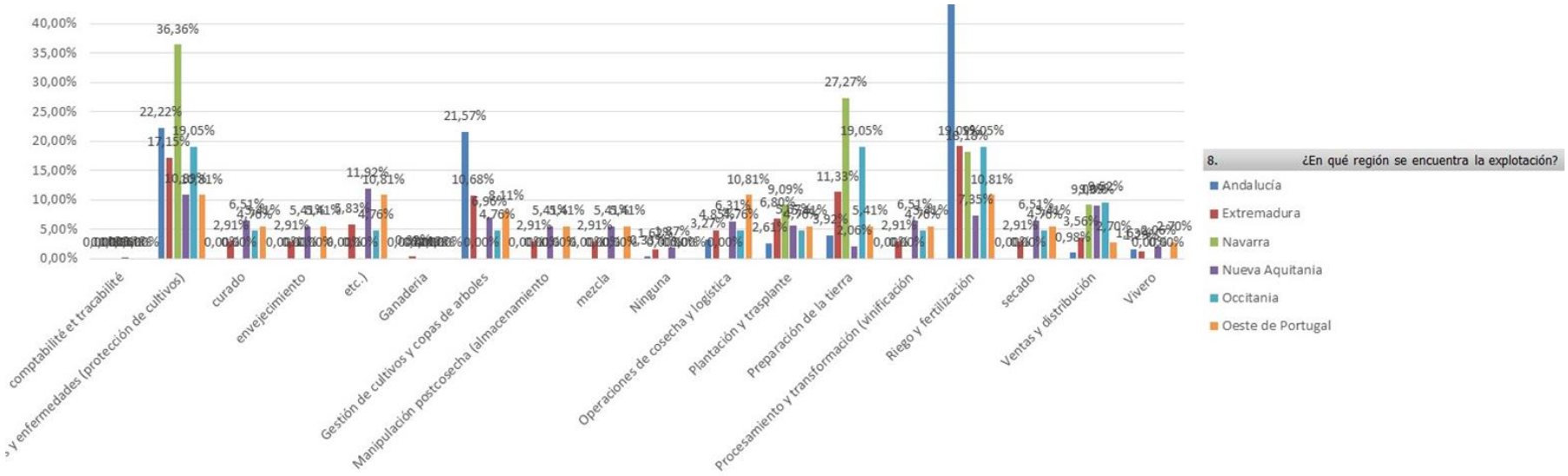
The next chart provides a territorial comparison showing that farm managers or owners are considered the priority target group for this training, followed by technical staff and field supervisors, reflecting a very similar view among farm owners across the six territories analyzed.



One of the most relevant points is the largely shared perception among farmers of digital technologies and their applications as an investment. This allows for optimism regarding their willingness to undertake the process when adequate financing and support are available to implement and adopt these solutions.



When asked which area or stage of cultivation would benefit most from digital technologies, crop protection and irrigation and fertilizer management stand out above others. However, land preparation is also a high priority in some territories such as Navarre and Occitania, confirming the views of sector experts.



The following sections of this document provide a detailed analysis of each region, offering an in-depth overview and allowing conclusions to be drawn regarding the suitability of the AGRITECH project, as well as the selection of the pilots defined by the consortium partners.

1.2 METHODOLOGY

Different methodological instruments were used to prepare this Diagnosis:

1. **Survey**: An online questionnaire addressed to the owners of agricultural holdings in the six SUDOE regions targeted by the project. The survey is included as Annex 1 to this document.
2. **Situation report**: A document prepared by the project partners, compiling quantitative and qualitative information from the region in which their pilots will be implemented. This document provides both qualitative and quantitative information and is supported by studies, analyses, and other reliable and recent sources that ensure the validity of its content. CONETIC developed a general content index to be included in the report to facilitate homogeneity and comparability between regions, as well as to ensure the collection of relevant information for the Diagnosis. The template is included as Annex 2 to this document.
3. **Interviews with key regional stakeholders:** After identifying key stakeholders involved in the development, digital transformation, and modernization of the agricultural sector in the six regions, interviews were conducted to gather qualitative information on the state of digitalization of small agricultural holdings in each region. CONETIC proposed a standard questionnaire to guide the interviewers. The questionnaire template is included as Annex 3 to this document.

Based on the information collected, CONETIC carried out the analysis and prepared this Diagnosis, which will be validated by the partners through focus groups with relevant agricultural and digital sector stakeholders in the six regions, leading to the final version of Deliverable **E.1.1.1, Diagnosis of the level of digitalization of small enterprises.**

2. REGION 1: NAVARRE

2.1. TERRITORIAL CONTEXT

The Chartered Community of Navarre is located in northern Spain and borders the Basque Country and the French region of Nouvelle-Aquitaine, with which it forms a Euroregion, as well as the autonomous communities of Aragon and La Rioja. Navarre has a population of 686,000 inhabitants, of whom 56.5% live in the metropolitan area of Pamplona.

The agri-food sector, which includes agriculture, livestock farming, forestry, and the agri-food industry, has a production value at basic prices of €5,665,212 thousand, representing 7.5% of the region's total Gross Value Added (GVA). This sector generates 15,178 Agricultural Work Units and occupies 511,626 hectares of Utilised Agricultural Area (UAA). Of this area, 60.3% is devoted to cereal crops, followed by horticultural and industrial crops.

With regard to progress in digitalization, recent projects such as 4Growth (digitalization of agriculture and forestry integrating seven digital observatories) have shown that, although the sector is undergoing a process of digital transformation, the adoption of new technologies requires additional impetus to become real and widespread across all holdings. In that project, participants were asked to assess the current level of digitalization on a scale from 1 to 5, obtaining an average score of 2.75, which indicates a moderate level of adoption of digital solutions.

The same project identified that the sector is dominated by small-sized holdings with limited scaling capacity, which conditions decision-making. In addition, there are training gaps in the use of new technologies linked to the ageing of the active population: only 23% of people employed in the sector are under 40 years of age, while 40% are over 55. Holdings with an advanced level of digitalization remain a minority and, in general terms, technological adoption is still at an incipient stage.

In addition to barriers related to age and training, there are other difficulties, such as the high cost of acquiring technologies and licenses, as well as the complex interoperability between equipment and systems from different brands and ecosystems.

In this context, actions are needed to foster the adoption of new technologies in the agricultural sector, especially among small holdings, with the aim of improving their competitiveness, sustainability, and attractiveness for new generations.

2.2. LEVEL OF DIGITAL MATURITY

Despite the incipient degree of digitalization of agricultural holdings in Navarre, there are success stories that demonstrate the region's potential and the opportunities to improve efficiency, sustainability, and profitability in the sector. Navarre also shows notable potential for digitalization due to the presence of an innovative ecosystem that integrates the entire digitalization value chain, from agricultural machinery dealers and manufacturers to technology companies and training and applied research centres, capable of driving knowledge transfer to the field.

Thanks to this context, there is considerable awareness of precision agriculture solutions, driven in part by the local technological offering, as well as emerging awareness of automated machinery, robotics, and information management systems.

The most prominent success cases in the region are linked to management systems for optimizing input use, such as fertilizers, through digital platforms supported by GIS technologies, satellite imagery, and some sensor-based initiatives.

These success stories show that there is real potential to address digitalization in Navarre's agricultural sector, where projects such as AGRITECH can help multiply and generalize experiences of this kind.

2.3. STRENGTHS

This section presents the strengths of the Navarre territory in facilitating digital transformation in the agricultural sector:

•**NEAR-UNIVERSAL RURAL CONNECTIVITY:** Navarre starts from a clearly advantageous position in terms of rural connectivity. Recent public investments have made it possible to achieve ultra-fast broadband coverage (≥100 Mbps) for around 97.7% of the rural population, placing the region among those best positioned for the adoption of digital technologies in agriculture. This infrastructure is a key enabler for data-based solutions, such as cloud platforms, IoT sensors, and real-time monitoring systems, and provides a solid foundation for the deployment of digital technologies in the agricultural sector.

Nevertheless, the Connectivity Plan 2030 highlights that territorial inequalities persist, especially in dispersed rural areas or areas with complex orography, where connection quality and stability remain insufficient. These localized shortcomings can create digital gaps between holdings.

• **A STRONG AND WELL-STRUCTURED COLLECTIVE INNOVATION AND SUPPORT ECOSYSTEM:** The territory has a consolidated and well-articulated innovation ecosystem that actively promotes digitalization in the agricultural sector. Collaboration between public administrations, technology centres, universities, cooperatives, and private companies has resulted in numerous research, development, and innovation projects aimed at validating and transferring digital solutions to the field. This institutional framework not only fosters the generation of applied knowledge, but also acts as a facilitator of technological adoption by reducing risks for farmers and promoting open innovation models. In addition, technical support and result transfer help adapt digital tools to the real needs of Navarre's primary sector.

• **DIGITALIZATION-ORIENTED PROGRAMMES AND FUNDING:** Navarre has a solid framework of programmes and funding mechanisms specifically aimed at the technological modernization of the agricultural sector. European, national, and regional funds channel financial resources towards the adoption of digital technologies, highlighting initiatives such as the "Acerca Navarra" programme, focused on digital skills development and funded by the Recovery and Resilience Mechanism. These aids enable farmers and livestock producers to undertake investments in digital equipment, specialized software, and training, reducing the economic barriers associated with technological transformation. The alignment of these policies with sustainability and competitiveness strategies also strengthens the medium- and long-term impact of rural digitalization.

• **SUPPORT, ASSISTANCE, AND SIMPLIFICATION:** There is a growing supply of specialized digital solutions for the agricultural sector in Navarre, supported by demonstrator experiences and pilot projects already in operation. Precision agriculture systems integrating IoT sensors, drones, satellite imagery, and smart machinery with variable-rate application and yield mapping have been implemented. These technologies make it possible to optimize key processes such as irrigation, fertilization, and pest control based on real-time data and predictive analysis. The results of these experiences show tangible improvements in productivity, efficiency in input use, and environmental sustainability. Their demonstrative nature also facilitates the dissemination of good practices and increases sector confidence in the added value of digitalization.

2.4. AREAS FOR IMPROVEMENT

Digitalization of the agricultural sector is at an early stage and is progressing unevenly. While basic digital tools, such as mobile phone use, weather applications, GPS, or digital farm logs, are already fairly widespread, more advanced technologies or those requiring greater investment still show limited adoption. This situation is particularly evident in small, individually managed holdings, whereas adoption is more frequent when carried out collectively through cooperatives, irrigation communities, or other organized structures.

The main areas for improvement identified are:

• **ORGANIZATIONAL CHANGE MANAGEMENT**: The ageing of the agricultural sector and the lack of generational renewal reduce the willingness to invest and to change established working methods, especially when returns on investment are perceived in the medium or long term. This is compounded by fear, mistrust, and insecurity regarding unfamiliar technologies, as well as perceptions of complexity. In many cases, the difficulty is not so much technical as psychological, reinforced by lack of time, limited connectivity in some rural areas, and difficulty in clearly identifying immediate economic benefits. Cultural change management is therefore important, including training leaders so that they involve the rest of the workforce, feel competent in new environments, and introduce changes gradually.

• **CONTINUOUS SUPPORT**: Close and ongoing support emerges as the most decisive factor for effective progress in digitalization. One-off training actions are not sufficient; personalized advice adapted to the pace and needs of each farmer is key to building trust. The opportunity to test technologies through pilot projects or trials under real conditions significantly reduces initial resistance and allows farmers to verify the practical usefulness of digital tools before making investments.

• **COOPERATIVE / SUPPORT MODEL**: Cooperatives, agricultural associations, and intermediary entities play a central role in the sector's digital transition. These organizations act as a bridge between farmers, public administrations, and technology providers, facilitating access to digital tools, financial aid, and training. They also enable cost-sharing, risk reduction, and adaptation of technology to real farm contexts. Digitalization is much more viable and efficient when approached from a collective and territorial logic rather than relying exclusively on individual initiatives.

• **HIGH-IMPACT TECHNOLOGIES**: The high cost of technological implementation represents a significant barrier, as it requires a substantial initial investment that is particularly difficult for small holdings with tight margins. As

a result, the technologies that gain greater acceptance among farmers are those that deliver clear, direct, and visible benefits in the short term. Solutions that save inputs, such as efficient irrigation or variable-rate fertilization, stand out, as do tools that simplify mandatory administrative management. Simple technologies integrated into daily routines, such as weather apps, messaging, or positioning systems, also have a positive impact, especially when accompanied by technical advice.

• **DIGITAL LITERACY**: Training to drive digitalization must be practical, continuous, and coordinated among the different territorial actors. There is clear demand for content adapted to farmers' real skill levels, focused on basic digital skills, data interpretation, and autonomous use of tools. Interviews with key sector stakeholders also highlight the importance of coordination among administrations, universities, cooperatives, and agricultural organizations to avoid duplication and contradictory messages, and to offer a coherent and sustained training supply over time.

Transversally, all interviews agree that digitalization should not be understood as an end in itself or as a universal solution. It is a tool that must be adapted to each type of holding, integrated with traditional knowledge, and deliver real and measurable value. The success of digital transformation in agriculture will depend on its practical, gradual nature and its adjustment to the diversity of productive and territorial realities.

2.5. RELEVANT STAKEHOLDERS IN THE TERRITORY

There are various stakeholders that play a key role in Navarre's agricultural sector, both within the sector itself and in organizations that, while not directly involved in agricultural production, can provide essential goods and services for its modernization.

First, there are individuals and entities that coordinate the production and marketing of agricultural and livestock products in Navarre. This group includes farmers and livestock producers, as well as first- and second-tier cooperatives that form the backbone of the sector in many municipalities. They are joined by the main professional and trade organizations in the sector, such as UAGN (Union of Farmers and Livestock Producers of Navarre), EHNE (Euskal Herriko Nekazarien Elkartasuna), and UCAN (Union of Agri-food Cooperatives of Navarre), which represent producers' interests and the agricultural model.

There are also companies supplying agricultural machinery and inputs such as fertilizers and phytosanitary products. These companies, along with other specialized firms, also offer digitalization solutions for agricultural holdings and can act as the final link between innovation and agricultural production.

In the academic and research sphere, in addition to INTIA, Navarre has the UPNA (Public University of Navarre), which through its Higher Technical School of Agricultural Engineering and Biosciences collaborates in research projects and trains future sector professionals. In the same vein, the Integrated Agroforestry Centre plays a relevant role in training mid- and higher-level professionals.

Finally, the Government of Navarre, through the Department of Rural Development and Environment, as well as local administrations through consortia, associations, or Local Action Groups, plays a central role in strategic and regulatory planning that will shape the modernization and sustainability of the agricultural sector.

2.6. SURVEY RESULTS

The statistics collected in Navarre are based on a very small sample that cannot be considered representative of the entire farming population of the region (9 surveys). However, they do provide a consistent qualitative view of how digitalization is perceived by those working directly in the field.

The profile that emerges is that of a farmer with an average age close to fifty, predominantly male, with medium-level education and already consolidated holdings. These are not new or experimental profiles, but experienced professionals, notable for both their critical perspective and their caution when adopting new technologies.

The holdings analysed are generally medium-sized, with a significant cultivated area and mainly focused on extensive crops such as cereals and oilseeds, although olives, vineyards, and fruit trees are also present. The labour structure is very tight, with few or no employees, which means that any digital tool is evaluated based on its real capacity to save time and facilitate daily work. In this context, digitalization is not perceived as a technological whim, but as something that only makes sense if it delivers operational efficiency.

Regarding the general perception of digitalization, Navarre farmers show a relatively positive attitude. Technology is seen more as a potential investment than as a cost, provided it helps improve productivity and optimize input use. The interest lies not so much in innovating for innovation's sake, but in using tools that enable better production, lower costs, and greater control over crops. This practical outlook runs through the entire questionnaire.

Technological needs are clearly concentrated in the most critical stages of the production cycle. Farmers demand digital support especially for pest and disease control, land preparation, and crop management. These are areas where errors have a direct impact on economic results and where timely information can make a difference. This indicates a demand for solutions strongly focused on field-level decision-making, rather than complex platforms or systems that are difficult to integrate into daily routines.

Despite this interest, the current use of specialized digital tools remains limited. In many cases, advanced agricultural software is not used, or if it is, only partially. This does not seem to stem from outright rejection of technology, but rather from a combination of lack of awareness, insufficient support, and doubts about real usefulness. Digitalization is present more as an idea than as a fully integrated practice.

Barriers appear quite consistently. The cost of technologies and uncertainty about their profitability are the main constraints. Added to this is the lack of practical training and close technical support, which generates mistrust towards solutions perceived as complex or poorly adapted to on-the-ground realities. There is no strong cultural resistance, but there is a cautious attitude. Before investing, farmers want clear guarantees that technology will work and make their work easier.

Overall, although the sample does not allow for generalizations, the data from Navarre convey a very coherent message and offer a realistic, day-to-day view of farming that is particularly valuable for guiding policies and digital tools better tailored to real needs.

Los agricultores están abiertos a la digitalización y reconocen su potencial, pero necesitan soluciones sencillas, asequibles y bien explicadas. La principal demanda no es más tecnología, sino mejor tecnología, acompañada de formación y apoyo que reduzcan el riesgo percibido. Es una visión realista, anclada en el día a día del campo, que resulta especialmente valiosa para orientar políticas y herramientas digitales más ajustadas a sus necesidades reales

.

3. REGION 2: ANDALUSIA

3.1. TERRITORIAL CONTEXT

Andalusia is located in southern Spain and is characterized by a high degree of geographical diversity, ranging from extensive coastal areas to mountainous inland regions. With a population of over eight million inhabitants, it is the most populous autonomous community in the country and one of the largest in terms of surface area. Its capital, Seville, together with other major cities such as Málaga, Granada, and Córdoba, act as hubs of economic, cultural, and tourism activity.

The Andalusian economy is structured around three major productive sectors. The services sector is the main pillar, representing more than 70% of regional Gross Domestic Product (GDP), and includes activities such as tourism, commerce, education, healthcare, and public administration. The industrial sector, although with a lower relative weight than in other Spanish regions, shows significant specialization in the agri-food industry, chemicals, aeronautics, with a strong presence in the provinces of Seville and Cádiz, and the processing of agricultural products. The agricultural sector, for its part, maintains a strategic role both economically and socially.

The Andalusian agricultural sector stands out for the diversity of its production. Major crops include olive groves, especially widespread in the provinces of Jaén, Córdoba, and Granada; vegetables such as tomatoes, peppers, cucumbers, and courgettes, with a strong concentration in Almería; fruit crops, with particular relevance of berries such as strawberries, blueberries, and raspberries in Huelva, and citrus fruits in Seville and Córdoba; as well as cereals and legumes, predominant in rainfed areas of provinces such as Cádiz and Seville.

In macroeconomic terms, the agricultural sector contributes around 7% of regional GDP, more than double the national average, and generates approximately 9% of employment in Andalusia, constituting the main source of work in nearly half of rural municipalities. In addition, Andalusia accounts for around one third of national agricultural Gross Value Added (GVA) and 35.9% of Spain's agricultural income, reinforcing its key role within the Spanish agri-food system.

Within this regional context, the Axarquía region, where the pilot projects will be implemented, has a diversified economy in which agriculture has historically played a central role. Subtropical crops stand out in particular, especially avocado and mango, which have positioned the region as an international export benchmark, generating employment, investment, and economic dynamism. Alongside these crops, viticulture and raisin production, horticultural crops both outdoors and under greenhouses, and olive groves in inland areas complete the agricultural production structure. The agricultural fabric of Axarquía is predominantly made up of small and medium-sized holdings, with an average surface area of approximately 4 hectares.

Tourism is another economic pillar of the region, combining sun-and-beach tourism with a growing trend in rural and inland tourism. This is complemented by the agri-food industry and services linked to commerce and tourism, creating a dynamic economic fabric that complements the primary sector.

With regard to the digitalization process, the Axarquía region benefits from various regional and national strategies aimed at modernizing the agricultural sector. Among them, the Axarquía Leader Local Development Strategy 2023–2027 identifies digitalization as a key tool for improving the competitiveness and sustainability of agricultural holdings. Likewise, the MetaDigital Rural–Málaga training programme aims to equip rural populations with basic and advanced digital skills through in-person workshops and outreach activities, such as technology fairs in towns like Canillas de Aceituno, where solutions based on IoT, artificial intelligence, and robotics are showcased. At the regional level, 45 workshops adapted to local needs have been scheduled, targeting specific groups such as young people, women, farmers, and entrepreneurs, with active participation from ASAJA Málaga.

3.2. LEVEL OF DIGITAL MATURITY

From the perspective of the level of digitalization of agricultural holdings, the Axarquía region shows a medium-to-high degree of technological adoption among larger holdings, which represent approximately 30% to 40% of the total. In contrast, smaller holdings, which are the majority in the region, display intermediate levels of digitalization, estimated at between 60% and 70%, with relatively widespread implementation of automated irrigation systems. However, these holdings show shortcomings in the adoption of more advanced digital technologies, such as sensor systems, specific mobile applications, integrated management platforms, electronic farm logs, the use of drones, or data-driven decision-support tools.

According to information provided by the Business Agency for Transformation and Economic Development, attached to the Regional Ministry of Economy, Finance, and European Funds of the Government of Andalusia, there are 1,225 companies across Andalusia with a CNAE classification associated with IT consultancy activities. These companies are distributed throughout the region, with a notable concentration in Seville and Málaga. In the latter province, 486 registered companies are recorded, confirming its role as one of the main regional hubs of technological activity.

In the case of Málaga, the creation in 1992 of the Andalusia Technology Park, now known as Málaga TechPark, is particularly relevant. It is one of the main innovation and business development hubs in Spain. Approximately 34% of the companies located there fall within the “Information, IT, and Telecommunications” sector, which also represents a significant share of the technological employment generated by the park. It hosts more than 715 companies and 27,940 workers, and its contribution is estimated at around 8% of GDP and employment in the province of Málaga, as well as 1.65% of GDP and employment in Andalusia. Within this ecosystem, Málaga TechPark Execs stands out as a club of executives and business leaders created to foster collaboration among companies, promote innovation, and highlight professional excellence within Málaga’s technological environment. This club brings together more than 50 business leaders, including CEOs and senior executives, as well as academic and corporate entities linked to the territory.

With regard to the agrotech field, the European Digital Innovation Hub specializing in technologies for the agri-food sector points to the existence of more than 250 companies, knowledge centres, and entrepreneurs in Andalusia participating in this ecosystem. This figure could be higher if agricultural and livestock companies that incorporate technology into their processes without explicitly identifying themselves as “agrotech” were included. Although there are no official disaggregated data, the concentration of technological activity in the

province of Málaga makes it possible to estimate, based on territorial deployment trends, that between 20% and 30% of these entities are located in Málaga and its surrounding area.

In addition, Málaga has an active entrepreneurial ecosystem, with around 150 technology startups, of which an estimated 10% to 15% are directly linked to the agri-food sector, whether through smart agriculture solutions, data management, applied biotechnology, or digital services associated with rural environments.

This ecosystem is complemented by initiatives and entities present in Málaga and linked to the digitalization of the agri-food sector. These include programmes connecting startups with sector companies, international events focused on Agriculture 4.0 and agricultural technology such as Expo AgriTech Málaga, companies specialized in biotechnology applied to agriculture headquartered in Málaga, and digital platforms aimed at the agricultural market for comparing agricultural product prices. Together, these agents help consolidate a sufficient technological base to support the deployment of digital solutions and the execution of applied innovation projects in the territory.

Alongside technological availability, representative experiences have been identified in Andalusia that demonstrate the potential of digitalization applied to the agri-food sector from both a technical and organizational perspective. These initiatives show that the combination of digital tools, agronomic knowledge, and cooperation among stakeholders makes it possible to move towards more efficient, sustainable, and resilient production models, especially in a context marked by water scarcity, environmental pressure, and the need to improve competitiveness.

Despite the broad availability of specialized technology in Andalusia's innovation hubs, a significant gap remains: digitalization still fails to reach SMEs and small farmers effectively.

Overall, these capabilities and experiences demonstrate a solid foundation for driving agri-food digitalization in Andalusia, supported by interaction among farmers, cooperatives, research centres, public administrations, and technology companies. Far from being isolated initiatives, they form an ecosystem with scaling potential, capable of adapting technologies to real territorial conditions and sustaining progressive modernization processes in the sector.

3.3 STRENGTHS

This section presents the strengths of the Andalusian territory that favour digital transformation in agriculture:

• **STRONG AND WELL-STRUCTURED COLLECTIVE INNOVATION AND SUPPORT ECOSYSTEM**: Andalusia has a solid technological base, with 1,225 companies linked to IT consultancy distributed throughout the region. Seville and Málaga concentrate a significant share of this activity, with Málaga standing out with 486 registered companies. This concentration reinforces the availability of advanced technological services applicable to the agricultural sector. Proximity between technology companies and the productive sector facilitates digitalization processes.

• **STRONG AND WELL-STRUCTURED COLLECTIVE INNOVATION AND SUPPORT ECOSYSTEM:** Málaga TechPark is one of the main innovation hubs in southern Europe and a strategic asset for the Andalusian agricultural sector. It hosts more than 715 companies and nearly 28,000 workers, with strong specialization in ICT, R&D, and biotechnology. Thirty-four percent of its companies belong to the Information, IT, and Telecommunications sector. Its economic impact strengthens regional capacity to generate and transfer technology. The Andalusian agrotech ecosystem brings together more than 250 companies, knowledge centres, and entrepreneurs linked to agri-food digitalization, a significant share of which is concentrated in Málaga and its surroundings due to technological deployment. This is complemented by an active entrepreneurial fabric with startups focused on smart agriculture and data management, fostering innovation applied to the primary sector.

• **CLIMATE AND ENVIRONMENTAL AWARENESS:** Andalusia has a wide range of technological solutions for the agricultural sector, particularly in precision agriculture. The use of IoT sensors, drones, satellites, GPS, and smart machinery makes it possible to optimize irrigation, fertilization, and pest control. These technologies facilitate more efficient resource management and reinforce the sustainability and competitiveness of holdings.

• **SHARED DATA CULTURE:** There are advanced data management and analysis tools that support decision-making in agriculture. Agricultural management platforms, Big Data, and predictive models make it possible to anticipate yields and reduce climate risks. Technologies such as blockchain improve product traceability, contributing to a more professionalized and data-driven agriculture.

• **SUPPORT, ASSISTANCE, AND SIMPLIFICATION**: Andalusia has demonstrator experiences and pilot projects that show the real potential of agri-food digitalization. Initiatives in precision irrigation, artificial intelligence, agricultural robotics, and advanced connectivity show positive results. The involvement of cooperatives, research centres, and public administrations strengthens knowledge transfer. Together, these elements create an ecosystem with the capacity to scale and adapt to the territory.

3.4. AREAS FOR IMPROVEMENT

The analysis of the Andalusian territory reveals a series of structural weaknesses that condition the competitiveness and modernization capacity of the agricultural sector. These limitations affect both productive structure and technological adoption, as well as the ability to adapt to climate and sustainability challenges:

• **TECHNOLOGICAL ADAPTATION TO SMALL HOLDINGS:** The productive structure is characterized by the predominance of minifundia and small family-run holdings. This configuration limits investment capacity and makes it difficult to achieve economies of scale, reducing competitiveness in agricultural markets. This reality conditions the incorporation of technological innovations and the professionalization of management.

• **RURAL CONNECTIVITY:** A significant digital divide persists and technological adoption is uneven in the Andalusian agricultural sector. Digitalization remains partial, with connectivity shortcomings in certain rural areas. This is compounded by deficits in technology training adapted to farmer profiles and an ageing workforce, limiting full exploitation of digital tools to improve efficiency and decision-making.

• **CLIMATE AND ENVIRONMENTAL AWARENESS**: Water scarcity and high climate vulnerability are among the main structural challenges of the territory. Heavy dependence on irrigation is exacerbated by recurrent droughts and rising temperatures. This context requires progress towards greater efficiency and productive adaptation. The medium- and long-term sustainability of the sector depends on water modernization, genetic improvement, soil conservation, and the promotion of technologically skilled generational renewal.

3.5. RELEVANT STAKEHOLDERS IN THE TERRITORY

This section first characterizes relevant stakeholders at the regional level in Andalusia and then focuses the analysis on the specific project territory, the Axarquía region. While some actors operate at both levels, their scope of action, influence, and degree of involvement vary depending on the territorial scale.

Relevant stakeholders at the Andalusian level

The Andalusian agri-food system is supported by a broad and diverse network of stakeholders interacting along the value chain, forming a dynamic and strategic ecosystem for the regional economy. Key stakeholders include agricultural producers, comprising farmers and livestock producers of small, medium, and large scale, operating under both family and business models. These actors are often organized through agricultural cooperatives, which enhance marketing, processing, and bargaining power. Agricultural Transformation Companies (SATs) also play an important role as business structures aimed at optimizing productive and commercial processes.

The agri-food industry is another fundamental pillar, including both processing companies that transform raw materials into finished products such as olive oil, wine, preserves, and horticultural products, and distributors and marketers that connect primary production with national and international markets.

Professional agricultural organizations act as representatives of farmers' and livestock producers' interests, playing a key role in dialogue with public administrations, sectoral advocacy, and agricultural policy negotiation.

Institutional actors also play a decisive role. The Government of Andalusia, through the Regional Ministry of Agriculture, Livestock, Fisheries, and Sustainable Development, leads agricultural, rural development, and sustainability policies. At the local level, municipalities and provincial councils support rural development and resource management initiatives, often through Rural Development Agents. The central government and the European Union are also involved, particularly in the design and implementation of the Common Agricultural Policy (CAP).

Research, training, and innovation centres form another essential axis of the ecosystem, including universities with strong agricultural specialization such as the University of Córdoba and the University of Almería, as well as IFAPA, which promotes innovation, technical training, and knowledge transfer to the productive sector.

Complementarily, financial and insurance entities provide specialized services to the agricultural sector, including financing, agricultural insurance, and economic analysis that facilitate investment and risk management. Finally, consumers and civil society, through consumer associations, environmental organizations, and fair-trade

platforms, increasingly influence the orientation of the productive system towards more sustainable and transparent practices.

Altogether, this network of stakeholders constitutes a key agricultural ecosystem for the Andalusian economy, contributing more than 31% of Spain's agricultural Gross Value Added according to various institutional and sectoral sources.

Relevant stakeholders in the Axarquía region

At the regional level, Axarquía presents a network of agricultural stakeholders that combines traditional productive structures with more advanced export- and innovation-oriented models adapted to the area's territorial and climatic specificities.

Family farmers and small holdings predominate, many with mixed production systems combining avocado, mango, citrus fruits, and vineyards. Although precise statistical data are not available, average holding size suggests that more than 60% correspond to small and medium-sized holdings. Alongside these, there are medium and large holdings specialized in export-oriented subtropical fruits. Cooperatives and SATs play a central role in supply concentration, cost reduction, and marketing, with leading entities such as TROPS standing out as a benchmark in avocado and mango production and marketing.

In processing and marketing, the region has auction markets and fruit and vegetable centres that grade, package, and distribute production on a large scale, as well as local agri-food industries linked to differentiated quality products such as wines with the Málaga and Sierras de Málaga Designations of Origin, raisins with the "Pasas de Málaga" Protected Designation of Origin, olive oil, and organic products. Exporters and specialized logistics platforms distributing subtropical fruits to European and international markets also operate in the area.

Professional organizations and agricultural associations are also active, including OPAs with territorial representation, agri-food cooperatives integrated into regional federations, and specific associations of subtropical producers, winegrowers, raisin producers, and organic farmers. Irrigation communities are strategic stakeholders, particularly in a context of water scarcity, with those linked to the La Viñuela reservoir standing out due to their critical role in farm viability.

Institutionally, the Government of Andalusia operates through the Regional Ministry of Agriculture, Fisheries, Water, and Rural Development and the Regional Agricultural Offices present in Axarquía. Municipalities, especially those with a strong agricultural base such as Vélez-Málaga, Torrox, Algarrobo, and Almáchar, support local development. The Ministry of Agriculture, Fisheries, and Food is also involved in managing CAP aid, digitalization programmes, and innovation initiatives. Rural Development Centres such as CEDER Axarquía manage European LEADER funds and promote rural development and territorial innovation projects.

In terms of knowledge, innovation, and digitalization agents, the University of Málaga, IFAPA, and other research centres stand out, along with technology companies and agricultural service providers offering sensor solutions, farm management software, and consultancy services for farm modernization and digitalization.

Finally, the ecosystem is completed by market- and consumption-related agents, including national and international distributors and supermarket chains, the main recipients of avocado and mango production; the HORECA channel and gastronomic tourism, which enhance the added value of products such as wines, raisins, olive oil, and subtropical fruits; and local and international consumers increasingly sensitive to traceability, sustainability, and quality criteria.

Overall, the agricultural stakeholder network in Axarquía combines a predominance of small and medium-sized holdings with cooperatives and large export operators, integrating irrigation communities, public administrations, and knowledge centres. This territorial diversity allows the coexistence of traditional crops such as raisins, vineyards, rainfed olive groves, and arable crops with high-value irrigated crops such as subtropicals. In this context, modernization and digital transformation represent a strategic opportunity to improve economic and agronomic management, generate added value, and enable the implementation of innovation projects adapted to real territorial conditions.

3.6. SURVEY RESULTS

3.6.1 Farmer profile

The average age of surveyed farmers in Andalusia is around 46 years (median 48), with a range from young people aged 18 to a maximum of 76 years. This indicates incipient generational renewal and a limited presence of very elderly producers, with only around 10% over 60 years old, resulting in a somewhat younger population than in neighbouring regions. In terms of gender, the sector is male-dominated but with some female presence: around 76% identify as men and 24% as women, with no non-binary cases reported.

The educational level of Andalusian farmers is generally lower than in the French regions analysed. Most respondents, around 62%, reached secondary education at most, while about 19% have only primary education. In contrast, only about one in five has higher education, with around 7% having technical vocational training and 12% university education. In terms of agricultural experience, mid-career professionals predominate, with an average of 17 years working in the field. A minority, approximately 9%, have more than 30 years of experience, while around 11% are relatively new farmers with less than five years of experience. The majority therefore occupy an intermediate stage of their agricultural careers, with limited representation of both near-retirement veterans and complete newcomers.

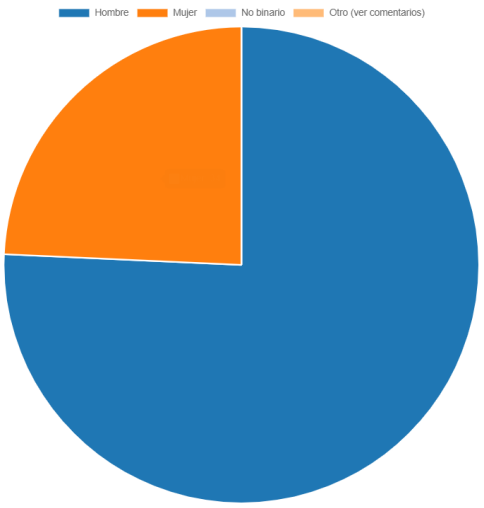


Chart X: Age distribution of surveyed farmers in Andalusia

3.6.2 Characteristics of the holding

Andalusian agriculture reflected in the survey shows a highly specialized production profile in subtropical fruit crops, mainly avocado and mango. Practically all respondents grow one or the other, with around 59% mentioning avocado and around 48% mango, and mixed production being common. Only a few cases reported other crops, such as maize or generic “subtropicals,” confirming that the sample is concentrated in tropical belt holdings.

The size of surveyed Andalusian holdings is relatively small. Median cultivated area is 6 hectares, indicating that at least half of holdings are very small, with a significant number of minifundia between 1 and 5 hectares. Only a small proportion exceed 10 hectares, and one case reaches 40 hectares. Labour availability is correspondingly limited: the median number of permanent employees is one, and around 21% of holdings have no salaried workers beyond the owner. Average employment is about 1.2 workers, inflated by a few larger farms, but overall these are family-run holdings where only the farmer and one or two permanent workers are employed.

3.6.3 Level of digitalization

In Andalusia, the current level of digital adoption is limited and heavily constrained by connectivity issues. An overwhelming majority of respondents, around 85%, lack Internet connection or even mobile signal inside farm buildings, hindering on-site use of digital tools. Only around 12% report good indoor connectivity, while about 4% have very weak occasional signal. In open fields, coverage improves somewhat, with around 76% reporting mobile data coverage, although 19% describe it as very weak or intermittent and 4% report no coverage at all.

As a result, around 74% rely on mobile networks as their main means of connectivity when available, while very few have fixed broadband: only about 3.6% report having Wi-Fi or local networks, generally linked to fibre or ADSL, and around 24% report having no connectivity at all on their holdings. Digital infrastructure is therefore a critical weakness.

Personal technological equipment reflects this situation. Smartphones are virtually the only widely used digital tool, with around 83% using them regularly for agricultural management. In contrast, only about 12% use a personal computer and around 4% use a tablet. A notable proportion, around 11.5%, report using no electronic devices at all, relying exclusively on traditional methods, while around 8% use only a basic mobile phone. Adoption of advanced agronomic equipment is very low: only around 5% use sensors and about 4% have their own weather stations. No respondents reported using drones or GPS-guided machinery. Digitalization in terms of hardware is therefore largely limited to smartphones.

Use of specialized agricultural software or applications is similarly limited and focused on specific needs. Around 47% of farmers do not use any digital farm management tools, while around 53% use at least one application. Among users, irrigation management dominates: around 48% of all respondents use technology-assisted irrigation control systems. Around 18% use fertilization control tools, often linked to fertigation systems. Other applications, such as weather monitoring, pest and disease control, crop planning, communication with technicians, or economic management, are used by small minorities. This indicates that digitalization is currently focused on very specific problems, mainly water efficiency, rather than integrated farm management.

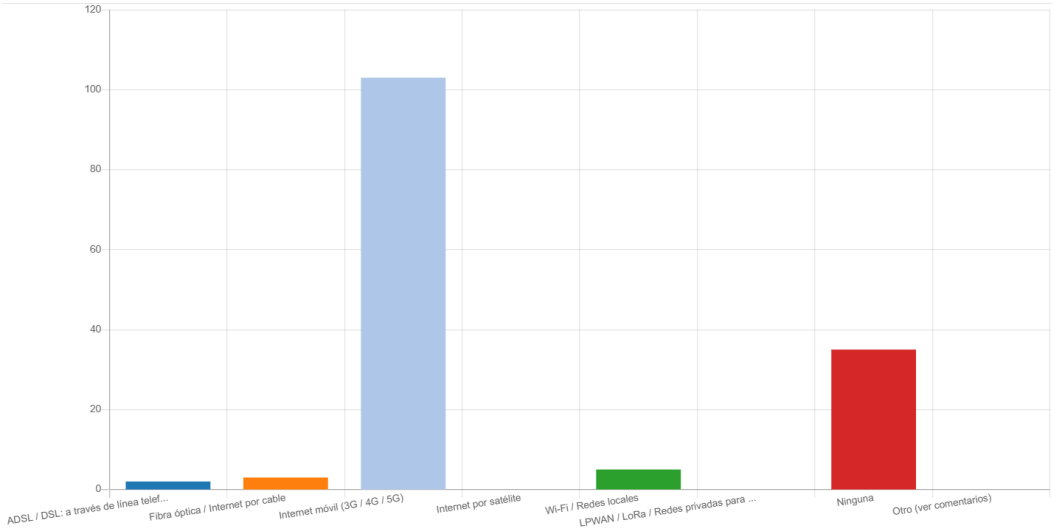


Chart X: Connections used on farms (number of respondents)

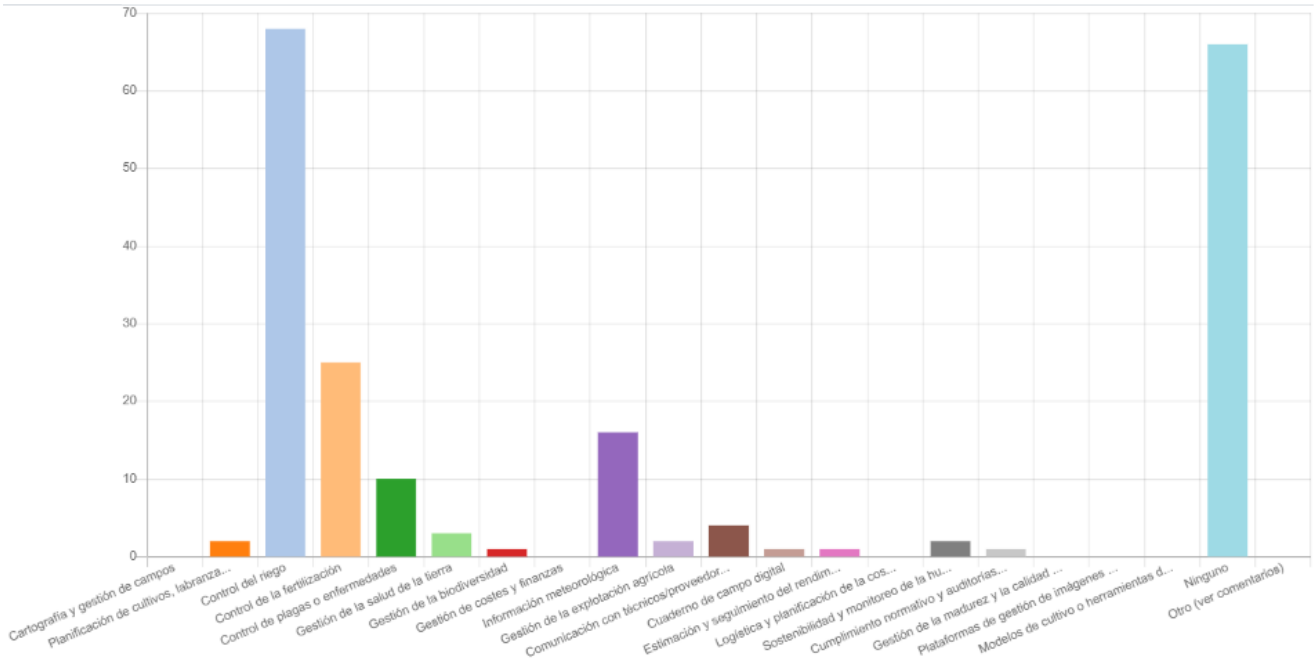


Chart X: Specialized software, applications, or digital tools used for agricultural tasks **(Nº respuestas)**

3.6.4 Barriers and needs

Andalusian farmers identify clear barriers to digital transformation, mainly related to infrastructure and financial resources. Lack of connectivity is the most severe obstacle, with around 70% rating it as a moderate or critical barrier. High costs of technology are the second major obstacle, with around two thirds considering them a significant barrier, including around 13% who see them as critical.

Lack of digital skills is also relevant, with around 43% rating it as a moderate or critical barrier. Other factors, such as lack of time or technical support, are generally perceived as minor to moderate constraints rather than critical ones. Overall, the picture suggests that improved connectivity and reduced costs would unlock significant latent interest in digitalization.

Nearly 78% of respondents expressed interest in receiving further digital skills training. Areas of greatest interest include precision irrigation and fertilization, efficient water use, precision agriculture, crop monitoring, sensors, and drones. However, only around 22% have previously received any digital agriculture training, highlighting the need for structured programmes.

Regarding who should be trained, around 79% believe the farm owner or manager should be the primary recipient, followed by technical staff at around 47%, and permanent workers at around 22%. Temporary workers and external providers are rarely considered priorities.

The strategic outlook towards technology is notably optimistic. Around 79% view digitalization as an investment rather than a cost. The main objectives of future digital investment are improving efficiency, selected by around 45%, and improving water management, selected by around 33%.

Consistent with this focus, the crop stage where farmers most want technological support is irrigation and fertilization, selected by around 96% of respondents. Pest and disease control and crop canopy management follow at around 49% and 48% respectively.

4. REGION 3: EXTREMADURA

4.1. TERRITORIAL SITUATION

Extremadura is located in the southwest of Spain and is characterized by a strongly rural profile, where the primary sector plays a decisive role in the region's economic and social structure. The agricultural sector contributes around 7.7% of regional Gross Domestic Product (GDP), a value well above the national average, and the agri-food sector generates more than €3 billion annually, representing close to 50% of the region's manufacturing industry. Likewise, the sector employs approximately 9.5% of the working population, consolidating itself as one of the main drivers of activity and employment in the territory.

The agrarian fabric of Extremadura is characterized by high structural and productive diversity. The region combines family farms, cooperatives, and agricultural processing companies (SATs), reflecting the coexistence of different management and organizational models. This diversity is rooted in a territory of strong agro-climatic contrasts, where rainfed systems and dehesas coexist with intensive irrigated farming, especially in the Upper and Lower Guadiana plains (Vegas Altas and Vegas Bajas). These are complemented by new irrigation schemes in Tierra de Barros and mountain irrigation areas, established in traditionally rainfed zones which, in response to the effects of climate change, have had to incorporate more efficient irrigation systems. In these environments, water allocations are limited, requiring increasingly rigorous, technology-driven, and data-based management of water resources.

A significant part of Extremadura's irrigated areas is classified as a Nitrate Vulnerable Zone (NVZ), in accordance with Directive 91/676/EEC on the protection of waters against pollution caused by nitrates from agricultural sources. This situation entails the mandatory application of specific action programs aimed at reducing pollutant loads, encouraging the rational use of fertilizers, and improving efficiency in nitrogen management, reinforcing the need to incorporate control, monitoring, and decision-support tools.

From a productive standpoint, vegetables stand out, with processing tomatoes as the emblematic crop, representing approximately 36% of the region's agricultural value, followed by fruit (23%) and cereals (20%). Overall, these productions account for around 5% of national agricultural value. Olive groves also maintain a structural role within Extremadura's agrarian system, and in recent years the hedgerow olive grove model has gained particular relevance, becoming established as an alternative to traditional olive groves. Its expansion responds to the search for greater productive efficiency and competitiveness, as well as labor shortages in rural areas associated with depopulation processes. However, this model poses new sustainability challenges, especially regarding water consumption and soil conservation.

Alongside these crops, the Jerte Valley cherry is one of the most representative and identity-defining products of Extremadura's agriculture. Protected under the "Cereza del Jerte" Protected Designation of Origin (PDO), this mountain production combines tradition, quality, and added value, generating employment in rural areas with complex terrain and contributing to population retention. Increasingly, its production incorporates sustainable techniques and digitization processes aimed at controlling ripening, traceability, and harvest optimization.

Overall, Extremadura's agrarian structure reflects high productive and territorial diversity, where traditional systems coexist with highly technified farms. This balance between innovation and tradition provides a solid foundation for advancing toward a more sustainable, competitive agrarian model adapted to the region's agro-climatic conditions.

In terms of digitization, Extremadura promotes various public and private initiatives aimed at modernizing the sector. Programs such as Kit Digital facilitate the adoption of tools such as electronic farm logbooks, livestock monitoring systems, or farm sensorization. Likewise, European projects such as TECH4E or TID4AGRO promote the modernization of agri-industrial SMEs through the use of IoT technologies, sensors, and traceability solutions. These are complemented by initiatives such as Smart Rural Living, aimed at developing "smart districts," and regional support lines for precision agriculture and Industry 4.0 technologies, aligned with the RIS3 Extremadura Strategy and the Recovery, Transformation and Resilience Plan (PRTR).

However, significant obstacles remain for widespread digitization, especially in smaller farms. These include low technology adoption, connectivity limitations in certain rural areas, and the need for ongoing training for effective use of digital tools. In this context, pilot projects based on accessible and scalable technologies, such as LoRaWAN networks developed in initiatives like TECH4E and TID4AGRO, are strategic to demonstrate real-world improvements in irrigation efficiency, input optimization, and farm competitiveness, helping reduce the digital divide in rural Extremadura.

4.2. LEVEL OF DIGITAL MATURITY

In recent years, Extremadura's agricultural sector has been immersed in a process of progressive transformation. While a significant share of farms still maintains traditional productive structures, a sustained increase is observed in the adoption of digital technologies by farmers and livestock producers, aimed at improving profitability, optimizing resource use, and strengthening environmental sustainability. Overall, the level of development can be described as moderate, with more significant progress in subsectors and production systems with higher levels of technification.

Nevertheless, technology adoption is clearly uneven. Larger irrigated farms are advancing more rapidly in implementing precision agriculture solutions, while small farms, rainfed systems, dehesas, and mountain irrigation areas show more limited digitization levels, constrained by investment costs, connectivity restrictions, and the lack of specific technical training. Differences are also evident in modernization and digitization levels among Extremadura's Irrigation Communities, with highly digitalized entities coexisting alongside others that have prioritized the modernization of basic irrigation infrastructure in recent years. Overcoming these barriers requires a coordinated combination of investments in digital infrastructure, economic incentives for equipment acquisition, and continuous training and advisory programs tailored to farm realities.

Extremadura avanza de forma progresiva hacia la digitalización del sector agrario, con un desarrollo moderado y desigual, más avanzado en explotaciones de mayor tamaño y regadío, y con importantes limitaciones en pequeñas explotaciones por costes, conectividad y falta de formación.

Technology transfer plays a central role in this digital transition process. Operational groups and cooperation projects bring digital tools closer to the productive sector through demonstration trials, technical workshops, and advisory actions. However, there remains a need to strengthen dissemination mechanisms and personalized support, especially to ensure these solutions effectively reach small and medium-sized farms.

Extremadura has a solid scientific and technical base supporting this process, sustained by entities such as the National Agri-food Technology Center (CTAEX), the Extremadura Center for Scientific and Technological Research (CICYTEX), universities, cooperatives, and innovation operational groups. These institutions promote experimentation, technology transfer, and specialized training, encouraging the adoption of digital tools, advanced sensorization, and sustainable solutions by new generations of agricultural professionals.

From an institutional perspective, the Government of Extremadura promotes sector digitization through specific programs and calls within the framework of the Rural Development Program (PDR) and the Smart Specialization Strategy (RIS3 Extremadura). These initiatives foster the adoption of technologies such as soil sensors, agro-climatic stations, automated irrigation, drones, farm management software, and digital traceability platforms. Complementarily, European projects framed in programs such as Horizon Europe, Interreg, LIFE, ERDF (FEDER) or EAFRD (FEADER) support rural digitization, fund training actions, and promote innovation networks, with special attention to small farms and territories with fewer resources.

Extremadura's business fabric linked to the agri-food sector is diverse and dynamic. Among the most innovative areas is the use of drones and aerial remote sensing, with a growing number of specialized companies in the region offering services in photogrammetry, topography, thermal analysis, crop mapping, and RPAS pilot training. These solutions provide high-precision information for the management of plots, hydraulic infrastructures, and forest areas, improving crop monitoring and agronomic treatment planning.

In precision agriculture, companies stand out for combining sensors, soil analysis, and remote sensing. Their tools support decision-making to optimize irrigation, fertilization, and crop health, reducing environmental impacts and improving productive efficiency. Likewise, solutions are being developed for the agri-food industry, such as harvest planning platforms and production forecasting.

Regarding efficient water management, smart irrigation projects are being promoted through data transmission systems aligned with sustainability objectives and climate change adaptation. Meanwhile, IoT companies have

consolidated in the sensorization of livestock and forestry operations through LoRaWAN technology, offering remote monitoring solutions and developing specific sensors in R&D&I projects.

In digital farm management, IoT-based systems have been developed to optimize decision-making and digitize agri-food SMEs. Participation in innovation projects has allowed LoRaWAN networks to be incorporated into their solution catalogs, expanding the applicability of these technologies in rural environments.

Rural connectivity is an essential enabling factor for this ecosystem. In this area, regional operators play a key role in providing fiber optics, wireless networks, and telecommunications services in rural and mountainous areas where other providers do not reach. These actions have enabled high-speed connectivity for many rural municipalities and farms, facilitating the adoption of digital solutions even in territories with structural limitations.

Complementarily, pilot projects for deploying LoRaWAN networks have been developed in collaboration with local entities and ICT demonstration centers, aimed at assessing the technical and economic feasibility of these networks and facilitating their expansion throughout rural Extremadura. These experiences have served as a basis for designing replicable models in low-density and complex-terrain areas, and for creating public and collaborative coverage networks aimed at facilitating small farms' access to low-cost, high-efficiency technologies.

Overall, these initiatives shape an emerging, diverse, and high-growth-potential business and technological ecosystem capable of offering solutions adapted to Extremadura's agro-climatic and productive conditions. Consolidation of this ecosystem will depend on strengthening public-private collaboration, improving market access, and fostering integration into innovation networks at national and international scales.

La región cuenta con un ecosistema institucional, científico y empresarial sólido que impulsa la innovación y la transferencia tecnológica, siendo clave reforzar la adopción práctica en campo, la colaboración público-privada y el apoyo específico a las pequeñas explotaciones para reducir la brecha digital y mejorar la sostenibilidad del medio rural.

Extremadura therefore has an institutional, business, and technical base well suited to advancing toward a more innovative and digitized agrarian model. The main challenge lies in strengthening the practical adoption of technologies in the field and reducing the gap between scientific knowledge and productive reality. To achieve this, it will be key to combine public support, continuous technical advisory services, and cooperation among farmers, technology centers, and companies, ensuring the inclusion of small farms and consolidating digitization as a real tool for rural development, sustainability, and territorial resilience.

4.3. STRENGTHS

Extremadura's agricultural sector shows progressive evolution toward more efficient, technified, and sustainable production models. The gradual incorporation of digital solutions and links with the agri-food industry are driving modernization processes adapted to the territory's characteristics. This progress is supported by a combination of technical capacities, infrastructures, scientific knowledge, and public-private cooperation, as outlined below:

- **Climate and environmental awareness:** Extremadura's agricultural sector has increasingly incorporated technologies such as smart irrigation, moisture and nutrient sensors, drones, and digital management and traceability platforms. These solutions optimize resource use and reduce environmental impact. Innovation has been oriented especially toward improving profitability and productive efficiency, reflecting sustained transformation of the production model.

- **Technological suitability for small farms:** Certain production systems show a high level of technification, especially those with commercial and export orientation. Notable examples include intensive and hedgerow olive groves, processing tomatoes, irrigated fruit crops, and some pig and cattle farms. In these cases, automated feeding systems, environmental control, and health monitoring are used. These experiences serve as references for other subsectors.

- **Strong and structured collective innovation and support ecosystem:** Extremadura's agri-food industry plays a driving role in sector digitization. Processing industries for tomatoes, olive oil, meat products, and dairy incorporate automated processes and digital quality control systems. Their linkage with cooperatives and technology centers strengthens innovation transfer, generating added value and territorial competitiveness.

- **Cooperative / support model:** Agricultural cooperativism has consolidated as a key driver for collective adoption of digital technologies. Successful experiences based on IoT, data analysis, and traceability platforms exist. These initiatives facilitate shared training and reduce implementation costs. The collective approach improves the sector's adoption capacity.

- **Strong and structured collective innovation and support ecosystem:** Extremadura has a solid scientific and technical base supporting agricultural digitization. Entities such as CTAEX, CICYTEX, universities, and operational groups promote experimentation, knowledge transfer, and specialized training, encouraging advanced sensorization and sustainable solutions. Their work strengthens the territory's technological maturity.

4.4. AREAS FOR IMPROVEMENT

Despite progress in digitization and the existence of relevant experiences, Extremadura's agri-food sector still presents areas for improvement that limit the consolidation of digital transformation. These limitations respond to structural, technological, training, and organizational factors. Together, they explain uneven and insufficient adoption to generate systematic change across the whole territory.

- **Organizational change management:** Despite progress in digitization and relevant experiences, the sector still has areas for improvement that limit consolidation. These limitations respond to structural, technological, training, and organizational factors, resulting in uneven and insufficient adoption.

- **Support, assistance, and simplification:** There is a significant gap between the development of pilot projects and sustained implementation of digital solutions on farms. Although many demonstration initiatives have been technically successful, they do not always translate into stable day-to-day use. Advanced digitization is concentrated in more technified farms or in projects driven by research centers, while a significant part of the agrarian fabric remains at basic levels of adoption.

- **Support, assistance, and simplification:** Transfer, dissemination, and scaling of digital solutions face structural limitations. Technologies often remain experimental and do not consolidate as operational tools, hindering widespread digitization. There is a need to strengthen mechanisms that facilitate moving from pilot to real implementation.

- **Digital literacy:** The training gap and the sector's demographic structure are significant constraints. The high average age of farm holders and low youth incorporation limit available digital skills. Although there is interest in technology, training offered is sometimes insufficient or poorly adapted, hindering autonomous and efficient use of digital tools.

- **Rural connectivity:** Digital connectivity in rural areas remains a limiting factor in certain zones. Low-density areas and mountainous territories face greater difficulties, affecting cloud platform use and real-time monitoring. Despite alternative solutions, improving connectivity remains a structural requirement. The region has connectivity infrastructures adapted to rural environments as a key enabler. The deployment of fiber, wireless networks, and IoT solutions based on LoRaWAN has expanded digital access in rural and mountainous areas. Achieved coverage facilitates the implementation of low-cost solutions. These infrastructures are open, replicable, and aligned with the real needs of the territory.

- **Financial support:** Investment costs and perceived economic return limit technology adoption. In many small and medium farms, digitization is seen as a high investment, and lack of clear evidence of immediate benefits reduces willingness to invest. This is more pronounced where profit margins are low.

- **Interoperability:** Technological fragmentation and limited interoperability between systems create an additional barrier. Coexistence of incompatible solutions complicates data integration, increases perceived complexity, and generates user frustration. Ongoing technical support is also insufficient to continuously support adoption processes.

4.5. RELEVANT STAKEHOLDERS IN THE TERRITORY

Extremadura's agrarian ecosystem is structured around a diverse network of stakeholders involved across the entire value chain, from primary production to processing, innovation, and commercialization. This network is key to the functioning of the regional agri-food system and to driving modernization and digitization processes.

In primary production, family farms form the base of the productive fabric, characterized by high diversity in size, production orientation, and cultivation systems, ranging from rainfed and irrigated farming to extensive livestock production. Alongside them, cooperatives and Agricultural Processing Companies (SATs) play a fundamental role in supply concentration, crop modernization, product processing, and added value generation, acting as driving structures for the adoption of technical and organizational innovations.

The agro-industrial and processing sector constitutes another essential pillar. It includes agri-food industries linked to strategic productions such as processing tomatoes, olive oil, wine, Iberian meat products, cheeses, and the wider fruit and vegetable sector. These are complemented by packaging, distribution, and commercialization companies that connect regional production with national and international markets, adding value and strengthening the external projection of Extremadura's agri-food sector.

Professional agricultural organizations (OPAs), such as UPA-UCE, ASAJA, and COAG, play a relevant role in representing farmers' and livestock producers' interests, acting as interlocutors with public administrations and supporting training, advisory services, and innovation processes.

In knowledge, research, and technology transfer, Extremadura has a set of reference institutions. Notably, the Extremadura Center for Scientific and Technological Research (CICYTEX) serves as the main regional agrarian R&D&I body; the Agri-food Technology Center of Extremadura (CTAEX) focuses on innovation and technological support for companies; and the University of Extremadura, alongside agricultural vocational training centers, contributes to knowledge generation, human capital training, and technology transfer to the productive sector.

Public administration plays a central role in planning, regulation, and support for the agrarian sector. The Regional Government of Extremadura (Junta de Extremadura), through different departments, manages agrarian, rural development, irrigation, and irrigation community policies; promotes research, technical training, and knowledge transfer; drives digitization and business modernization; and supports the social economy, cooperativism, and labor societies, which are key elements of the Extremadura agrarian model. At the territorial level, provincial councils, associations of municipalities, and local councils coordinate resources, support rural development projects, and foster territorial cohesion. Irrigation communities play a strategic role in collective water management, optimizing water use and coordinating infrastructure at local and district scales.

Additionally, the ecosystem is supported by a network of auxiliary and technological services, including companies specialized in agricultural machinery, irrigation systems, fertilization, and sensorization, as well as startups and ICT SMEs specializing in IoT solutions, data analysis, and monitoring, which drive digitization in farms and the agri-food industry.

Finally, civil society and rural development entities complete the ecosystem through Local Action Groups (LAGs/GAL) and various sectoral associations, which promote social innovation, sustainability, territorial cooperation, and rural economic dynamization.

Overall, this network of stakeholders forms a solid and diverse agrarian ecosystem integrating production, industry, knowledge, administration, and technology, providing a fundamental basis for advancing toward a more competitive, sustainable, and digitized agri-food model in Extremadura.

4.6 SURVEY RESULTS

4.6.1 Farmer profile

The average age of the surveyed farmer in Extremadura is around 42 years, with a range from 18 to a maximum of 78 years. That is, some generational renewal is evident and very elderly producers are not common (only about 8% are over 60), shaping a comparatively young population. Regarding gender, the sector appears male-dominated, though with female presence: about 70% identify as men and around 29% as women. The educational level of Extremadura's farmers is generally higher than in other analyzed regions: most (about 62%) achieved higher education (around 38% with university studies and about 24% with technical vocational training), while approximately 22% remained at secondary education (compulsory secondary or high school) and only about 16% have only primary education.

In terms of agricultural experience, the sample includes very diverse profiles. The average number of years working in the field is about 14 (median about 8 years, notably lower than the average), reflecting the presence of many relatively new farmers. In fact, close to 33% have less than 5 years of activity, while an important minority (about 17%) has more than 30 years of experience. The rest (about 50%) are in an intermediate stage (between 5 and 30 years). Overall, a broad group of young or mid-career farmers predominates, with a smaller but significant contingent of veterans, resulting in a population with more newcomers than observed in neighboring regions.

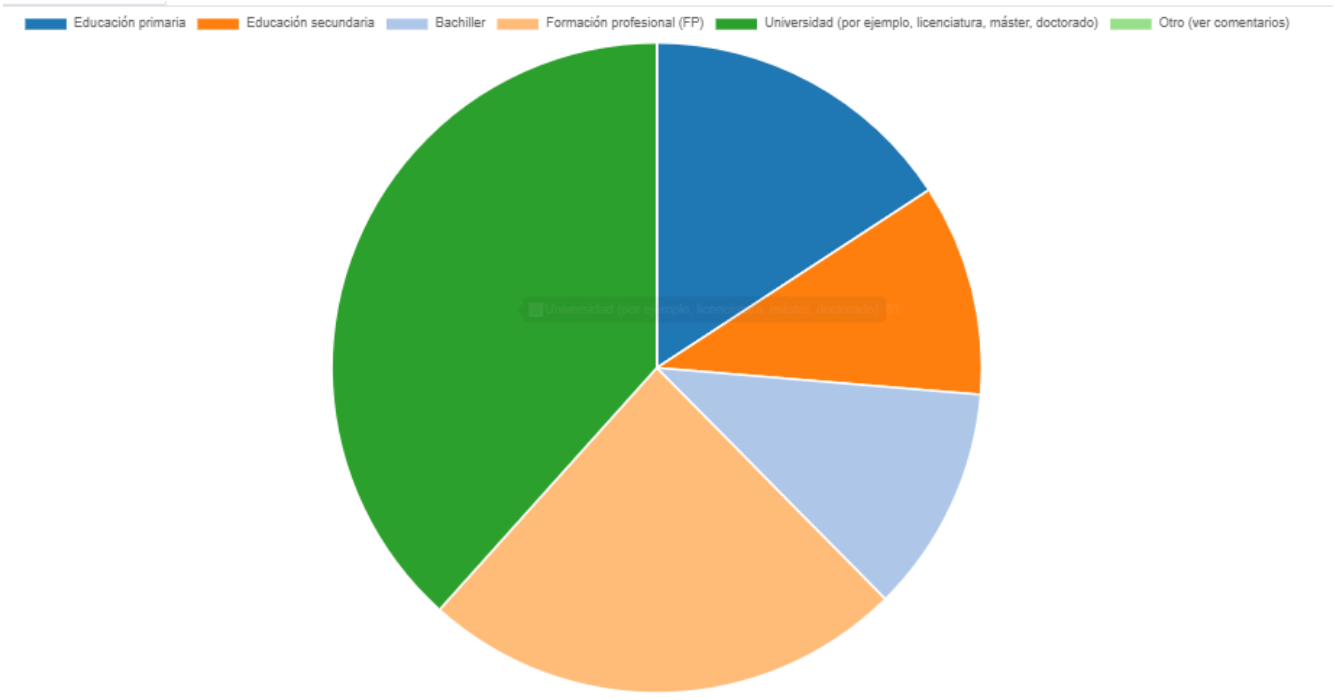


Chart X: Distribution of farmers by education

4.6.2 Farm characteristics

Extremadura's agriculture reflected in the survey shows a diversified production profile, without a dominant monoculture. Several subsectors stand out: on the one hand, rainfed fruit farming with cherry as the emblematic crop (mentioned by around 40% of respondents, often together with chestnut in about 26% of cases). On the other hand, olive growing is very common: approximately 24% of surveyed producers include olive groves among their main crops. Rainfed extensive farming (cereals and forages) appears in around 7% of surveyed farms. Likewise, a significant group (about 15%) is dedicated to intensive irrigated crops in the Guadiana plains (for example, processing tomato, maize, rice, or irrigated vegetables). Overall, the sample is heterogeneous in production orientation, reflecting Extremadura's agri-food diversity rather than the strong specialization seen in other regions.

Farm size varies notably, though it tends to be small in many cases. Median cultivated area is about 9 hectares (average about 42 ha, inflated by a few exceptionally large farms), indicating that at least half the farms are small or very small. In fact, around 36% have 5 ha or less (smallholdings), though a significant share (about 43%) exceeds 10 ha, including around 8% over 100 ha. Only a few cases reach several hundred hectares, with the maximum reported around 1,000 ha, raising the average considerably. Overall, modest family-scale farmers predominate.

In line with this, labor availability is minimal in most farms: the median number of permanent employees is 0, meaning that in at least half the cases the owner is the only permanent labor. Around 51% report having no employees besides the farm holder. The average (about 3.9 workers) is much higher due to a few large agricultural companies employing dozens of people (maximum declared was 175); excluding these outliers, most farms have one or two permanent employees at most. Essentially, it is a predominantly family-based, small-scale agrarian fabric with a few large farms breaking the general pattern.

4.6.3 Level of digitization

In Extremadura, the current level of digital adoption is moderate and seems to vary by area, though infrastructure conditions its scope. A considerable proportion of farmers do have connectivity: approximately 60% report having Internet access or at least mobile signal inside farm buildings. By contrast, around 26% have no indoor coverage at all, and another 7% only get a very weak signal occasionally (the remaining 7% did not specify). In open fields, coverage improves somewhat: about 66% report having mobile data signal in their plots, though around 16% describe it as very weak or intermittent and about 9% have no coverage on the land. Many depend on mobile networks outdoors, but indoor connectivity remains deficient for a substantial part of the sector.

Internet access relies mainly on cellular networks: about 64% use mobile Internet (3G/4G/5G) as their main way to connect. Very few have fixed broadband: only about 3% have fiber optics and 8% have ADSL, in total only about 11–12% with fixed-line Internet (usually associated with Wi-Fi/local networks inside the farm). Additionally, around 12% reported having no connection available at the farm. A small group (about 6%) uses satellite Internet as an alternative. Basic digital infrastructure therefore remains a critical issue in many rural areas: "black spots" without coverage persist and most depend exclusively on mobile networks for any digital

service.

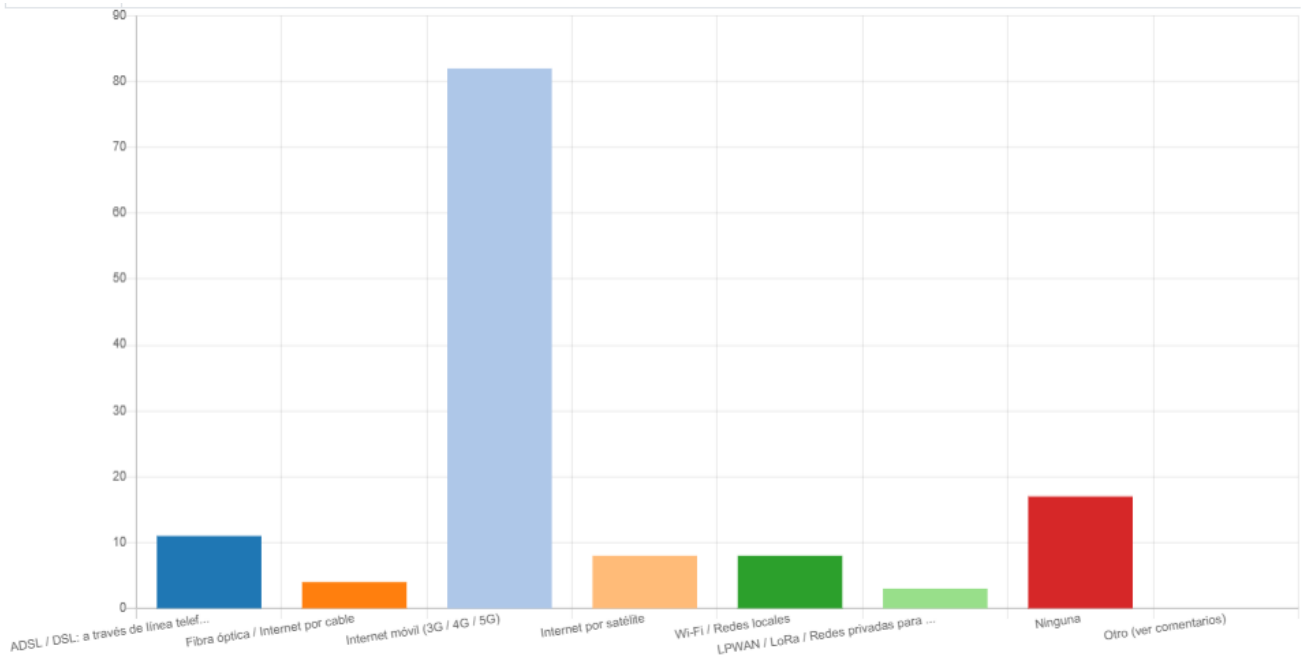


Chart X: Type of Internet/data connection

Personal technology equipment reflects this mixed picture. Smartphones are widely used, though not as universally as in other regions: about 63% use a smartphone regularly for agricultural tasks, making it the most used device. At the same time, computer use is relatively higher: around 30% use a PC or laptop for farm administration or technical tasks. Tablet use is lower (about 11%). Notably, about 9% report using no electronic device in their agricultural work, relying solely on traditional methods, and another 15% rely only on a basic mobile phone (calls/SMS) as their only technology. These percentages tend to correspond to older producers or those less digitally familiar. Overall, smartphones dominate, but coexist with a significant minority disconnected from modern tech and a relatively broad use of computers.

Regarding advanced agronomic equipment, adoption remains low on average. Only about 9% have GPS guidance systems or “smart” connected machinery, about 8.5% have installed field sensors (soil moisture probes, irrigation flow meters, or other IoT devices), and about 6% have their own weather stations. Drone use is still minor but present (about 6%). In other words, hardware digitization goes beyond smartphones for a small group of pioneers, while most still lack specialized equipment.

Consistently, the use of specialized software or applications is relatively common and diverse. About 60% use at least one digital farm-management tool (vs. 40% who use none). Among users, administrative/document management stands out: about 28% use a digital farm logbook or similar application for recording and traceability. Around 18% use weather apps, and a similar proportion (about 17%) use tech-assisted irrigation control. About 18% use integrated farm management software (task planning, plot management, inventories). Another 15% use digital communication tools with technicians or suppliers. Other uses include crop planning

(about 12%), fertilization control (about 12%), pest/disease monitoring (about 10%), and cost/finance management (about 10%). Some report vegetation cover/soil management (about 12%), regulatory compliance/certifications (about 11%), and yield estimation (about 5–7%).

In contrast, remote sensing and advanced data analysis adoption remains incipient: only about 5% use satellite imagery platforms, and almost none do specialized multispectral processing or routinely use decision-support models. Likewise, very few mention environmental sustainability/biodiversity tools (under 2%). In summary, Extremadura's digitization emphasizes both administrative management (digital logbooks, planning) and specific agronomic improvements (irrigation, fertilization, plant health), while precision agriculture and advanced data analytics are still far from the norm.

A related indicator is the use of digital cartography or remote sensing in operations: about 18% report using satellite images, field maps, or remote sensors (including drones). Connected machinery, though still minority, is somewhat more present: about 12% have tractors/equipment with Internet connection/telemetry, and about 80% said categorically they do not have connected machines (the rest did not know). These data suggest that some technologically advanced farms already exist, but most still operate with conventional machinery without automated data capture. Overall, Extremadura's average digitization level can be considered moderate, with widespread smartphone use and some management apps, and an emerging introduction of precision tools among a minority. Connectivity and infrastructure limitations still hinder broader adoption, though local examples of advanced digital agriculture already exist.

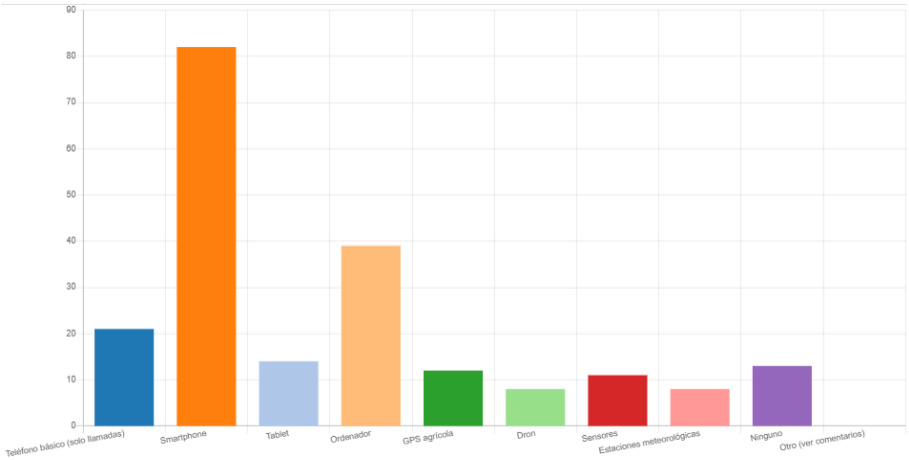


Chart X: Devices used in Extremadura farms

4.6.4 Barriers and needs

Extremadura's farmers identify several barriers to digital transformation, with infrastructure and economic obstacles standing out. Lack of Internet connectivity is the most frequently cited obstacle: almost no one considers it irrelevant (less than 1% said it is "not a barrier"), and around two-thirds rated it as an important barrier (moderate or critical). Many cannot realistically consider certain technologies until coverage improves or electricity becomes available in their plots (several mentioned lacking electrical supply, making it difficult to install sensors or equipment). High technology costs appear as the second main obstacle: around two-thirds

consider cost a significant barrier. About 15% rate cost as a critical barrier, while another roughly 50% see it as a moderate barrier that delays investment.

Other factors have somewhat lower but still notable impact. Lack of training/digital knowledge is mentioned by a considerable share: around 30–40% rate it as a moderate-to-critical barrier, though only about 10% see it as "critical." This suggests that part of the sector recognizes skill gaps that can slow adoption without adequate training. Cultural or attitudinal barriers (resistance to change, distrust in tech, not perceiving usefulness) seem among the least problematic, with many rating them as mild, and about 5–7% saying they are "no barrier" for them. In short, there is generally good predisposition toward digital innovation; the obstacles are more practical (network, money, training) than a lack of willingness. Similarly, lack of time and lack of technical support are recognized as low-to-moderate inconveniences but rarely as critical barriers.

Demand for support and training remains high. About half of respondents (around 50%) said they would "probably" be interested in more training, while about 30% showed little interest, and around 15% were neutral. Among those interested, key areas include drones and remote sensing, low-cost field sensors, efficient irrigation and fertilization management, interpretation of vegetation indices from imagery, use of digital farm logbooks, and even improving spreadsheet skills (Excel) for farm management.

So far, about 36% report having previously attended some course or training on digital tools applied to agriculture, while about 64% have not. Those trained mention workshops on precision irrigation (water control and fertigation via apps or probes), introductory courses on sensors, drone training, and digital farm logbook usage, among others.

Regarding who should be trained, about 66% believe the farm manager/owner should be the primary recipient, recognizing that decision-makers must lead transformation. Around 43% think the technical team should also be trained. In Extremadura, a larger share also supports training the broader workforce: about 26% mention permanent workers, about 24% mention machinery operators, about 12% mention seasonal workers, and about 13% mention external service providers. Only about 4% believe no group needs training.

Farmers' strategic view of technology is mostly positive: about 78% see digitization as an investment, while about 20% see it as a cost, and about 2% are unsure. The most frequent main objective for the next digital investment is "improving efficiency" (about one-third). Close behind are "optimizing fertilizer and pesticide use" and "improving water management" (together around 20–25%). Reducing costs or increasing profitability is less prioritized (about 15–20%), similar to reducing environmental impact (about 15%). Increasing production or improving quality is rarely cited (about 5–10%).

Consistently, the crop stage where farmers want more technological support is led by irrigation and fertilization. About half also want improvements in soil preparation and in-crop management, and around 40% prioritize pest and disease control. Planting/transplanting (about 25%) and harvesting (about 20%) appear as secondary priorities. Marketing/sales is barely mentioned (about 3–4%). A small segment (about 5–10%) marked "none," indicating some skepticism or satisfaction without tech.

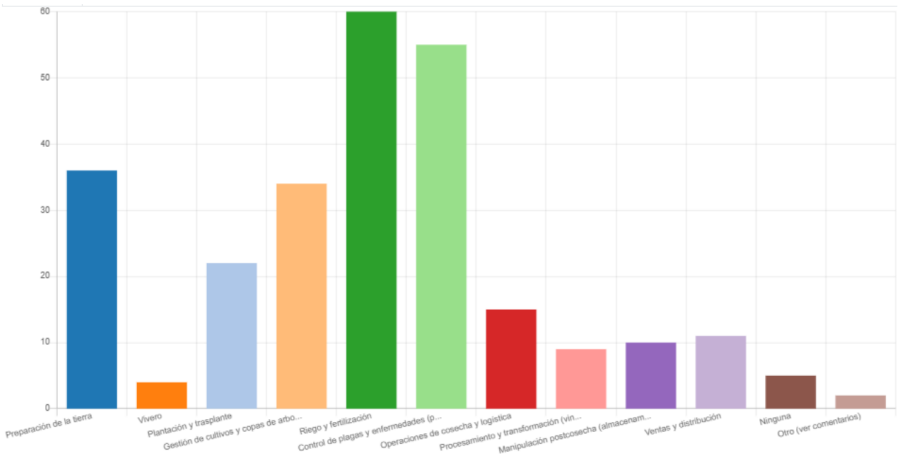
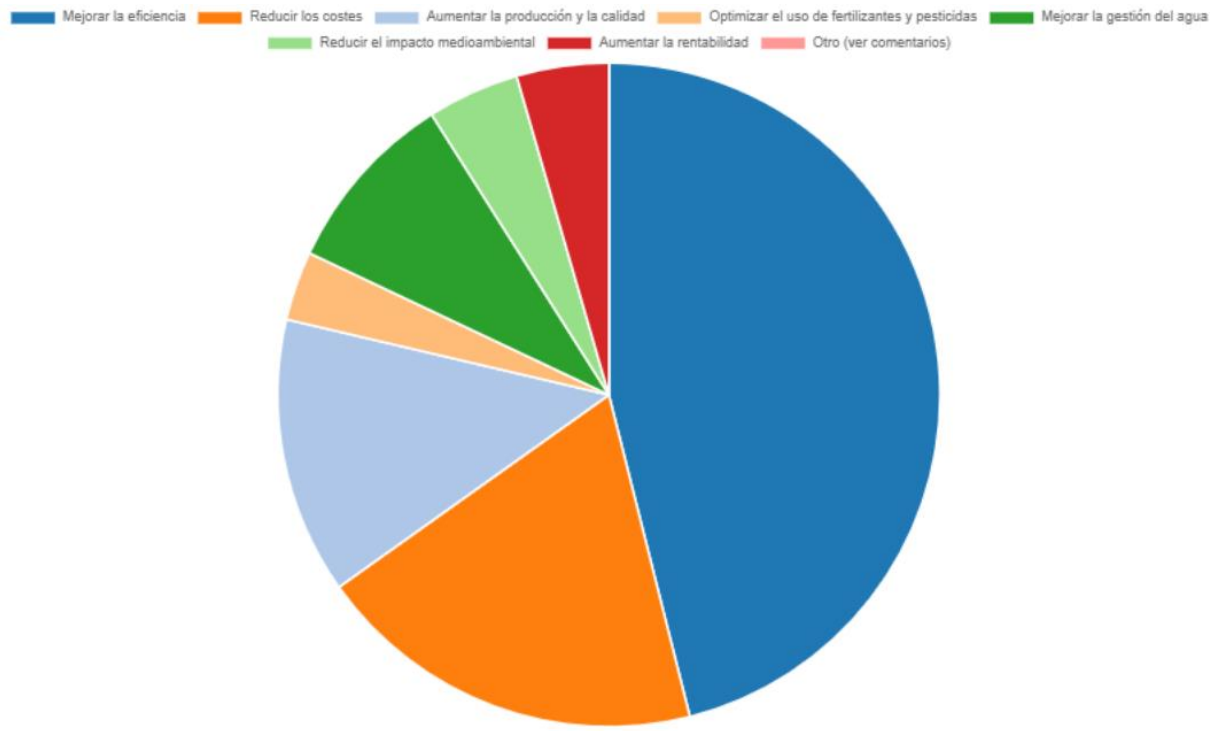


Chart X: Crop stage where you would like more technological Support

Finally, in the open question about needed but not implemented technologies, about 27% provided concrete examples. A recurring theme is irrigation automation and control (soil moisture probes, automated valves, remote control, fertigation equipment), mainly postponed due to high costs relative to farm size or income. Some also cited infrastructure constraints such as lacking water concessions or lacking electricity and signal. Drones were also mentioned, but often described as expensive and requiring training. Precision machinery (GPS, variable-rate systems) was similarly described as too costly without aid. The remaining 73% did not identify any specific pending technology, either because they feel no immediate need or because they are not aware of available solutions. Overall, the most desired innovations revolve around water management and input efficiency, plus advanced crop monitoring, with economic constraints (and secondarily connectivity/training) as the main reasons for not adopting them.


Mejorar la eficiencia
Reducir los costes
Aumentar la producción y la calidad
Optimizar el uso de fertilizantes y pesticidas
Mejorar la gestión del agua
Reducir el impacto medioambiental
Aumentar la rentabilidad
Otro (ver comentarios)

5. REGION 4: NOUVELLE-AQUITAINE

5.1. TERRITORIAL CONTEXT

Nouvelle-Aquitaine is the largest region in France, covering an area of 84,000 km² and composed of 12 departments (administrative divisions). Its regional gross domestic product amounts to around €160 billion (≈7.5% of French GDP). The region has a diversified economy that combines industrial and service sectors, a dynamic tourism activity, and a strong presence of the aerospace and agri-food sectors. It is also characterized by a high proportion of its working population employed in agriculture and forestry, making it the leading agricultural region in Europe in terms of value (Cap Métier Nouvelle-Aquitaine,, 2024 and 2025).

The region has more than 60,000 agricultural holdings, covering 4.2 million hectares of agricultural land, which represents 15% of France's total agricultural area (Nouvelle-Aquitaine, 2024).

Among the main agricultural sectors in the region, the wine sector stands out for its economic value. Vineyards cover 224,800 hectares (2020), making Nouvelle-Aquitaine the second-largest wine-producing region in France, and include 13,500 wine holdings, two thirds of which produce quality wines (DRAAF, 2024). Two major wine-producing areas can be distinguished:

- **Charentes–Cognac**, with 91,000 hectares of vineyards, of which 2% are organic, 4,700 holdings and an average size of 19 hectares;
- **Aquitaine**, with 131,000 hectares of vineyards, 18% organic surface area, 6,600 holdings and an average size of 20 hectares (Agreste, 2020).

These two wine-producing areas differ significantly in their organization, final products and markets.

Digital agriculture plays a central role in national and regional public policies due to its capacity to promote new practices that are more environmentally friendly or more economically efficient. An example of this is the **Neo Terra roadmap**, which aims to accelerate the agroecological transition of all farms in the face of climate change. This strategy promotes the preservation of living soils, the gradual elimination of synthetic pesticides, the rational use of water resources, the maintenance of high-quality livestock farming and the restoration of biodiversity, while ensuring a decent income and encouraging generational renewal in the agricultural sector (Neo Terra, 2025). In this context, digital technology is an essential tool to address these challenges. It is not a solution in itself, but rather a catalyst that enables these objectives to be achieved with greater precision.

One ongoing initiative is the **VitiREV programme (2020–2028)**, a multi-partner regional initiative for the wine and spirits sector co-financed by the State and the Region, whose objective is to reduce or eliminate the use of plant protection products in viticulture by 2050. This initiative places strong emphasis on digitalization and robotics, supporting the adoption of precision tools and the reduction of inputs. Various studies associated with the project, such as those by AFPA, DESIRA and the AGROTIC Chair, agree that although the sector is traditional and shows delays in digitalization, the digital transition is inevitable. However, the level of equipment remains

very uneven and is closely linked to the size and investment capacity of the holdings, with larger companies being better equipped.

On the other hand, the level of investment is a central element in the digitalization issue and directly conditions its development in the sector. The main obstacles to investment identified by professionals themselves are primarily cost, but also difficulties in making full use of the possibilities offered by digital tools and, consequently, in carrying out an adequate cost–benefit analysis.

The adoption of digital solutions also depends on the type of activity, being more present in commercial and sales-related areas, such as communication or marketing activities

The wine sector in Nouvelle-Aquitaine, selected for the implementation of pilot projects, is composed of 90% wine-producing companies with fewer than 10 employees. Therefore, the AgrDemoLab strategy and methodology developed by Agritech will be aimed at the vast majority of wine holdings in Nouvelle-Aquitaine.

5.2. NIVEL DE MADUREZ DIGITAL

The level of digital maturity of the wine sector in Nouvelle-Aquitaine is characterized by strong heterogeneity, confirming a “two-speed” model. On the one hand, there is a small core of dynamic farms and wineries (often larger, with more capital or linked to collective projects or active interprofessional bodies) that use relatively advanced digital tools: digital field logs, DSS/OAD for treatments, carbon footprint calculation tools, parcel GIS, winery sensors or traceability solutions. These holdings represent a minority in number but a significant proportion of surface area (between 40–50% in some collective schemes, according to sector experts interviewed).

On the other hand, the vast majority consists of small wine holdings, particularly family farms, cooperative members and winegrowers of advanced age or with low administrative capacity, which show a low or basic level of digitalization, limited to mandatory or delegated uses (administration carried out by cooperatives, technicians or interprofessional bodies). In many cases, analogue practices persist (paper notebooks, little use of computers, total dependence on advisors), even for functions that will soon become mandatory.

Interviews conducted with experts as part of this diagnosis confirm that digitalization:

- Is more advanced in administrative, certification or marketing tasks than in daily technical vineyard management;
- Depends heavily on the age, profile and role of the decision-maker (farm manager, technician, cooperative);

- Progresses more through regulatory obligation than through spontaneous initiative (e.g. mandatory digitalization of treatment records by 2027).

Overall, the level of digital maturity of the regional wine sector in Nouvelle-Aquitaine can be classified as **incipient to intermediate**, with islands of excellence but without widespread adoption among small holdings.

5.3. STRENGTHS

The wine sector in Nouvelle-Aquitaine has structural strengths that favor digitalization:

- **Strong and well-structured collective innovation and support ecosystem**: the region has two active interprofessional organizations (Bordeaux and Cognac), as well as clusters that promote innovation and digitalization. This ecosystem includes technical intermediaries, cooperative technicians, chambers of agriculture, interprofessional bodies and consultants who play a key role as digital intermediaries, compensating for the low digital autonomy of many winegrowers.

- **Digitalization-oriented programmes and funding**: flagship programmes such as VitiREV act as catalysts for innovation, pilot testing and technology transfer supported by public resources. Sector-specific digital solutions have been developed (DEVOPP/DEVOP for treatment logs, environmental certification tools, IFT calculation, carbon footprint), reducing entry barriers for small holdings.

- **Growing awareness of climate and environmental challenges**: climate change, regulatory pressure and the need to reduce inputs are driving interest in digital tools, particularly in precision viticulture and treatment management.

- **Shared data culture**: in some collective systems (environmental management, benchmarking of practices), winegrowers have internalized the value of sharing data to compare themselves with peers and improve practices. For example, early warning systems allow the sharing of pest detection data so that neighboring farms can adjust phytosanitary doses to specific needs.

5.4. ÁREAS DE MEJORA

The main areas for improvement, particularly relevant for small wine holdings, are:

- **Digital literacy**: there are large differences in digital literacy. In many cases, technicians from digital solution providers “do things for” the winegrower, which limits autonomy and effective use of tools.

- **Organizational change management**: lack of time and mental overload are the main declared barriers. Digitalization is perceived as an additional task competing with field work.

- **Support, assistance and simplification**: more complex tools (GIS, multifunction platforms) have low adoption rates and insufficient usability. Use is especially problematic when tools are only used once a year, leading to loss of skills.

- **Interoperability**: the coexistence of multiple unconnected tools (PDFs, Excel files, private and public platforms) leads to duplicate data entry and frustration, especially in small structures.
- **Improving trust in data use**: there is recurrent fear of data reuse for control or sanction purposes (certifications, administration, AOC), which hinders voluntary use.
- **Rural connectivity**: "white zones" with limited internet access still exist in parts of the vineyards (rural Gironde, peripheral areas), limiting real-time tool use in rural areas.
- **Financial support**: economic constraints are significant. The current wine crisis drastically reduces investment capacity, even when solutions are technically relevant.
- **Less supportive cooperative model**: in highly assistive cooperatives, this acts as an indirect brake on digitalization. Winegrowers have little incentive to invest in their own digital tools when decision-making is outsourced.

5.5. SURVEY RESULTS

Farmer profile

The average age of the farmers surveyed in Nouvelle-Aquitaine is around 50 years. A considerable proportion are over 60 years old (19% are over 60), reflecting an ageing agricultural population. The sector is clearly male-dominated: 86% identify as men, compared to 13% women. The educational level is high: nearly 58% hold university degrees (Bachelor's, Master's or PhD) and around 36% have technical vocational training; only a small minority (<5%) completed only secondary or primary education. In terms of agricultural experience, farmers with long professional trajectories predominate, with 39% having more than 30 years of experience, although there is a small fraction of new farmers (only 5% have less than 5 years of experience).

Characteristics of the holding

The agriculture analyzed in Nouvelle-Aquitaine for this diagnosis is focused on the wine sector, with farm sizes varying significantly. The median farm size is 5 hectares, indicating many medium-scale vineyards, although the average size (42 ha) is higher due to the presence of some large estates. In general, small winegrowers coexist with a limited number of large-scale producers. Labour availability is also limited in most cases: half of the holdings have no salaried workers or only one additional employee (median = 1). The average is 2 employees,

influenced by some larger wineries employing more than 10 workers (the maximum reported was 33). This panorama suggests predominantly family-run farms or agricultural SMEs with very small workforces.

In line with the wine-oriented focus, almost half of respondents (approximately 45%) stated that they produce wine as part of their activity, while the rest do not vinify (they grow grapes for sale or have other crops).

Level of digitalization

In Nouvelle-Aquitaine, a relatively high level of digital adoption is observed compared to other regions. The vast majority of farmers (around 88%) use at least one type of digital tool or software to support farm management, and only 12% report using none. Nevertheless, connectivity remains a challenge: while 70% have Internet access or good mobile coverage in farm buildings, 30% still lack indoor connectivity. In the fields, the situation is more restrictive: around 40–45% have no data signal (or only very weak coverage), which hinders the use of connected devices in real time outside the main farm buildings. To connect, many farmers rely on 4G mobile networks, although a significant number have fixed broadband: 53% have Wi-Fi/fibre or ADSL on the farm, while a minority use satellite solutions or specialized IoT networks (LoRa/LPWAN) in remote rural environments.

The use of electronic devices in agricultural tasks is widespread: 86% regularly use smartphones for field management (WhatsApp with technicians, apps, etc.), and 59% use a personal computer for administrative or technical purposes. It is also notable that almost half of farmers (48%) have their own weather stations or agroclimatic sensors to monitor weather and on-farm variables, which is consistent with the requirements of viticulture (which demands precise microclimatic data). One third still use basic mobile phones (calls only) as part of their equipment. Other advanced devices have a smaller but notable presence: 21% use agricultural GPS (e.g.

tractor guidance systems), 17% report using soil, irrigation or other field sensors, and 3% use drones for aerial observation or agricultural tasks (still an incipient level of adoption).

Regarding digital tools or specialized software, farmers in Nouvelle-Aquitaine use a wide range of applications. The five most common categories are:

- **Weather information**: 65% consult weather applications or platforms to plan activities.
- **Cartography and parcel management**: 55% use GIS, maps or GPS systems to manage fields and operations.
- **Crop planning**: 53% use software for planning sowing, operations or annual agronomic management.
- **Economic and financial management**: 46% use tools for cost control, farm accounting or similar purposes.
- **Communication and coordination**: 45% use digital tools to communicate with technicians, suppliers or to coordinate farm logistics.

Additionally, between 30% and 40% of respondents mention other applications such as digital field logs (operation records and traceability), pest and disease monitoring tools, or precision irrigation and fertilization control systems. It is noteworthy that only 12% indicated not using any digital tool, which reflects a relatively high level of digitalization in agricultural practices in the region.

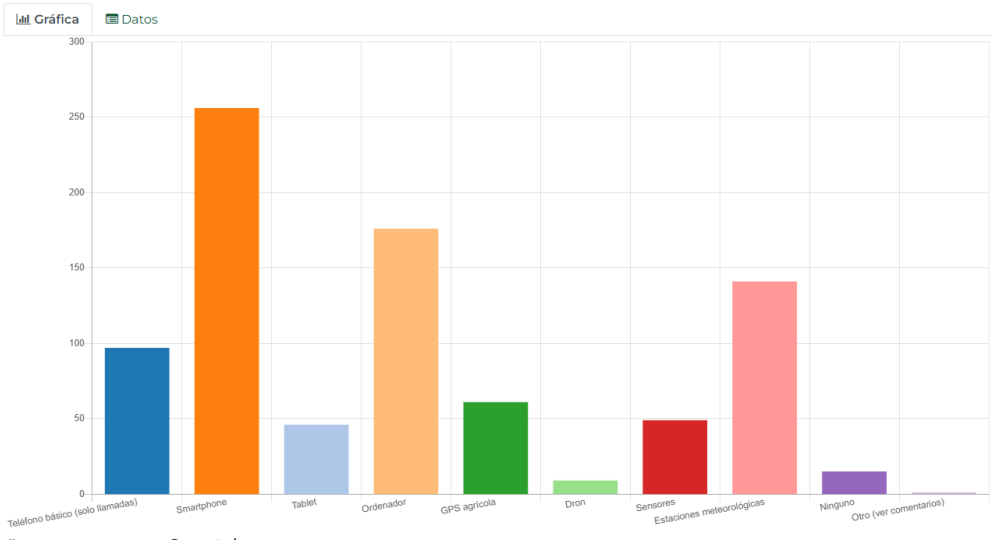


Image x. *Devices used for agricultural tasks.*

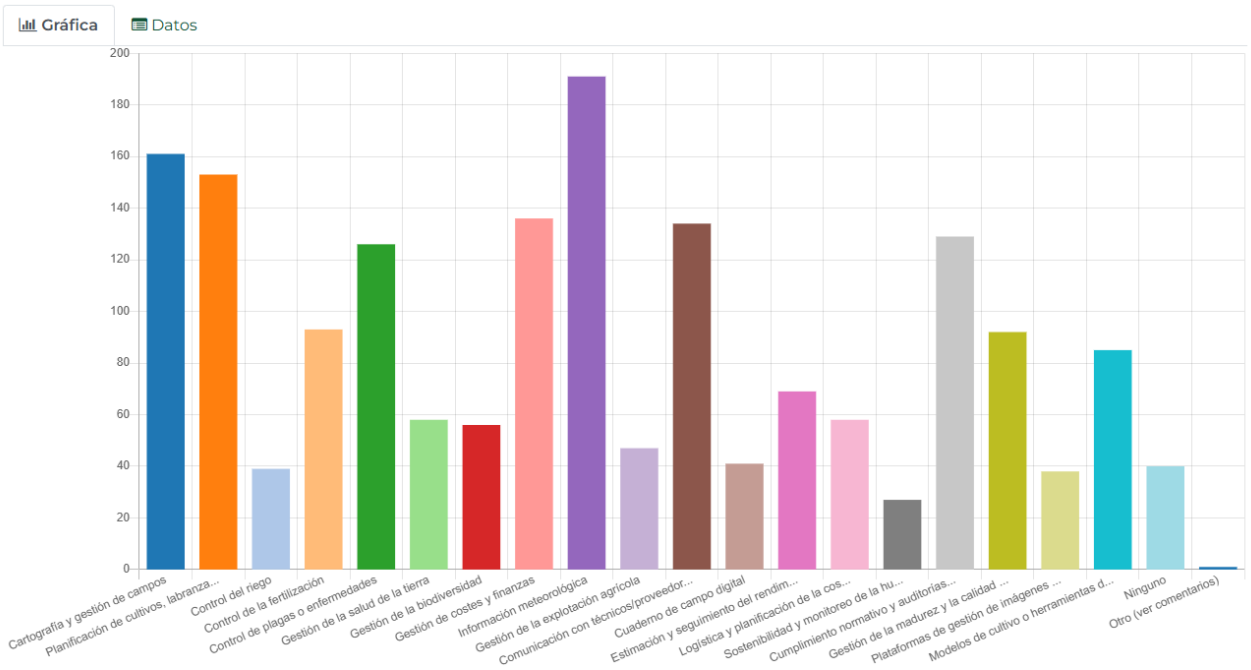


Image x. *Digital tools used to support agricultural tasks (software, applications, tools).*

However, the adoption of **more advanced technologies** such as remote sensing remains limited: only 17% reported using satellite imagery, onboard sensors or drones in their agricultural operations. **The connectivity of agricultural machinery** is another current weakness: around 87% state that their tractors or equipment are not connected to the Internet and do not automatically capture data. Only one in eight has "smart" or telemetric machinery, generally modern tractors equipped with GPS/ISOBUS in more technologically advanced farms.

Barriers and needs

Farmers in Nouvelle-Aquitaine identify various **barriers to digitalization**, mainly of a technical and economic nature. Overall, the **most critical obstacles** relate to **digital connectivity** and the **cost** of new technologies. Many producers indicate that the lack of stable connectivity across all areas of the farm limits their ability to use digital tools in the field; this factor is mostly rated as a "moderate to critical barrier." Likewise, the **high investment cost** of technologies (whether smart machinery, sensors or specialized software) is perceived as a significant problem: approximately one third consider it a critical barrier to adoption, while another significant group sees it as at least a moderate barrier. **Lack of technical training** also emerges as an obstacle: a substantial proportion of farmers feel that their digital skills are insufficient or that they lack trained staff, which in some cases prevents them from taking advantage of certain solutions (a gap that 40% rate as a critical barrier). In contrast, **cultural barriers** (such as resistance to change, lack of trust in technology, or failure to perceive value in digitalization) appear to be less widespread: nearly half of respondents consider them "not a barrier at all." In other words,

there is a **generally favorable attitude** towards digital innovation; the challenge lies more in addressing practical limitations (infrastructure, training and profitability).

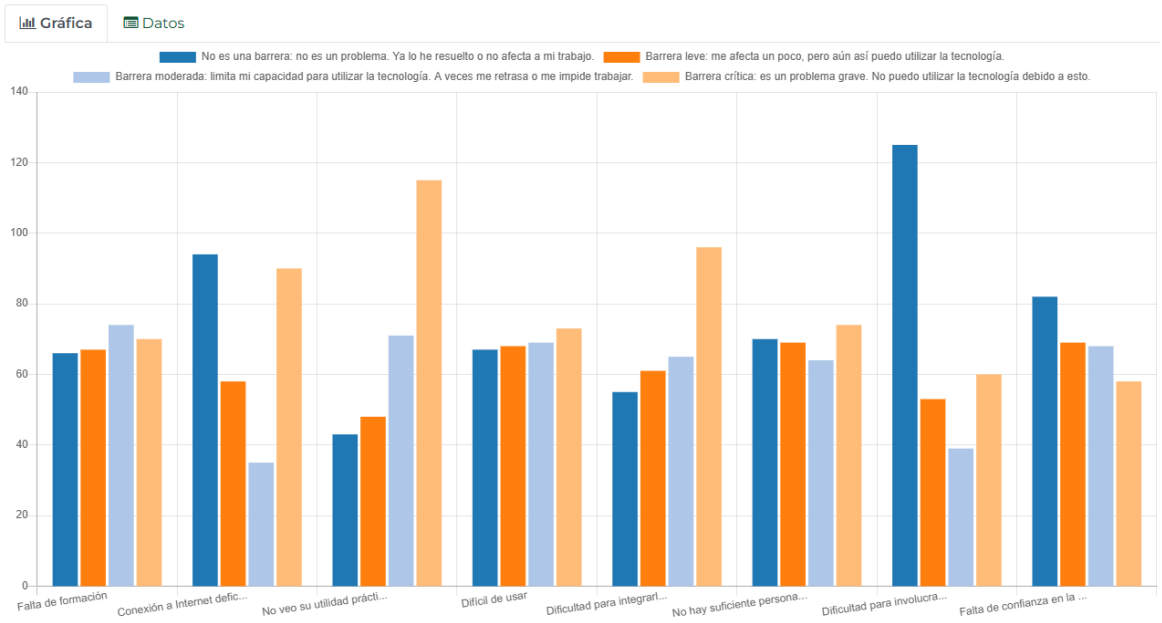


Imagen x. Barriers to digitalization and adoption of new technologies.

In line with the above, the **needs declared** by farmers focus on addressing technical and knowledge gaps. Paradoxically, the **demand for additional training** is not high in this region: nearly two thirds (63%) of producers stated that it was “unlikely” they would seek additional digital training, compared to only 27% who expressed interest in training (“probably yes”).

Nevertheless, approximately **35% have already received some type of training** in digital agricultural tools (for example, courses in management software, traceability, etc.), indicating the existence of a significant core with prior training experience. Those who do wish to receive further training often orient it towards specific areas such as **artificial intelligence, advanced office software or sensor management**, according to additional comments.

When asked which profiles should be prioritized for training within their holding, there is a clear consensus in **Nouvelle-Aquitaine**: the vast majority identify the farm manager or owner as the primary recipient of digital training (mentioned by 80% of respondents), recognizing that leadership must be prepared to drive transformation.

At a second level, given regional characteristics, two technical roles stand out: the oenologist (winemaking specialist) and the agronomic technical team (e.g. technical manager, field supervisors), each suggested by around 17% of respondents, especially in medium-to-large vineyards where such roles exist.

Regarding perceptions of technology, Nouvelle-Aquitaine shows some division: **54% perceive digitalization as an investment** for the holding, associated with future benefits, while **37% still view it as a necessary cost** (expense). Despite this, the **intention to invest** in new solutions is evident: all respondents identified at least one objective for their next digital investment. The predominant objectives are **improving profitability** (explicitly indicated by many as a main goal, seeking to increase income or production value) and **reducing operating costs**, followed closely by improving productive efficiency through automation and monitoring. Several also mentioned specific goals such as optimizing the use of inputs (fertilizers, plant protection products) to produce more precisely and sustainably, or increasing production and crop quality (especially winegrowers interested in improving grape and wine quality).

Finally, regarding **specific technologies needed** but not yet implemented, farmers in Nouvelle-Aquitaine provided numerous illustrative examples of innovations on their radar and the reasons for not having adopted them so far. One of the most common needs is **GPS guidance and precision agriculture in machinery**: many would like to equip their tractors with GPS autoguidance, variable-rate fertilization/seeding systems or other precision functionalities, but have not done so due to the high cost of such equipment and, in some cases, a lack of knowledge on how to use it.

Interest in **sensors and irrigation automation** (soil moisture probes, smart irrigation systems) to optimize water use is also recurring; those interested mention that they have not yet implemented these solutions due to a lack of available investment or because they are still evaluating the reliability of these technologies. Another emerging technology mentioned is **drones and agricultural robotics**: several winegrowers expressed interest in using drones to monitor parcels or even small robots for vineyard work, but acknowledge that these solutions are not yet sufficiently accessible (due to cost or because the technology is not mature enough for their current needs). In contrast, around 27% of respondents stated that they have **"no specific technology identified as pending"**, meaning they do not currently perceive technological gaps or are not aware of additional solutions they could incorporate.

5.6. RELEVANT STAKEHOLDERS IN THE TERRITORY

The wine sector in **Nouvelle-Aquitaine** constitutes a rich and diverse ecosystem, ranging from small family producers to prestigious estates, cooperatives and large international trading houses. This sector is supported by a dense network of professional organizations, public institutions and research centers.

Wine-growing holdings:

Although the average size of wine-growing holdings in Nouvelle-Aquitaine is 20 hectares, there is great heterogeneity in their typology, depending on:

- the cultivated area;
- the level of product valorization and the prestige of the AOC (Protected Designation of Origin) in which the holding is located;
- their degree of vertical integration: some holdings are limited to vine growing and harvesting, reselling the crop to intermediaries; others process the grapes, and some even integrate the marketing of the final product;
- their ownership structure (private investor, family farm, etc.).

The Cognac sector focuses on the production, ageing and export of spirits, with a standardized product dominated by large companies that are subsidiaries of major groups (LVMH, Pernod Ricard, Rémy Cointreau and Campari). It is a highly integrated sector, structured around contracts between producers and companies, which play a decisive role in the strategy and organization of the sector, as well as in the technical and qualitative monitoring of holdings. In addition, wine-growing holdings depend to a large extent on these companies from an economic point of view.

The Bordeaux sector is based on the production of a wide range of wines, predominantly red, linked to a highly segmented terroir and valorized through châteaux and appellations. It is characterized by strong hierarchical structuring, derived from the existence of historical classifications, and enjoys international recognition. The Bordeaux wine sector has a structured economic organization, but also a great diversity of actors.

Nevertheless, representative typologies of wine-growing holdings can be identified in Nouvelle-Aquitaine, such as small traditional family farms, cooperative operators, medium-sized heritage châteaux, prestigious estates and wine-growing holdings in the Cognac area, in some cases with mixed production systems. Although the vast majority of these enterprises are SMEs, they display very different production and value-creation strategies, vineyard sizes and investment capacities. As a result, they may face obstacles in their digitalization processes, although not necessarily of the same nature, intensity or degree of criticality.

Processing and marketing companies and entities

- **Wine cooperatives**: they bring together numerous winegrowers to pool production, marketing and wine distribution.
- **Trading houses (négociants)**: historic and highly influential actors in Bordeaux, Cognac and Armagnac, playing a central role in export and distribution.

- **New marketing actors**: e-commerce, direct sales, short supply chains and digital platforms that connect producers and consumers.

Professional organizations and institutions

- **Interprofessional organizations**: they represent winegrowers and merchants. Their role is to maintain permanent dialogue between both parties, carry out studies necessary for market guidance, organization and regulation, promote wines, ensure quality control and support research in order to adapt vineyards to current challenges. At the regional level, notable examples include the Bordeaux Wine Interprofessional Council (CIVB), the National Interprofessional Office of Cognac (BNIC), the Interprofession of Bergerac and Duras Wines (IVBD) and the National Interprofessional Office of Armagnac (BNIA).
- **Defense and management organizations (ODG) and trade unions**: ODGs are responsible for drafting the specifications of appellations, ensuring their implementation, keeping producer registers up to date for periodic submission to the INAO, and promoting, enhancing, protecting and defending their appellations, wines and terroirs. Examples include the Fédération des Grands Vins de Bordeaux, the General Union of Winegrowers of the AOC Cognac, and the numerous Defense and Management Organizations (ODG) representing wine AOCs throughout the territory.
- **Representative entities**: Union des Grands Crus de Bordeaux, Fédération des Vignerons Indépendants de Gironde, Alliance des Crus Bourgeois du Médoc, Fédération des Coopératives Vinicoles de la Gironde, Conseil des Grands Crus Classés de 1855.

Public institutions and administrations

- **The Nouvelle-Aquitaine Region**: guides regional public policies and supports the sector in its ecological, energy and digital transitions.
- **The Regional Directorate for Food, Agriculture and Forestry (DRAAF)**: a decentralized service of the Ministry of Agriculture, Food Sovereignty and Forestry. Under the authority of the Regional Prefect, it is responsible for implementing national and European policies on agriculture, forestry and food at the regional level.
- **Departments and municipalities**.

Knowledge, research, development and innovation actors

- **Research centers and universities**: Institute of Vine and Wine Sciences (ISVV, Bordeaux), INRAE Bordeaux, Bordeaux Sciences Agro, University of Bordeaux, among others.
- **Technical and experimental institutes**: French Institute of Vine and Wine, wine-growing experimental stations, Vinopôle, etc.
- **Chambers of Agriculture**: they work to represent farmers' interests, promote sustainable and innovative agricultural practices and provide technical advisory services for rural development.
- **Inno'vin cluster**.

Sectoral suppliers

In direct contact with winegrowers, suppliers develop and market solutions and services dedicated to the production of wines and spirits, including wine technology companies.

6. REGION 5: OCCITANIA

6.1. TERRITORIAL CONTEXT

Stretching from the southern Mediterranean coastline to the crests of the Pyrenees, and northwards from fertile plains to the foothills of the Massif Central, Occitania is a large agricultural region characterized by a remarkable diversity of climates, reliefs and soils. This diversity has been leveraged by farmers to develop a wide range of plant and animal productions, including viticulture, sheep milk production, extensive cropping systems and arboriculture.

The richness of these agricultural productions has fostered the development of a dense network of agri-food industries, composed mainly of small and medium-sized enterprises, alongside some large groups. As a result, with more than 64,000 agricultural holdings, mostly family-run, 5,400 processing companies and 400 cooperatives, the agri-food sector constitutes the main economic sector of the region. Overall, it generates around 164,000 jobs and an annual turnover of approximately €21 billion.

6.2. LEVEL OF DIGITAL MATURITY

In small agricultural holdings in Occitania, which are predominantly family-run, the level of digital maturity can be considered medium and heterogeneous. There is a relatively widespread digital base, especially for management and information-seeking purposes, but with uneven adoption of advanced production technologies.

In a recent survey on large-scale crops in Occitania, farm management software appears as the most widespread tool (80%), and 65% report using the Internet “often” or “very often” for technical information. The most commonly used sources are specialized websites (81%) and social networks (53%). This indicates that the “first digital step” (management and information) is relatively well established.

The same study identifies three clear farm profiles: 39% do not use digital technologies for production, 32% use “some,” and 29% have intensive use. This suggests a clear divide, with poorly digitalized farms coexisting alongside more advanced ones.

The most frequently adopted technologies are GPS (60%), autoguidance (44%), section control (39%) and variable-rate maps (33%) in large-scale cropping systems. For small holdings, these figures should be interpreted with caution, as farm size and investment capacity are often limiting factors. Nevertheless, they indicate the technological frontier already reached by part of the sector.

Regarding perceived benefits and barriers, the most frequently cited benefit is time savings (33%), while the main barrier is cost (41%), along with concerns related to data ownership and use by digital companies. These elements are typical of a “medium” level of digital maturity: value is recognized, but economic and trust-related barriers remain.

6.3. STRENGTHS

This section presents the strengths of the Occitania region in facilitating digital transformation in the agricultural sector:

- **STRONG AND WELL-STRUCTURED COLLECTIVE INNOVATION AND SUPPORT ECOSYSTEM**: Occitania has an active regional ecosystem for innovation and transfer oriented towards small holdings. Agropolis International is an example of this ecosystem, acting as a facilitator and bridge between research and territorial needs, particularly for the agricultural sector. Initiatives such as DigitAg, AgroTIC and Occitanum structure this governance and promote technological adaptation to diverse contexts.

- **DIGITALIZATION-ORIENTED PROGRAMMES AND FUNDING**: The region benefits from structuring programmes and projects such as Occitanum (Living Lab), which act as catalysts for applied innovation, enabling the development of prototypes, pilot trials and technology transfer. Other initiatives such as Mobilab AgroTIC bring digital technologies directly to farmers, facilitating dissemination, practical demonstration and knowledge exchange, reducing perceived complexity and democratizing access to digitalization. These initiatives lower economic and technical entry barriers and reinforce the transition from experimentation to practical use.

- **CLIMATE AND ENVIRONMENTAL AWARENESS**: There is a strong awareness of climate challenges and an environmentally oriented culture, meaning that innovation generally responds to these issues. Digital solutions developed in the region focus on irrigation efficiency and sustainable input use, with technologies such as soil probes that reduce excess water use and plant protection products.

- **SHARED DATA CULTURE**: Through collaborative networks such as CentipedeRTK, which enable shared use of geolocation infrastructure. Centimetre-level precision improves traceability and the quality of agricultural interventions. Data are treated as a collective asset, encouraging benchmarking of practices and continuous improvement.

- **TECHNOLOGICAL ADAPTATION TO SMALL HOLDINGS**: Occitania stands out for the co-design of low-cost / low-tech solutions. One example is the *compte-tour numérique*, which enables dose regulation on conventional machinery without high investment. Solutions are designed for small-scale contexts, reducing structural barriers to adoption.

Farmers' attitudes towards technology are generally positive, viewing digitalization as an investment and seeking to use technology to improve efficiency and optimize resources and operations. They acknowledge a lack of digital training and identify financing as the main barrier to adoption, while the lack of support throughout the process generates uncertainty and reluctance to engage in digital transformation.

6.4. AREAS FOR IMPROVEMENT

The main areas for improvement identified are:

- **DIGITAL LITERACY**: A significant proportion of holdings do not use digital technologies in production. In large-scale crops, 39% of producers remain at basic digitalization levels, with use concentrated on administrative tasks. There is clear room for improvement in practical digital skills to support increased adoption.
- **ORGANIZATIONAL CHANGE MANAGEMENT**: Technological adoption is perceived as an additional burden on fieldwork, mainly due to lack of time and operational overload, which hinder the integration of digital tools into daily routines.
- **SUPPORT, ASSISTANCE AND SIMPLIFICATION**: Continued use of tools is low. There is a lack of technical support adapted to farmers' contexts. Technology often fails to consolidate as an operational tool.
- **TRUST IN DATA USE**: There are concerns related to data appropriation and use by digital actors. These perceived risks hinder voluntary adoption, particularly in large-scale crops.
- **RURAL CONNECTIVITY**: Lack of connectivity at parcel level is a recurring issue, especially in vineyards. This limits real-time use of technologies and automated guidance systems, requiring specific technical solutions such as field antennas. Small and dispersed holdings are the most affected.
- **FINANCIAL SUPPORT**: Cost is identified as the main obstacle to technological adoption. In viticulture, solutions such as autoguidance, sensors or decision-support tools are perceived as too expensive, with uncertainty about return on investment. This barrier is more pronounced for small holdings.

6.5. RELEVANT STAKEHOLDERS IN THE TERRITORY

In Occitania, relevant actors within the agricultural sector include the Chambers of Agriculture at both regional and departmental levels, as well as producer associations and agricultural trade unions. Agricultural cooperatives and their regional federation are also fundamental, alongside agricultural service competitiveness clusters. In addition, agricultural machinery cooperatives and their respective regional federation play an important role, as does the agricultural trade sector.

Private agricultural advisory services are also significant, as are interprofessional associations by value chain or product, and technical agricultural experimentation institutes by sector. In the training sphere, agricultural training centers and higher agricultural and agronomic education institutions stand out. Agronomic research is another essential component, as are agricultural contracting companies, agricultural service providers and seed companies within the seed sector.

6.6. SURVEY RESULTS

The number of responses obtained in the Occitania region is very low (9 responses). Therefore, the results presented below are not statistically representative, but merely indicative.

Farmer profile

Most respondents in Occitania are men (7 out of 9, approximately 78%), with only 2 women in the sample. The average age is around 43 years, with farmers ranging from 24 to 60 years old, indicating a mix of young and experienced profiles. In terms of education, the profile is diverse: approximately one third have university education, while the rest are evenly distributed between vocational training, secondary education and primary education. Many of these farmers have extensive experience in the sector, with an average of around 20 years of farming experience (ranging from 5 to 35 years). This suggests that, although some newcomers are present, experienced professionals predominate.

Characteristics of the holding

Surveyed farmers in Occitania manage holdings with varied orientations. Several cultivate vineyards, reflecting the importance of viticulture in the region; approximately half of respondents reported growing grapes. Others mentioned crops such as fruit (apple, plum, strawberry), nuts (hazelnuts), cereals (wheat, maize) and grassland/pastures. In terms of farm size, surveyed holdings are medium to large, with a median surface area of around 100 hectares. Most are family-run businesses with limited labour resources. Apart from one isolated case with a high number of workers, most holdings operate with small workforces typical of family farms.

Level of digitalization

Machinery and connectivity: All respondents have basic agricultural machinery (e.g. tractors, implements, sprayers, irrigation systems). However, adoption of “smart” or digitally integrated equipment is limited. Only 2 out of 9 farmers (around 20%) report using tractors with GPS or automatic guidance. Approximately half of producers (4 out of 8 respondents) have access to shared machinery through local cooperatives, facilitating the use of equipment they might not otherwise afford. Machinery connectivity remains low: only 22% report having machines capable of Internet connection or automatic data collection.

Digital infrastructure (Internet): Most farmers have Internet access or at least mobile coverage in main farm buildings (5 out of 8 positive responses). However, around 38% still lack reliable indoor connectivity. Field coverage is mixed, with only about half reporting connectivity in their parcels. Connectivity solutions vary, including mobile Internet, fibre, IoT networks such as LPWAN/LoRa, and in some cases satellite links. Nevertheless, some farms still lack any form of connection.

Devices and digital tools used: Smartphones are the most widespread digital tool, used by approximately two thirds of respondents. Around half of them also use agricultural GPS devices. A smaller number use personal computers for data management or administrative tasks. Only isolated cases report using tablets, drones, sensors or weather stations.

Software and applications: Adoption of agricultural software is modest but present in certain areas. Common uses include cartography and parcel management, weather information, cost and financial management, and communication with technicians or suppliers. Around one third use digital tools for irrigation control and general farm management. Only a few report using tools for crop planning, fertilization control, pest monitoring, digital field logs, harvest logistics, regulatory compliance or decision-support models. Advanced precision agriculture tools such as satellite imagery or drones are used by only a small minority.

Digital skills: None of the surveyed farmers consider themselves advanced or expert users of digital tools. Most rate their skills as basic or acceptable, with difficulties particularly in office software, data management and specialized applications. Several respondents noted that digital tools need to be simplified, indicating usability as a barrier.

Overall, the level of digitalization among surveyed Occitania holdings can be described as low to moderate, with basic connectivity and common device use, but limited adoption of smart machinery, advanced sensors and specialized agri-digital software.

Barriers and needs

The main barriers identified include lack of technical training, high investment costs and insufficient connectivity. Some farmers explicitly mention lack of knowledge as a key obstacle. Cost and access to equipment and sensors are also highlighted. While many respondents rate these barriers as minor or manageable, a few identify them as critical constraints.

Despite acknowledging skill gaps, willingness to receive further digital training is limited: most respondents indicated they would probably not seek additional training. About half have already received some form of digital agriculture training. When asked who should be prioritized for training, most identified the farm owner or manager, followed by technical staff and machinery operators.

Attitudes towards technology are generally positive: most respondents consider digitalization an investment rather than a cost. Priority areas for technological support include pest and disease control, soil preparation and irrigation/fertilization management. Some respondents expressed interest in robotic solutions, but cited high cost and technological immaturity as barriers to adoption.

7. REGIÓN 6: WESTERN PORTUGAL

7.1. TERRITORIAL CONTEXT

The Western Portugal region is characterized by a marked urban–rural nature and a diversified economy, in which the agri-food, tourism and industrial sectors stand out, with a clear export-oriented focus, particularly in agricultural and agri-industrial products. Agriculture constitutes one of the structural pillars of the regional economy, both due to its economic weight and its social and territorial relevance.

The agricultural sector in the Western region benefits from a mild Atlantic climate, which allows high-quality agricultural production for much of the year. Fruit growing, horticulture and viticulture form strategic value chains, concentrating a significant share of national production, with particular relevance of Rocha pear PDO, Alcobaça apple PDO, horticultural crops and vineyards. In relation to regional GDP, agriculture represents approximately between 2.5% and 5%, in addition to the significant leverage effect of the associated agri-food industry (packaging, processing, logistics and export).

The productive structure is composed mainly of small and medium-sized family farms, highly specialized and, in many cases, integrated into producer organizations and cooperatives, which facilitates their integration into supply chains oriented towards large retailers and international markets. These coexist with larger farms with higher technological levels, both in open-field systems and greenhouse production.

From a strategic point of view, the Western Portugal region defines the agri-food system as a priority domain of smart specialization, integrating innovation, digitalization and sustainability within the framework of the **Western Strategy 2030** and the **2021–2027 programming period**. This regional orientation aligns with the national digital transition strategy and the **CAP Strategic Plan (PEPAC)**, which promote the adoption of Agriculture 4.0 technologies, data management and digital decision-support services.

In this context, initiatives such as **Agritech** respond to a real need to operationalize these strategies and reduce existing digitalization gaps within the territory.

7.2. LEVEL OF DIGITAL MATURITY

The level of digital maturity of small fruit farms in Western Portugal can be classified as **incipient to medium**, with uneven and fragmented adoption of digital technologies. Highly digitalized farms coexist, particularly in intensive horticulture and greenhouse systems, alongside many others with limited digital skills and very basic use of technological tools.

In open-field fruit growing, partial solutions predominate, such as mechanization, irrigation calibration or occasional use of agroclimatic sensors, generally managed through cooperatives or external technicians. Intensive horticulture, especially under greenhouse conditions, shows significantly higher levels of innovation, with automated fertigation systems, climate control and IoT integration. In contrast, arable crops and some

organic farms display lower levels of digitalization, focusing more on sustainable practices and certification than on advanced digital technologies.

The autonomous digital maturity of small producers remains low. In many cases, digitalization occurs indirectly, mediated by technicians from producer organizations, fruit and vegetable packing centers or demonstrative projects. While **this dependence on intermediaries facilitates initial access to technology, it limits the development of farmers' own digital capabilities.**

7.3. STRENGTHS

- **STRONG AND WELL-STRUCTURED COLLECTIVE INNOVATION AND SUPPORT ECOSYSTEM**: Western Portugal benefits from a highly consolidated associative and cooperative fabric, including cooperatives, producer organizations and sectoral associations that act as innovation catalysts. These structures enable cost-sharing, technical services and digital platforms, facilitating access to solutions that small farmers could not implement individually.
- **DIGITALIZATION-ORIENTED PROGRAMMES AND FUNDING**: The regional innovation ecosystem is supported by research and transfer entities such as INIAV, COTHN and the Rocha Center. These organizations provide applied research, experimentation and specialized technical support, reinforcing the adoption of digital solutions adapted to the territory and closely linked to the main regional value chains.
- **SUPPORT, ASSISTANCE AND SIMPLIFICATION**: The Smart Farm Colab (SFCOLAB) plays a key role in democratizing Agriculture 4.0 by promoting inclusive digital solutions, training and on-farm demonstrations that reduce adoption barriers and facilitate practical technology use. It also provides direct technical support to farmers.
- **CLIMATE AND ENVIRONMENTAL AWARENESS**: Fruit specialization and quality-oriented production drive the use of digital control and recording tools. Traceability and certification requirements act as drivers of digitalization, generating a spillover effect on smaller farms.
- **DIGITAL LITERACY**: There is a generally positive attitude towards technological innovation in the territory. The gradual incorporation of a new generation of farmers strengthens this trend, as these profiles show greater digital familiarity, favoring future adoption of digital solutions.

Farmers do not perceive clear barriers to digitalization, which can be interpreted more as a lack of exposure to advanced digital solutions than as a real absence of difficulties, given the low level of declared digitalization. Despite the existing training gap, they show a strong willingness to receive training and perceive digitalization as an investment that can support improved farm profitability.

7.4. AREAS OF IMPROVEMENT

- **RURAL CONNECTIVITY**: Digital connectivity in rural areas remains insufficient, with agricultural zones where mobile coverage and Internet access are unstable or nonexistent. This limitation conditions the use of real-time data-based solutions and constitutes a structural barrier to digitalization.
- **DIGITAL LITERACY**: A persistent training gap remains in the use of digital tools. The lack of intuitive interfaces reinforces the perception of complexity, and many farmers experience difficulties in interpreting data and using platforms, reducing effective adoption.
- **FINANCIAL SUPPORT**: Access to financial resources represents a significant barrier for small farms. Although public aid exists, it is competitive and not always adapted to the reality of smaller-scale farmers. Investment capacity is limited.
- **COOPERATIVE / ASSISTENTIAL MODEL**: Producers not integrated into collective structures face greater difficulties, likely due to reduced access to technical support and training. This places them in a position of greater digital lag.

7.5. RELEVANT STAKEHOLDERS IN THE TERRITORY

The agri-food ecosystem of the Western region is composed of a diverse range of actors collaborating at different levels of the value chain. These include **agricultural producers**, mostly small and medium-sized, primarily integrated into fruit, horticultural and wine value chains. **Cooperatives and producer organizations** such as Frutoeste, Frubaça and several wine cooperatives facilitate collaboration and sector strengthening.

Sectoral and rural development associations also form part of this ecosystem, promoting agri-food development in the region. **Research entities and technological centers** (such as INIAV, COTHN and the Rocha Center) play a crucial role in innovation and the development of new technological solutions. **Higher education institutions**, such as the Polytechnic Institute of Leiria (IPLeiria), contribute to training and knowledge generation in the sector.

Public administrations and territorial governance structures are also key actors, providing regulatory frameworks and support for the implementation of public policies fostering sector development. Alongside them are **suppliers of inputs, technology and services**, providing the necessary tools and resources for agri-food production. Finally, **wholesalers and marketing operators** are fundamental to the distribution and commercialization of agri-food products.

A particularly relevant actor within this ecosystem is **SFCOLAB**, which integrates a quadruple-helix innovation model, connecting science, the productive sector, public policies and society. With a strong focus **on technology transfer** and **pilot implementation under real farming conditions**, SFCOLAB plays a central role in regional digital transformation.

7.6. SURVEY RESULTS

The analysis of the Western Portugal region should be interpreted with caution, as the **sample is very small** (6 surveys), **allowing only an exploratory and indicative reading**.

From **the farmer profile perspective**, respondents include a mix of young farmers and more experienced profiles, suggesting some generational heterogeneity. Greater gender diversity is observed compared to other regions in the study. The declared educational level is high, with university education predominating, indicating potentially favorable human capital for the adoption of digital solutions, although this cannot be extrapolated to the entire territory due to the small sample size.

Regarding **farm specifications**, responses mainly refer to **fruit farms**, especially regionally typical crops such as apples and pears, with occasional combinations including olive groves or vineyards.

In terms of **digitalization level**, the region is at an early stage. Approximately half of respondents have Internet access in farm buildings, while field coverage is somewhat more frequent, probably via mobile networks. The smartphone is the main digital device used in agricultural activity, coexisting with the continued use of basic mobile phones. Use of computers, sensors, weather stations or GPS systems is very limited and anecdotal. None of the surveyed farmers have connected machinery or automatic data capture systems, and the use of satellite imagery, drones or remote sensing is virtually nonexistent.

The use of **software and digital tools** is fragmented and inconsistent. Some farmers use applications related to irrigation, pest control, planning or basic management, but no single tool category clearly dominates. The presence of farmers who use no digital tools at all is also detected, reinforcing the perception **of low operational digital maturity**.

Regarding **barriers to digitalization**, results do not show clearly identified critical obstacles, partly because many farmers have not yet progressed far enough in technological adoption to encounter complex problems. Connectivity, technology costs and lack of training appear sporadically as mild or moderate barriers, but without a consistent pattern. Notably, a significant proportion of respondents do not perceive clear barriers, which may reflect limited exposure to advanced digital solutions rather than an actual absence of difficulties.

By contrast, there is **relatively high interest in digital skills training**, especially compared to the French regions analyzed. Most respondents expressed willingness to receive training, despite having had almost no previous access to digital agriculture training programmes. This highlights a **training gap** but also a clear opportunity for capacity-building and support actions.

Perceptions of digitalization are predominantly positive: respondents tend to view it as an **investment** rather than a cost. Priority objectives associated with future digital investments focus mainly on **cost reduction**, followed by improved profitability and increased production or quality.

8. GENERAL CONCLUSSIONS

The comparative analysis of the territories studied – Navarre, Andalusia, Extremadura, Occitania, Nouvelle-Aquitaine and Western Portugal – highlights significant differences, but also common patterns in the digitalization process of the agricultural sector, particularly with regard to digital infrastructure, device usage, data collection needs, training and technological investment preferences throughout the production cycle.

The success of digital transformation in agriculture will depend on its practical and gradual nature, its adaptation to the diversity of productive and territorial realities, and sustained support for the training of professionals.

First, digital infrastructure emerges as one of the main differentiating factors between territories. Navarre clearly stands out due to its highly advanced rural connectivity, with widespread broadband coverage that facilitates the use of data-based solutions and real-time systems. In contrast, Andalusia, Extremadura, Occitania, Nouvelle-Aquitaine and Western Portugal show persistent connectivity limitations, especially in dispersed rural areas, mountainous zones or directly at parcel level. These shortcomings directly condition the adoption of advanced digital technologies, even in contexts where a mature technological offer exists. Transversally, connectivity is consolidated as a critical enabler, without which digitalization cannot effectively progress.

Regarding devices used in agricultural tasks, a very similar pattern is observed across all territories. The smartphone has become the central device, followed by the computer, particularly for administrative and management tasks. The use of more specialized devices, such as IoT sensors, connected machinery, drones or agroclimatic stations, is concentrated in more technologically advanced holdings or those integrated into cooperatives and collective projects. This phenomenon is more visible in Navarre, Occitania and certain areas of Andalusia, while in Extremadura and Western Portugal adoption is more uneven and dependent on external technical support. Overall, digitalization initially relies on technologies already integrated into farmers' daily routines, while more advanced tools require accompaniment and a clear demonstration of value.

With regard to data collection needs, there is broad convergence among territories in the demand for information related to irrigation, fertilization, plant health, yields and traceability. Farmers express interest in accessing data that allow them to optimize input use, reduce costs and comply with regulatory and market requirements. However, real capacity to collect, interpret and use these data varies greatly. Navarre and Occitania show a higher degree of structuring in data management, whereas in Andalusia, Extremadura and Western Portugal, data collection often remains partial, manual or fragmented, limiting its effective use.

Technical and data access limitations are largely shared across all territories analyzed, notably the lack of stable connectivity, platform fragmentation, low interoperability between tools and difficulties in accessing real-time parcel-level data. In Nouvelle-Aquitaine and Occitania, mistrust regarding data use appears more explicitly, while in Andalusia, Extremadura and Western Portugal, barriers are more closely linked to perceived tool complexity and lack of continuous technical support. In all cases, these limitations reduce the perceived value of digitalization and slow down investment.

Training emerges as one of the most critical and transversal factors in the analysis. Across all territories, a significant gap in practical digital skills is identified, exacerbated by the ageing of the agricultural sector. The most successful cases are found in regions where training is continuous, practical and linked to on-farm demonstrations, such as Occitania, Nouvelle-Aquitaine and Navarre. In Andalusia, Extremadura and Western Portugal, although relevant initiatives exist, training is often sporadic, poorly coordinated or insufficiently adapted to farmers' real skill levels. The analysis confirms that without applied training and technical accompaniment, technology does not become embedded in daily practice.

Regarding the prioritization of employees and providers for training, a clear consensus emerges across territories. Priority is given to farmers themselves and field operators, followed by cooperative technicians, agronomic advisors and technology service providers. In territories with strong collective structures, such as Extremadura, Andalusia and Western Portugal, cooperatives and intermediary entities play a key role as multipliers of training impact. In more advanced regions, such as Navarre and Occitania, specialized technicians also act as digital intermediaries between technology and the farm.

Finally, technological investment preferences according to crop phase show a high level of convergence across territories. The phases generating the greatest interest are those with a direct and visible economic impact, especially irrigation management, fertilization and pest and disease control. There is also interest in crop planning and monitoring, while harvest and post-harvest phases gain relevance in farms oriented towards international markets or with high traceability requirements. In general, farmers prioritize technologies that save inputs, reduce risks and simplify administrative obligations over more complex solutions or those with longer-term returns.

Overall, the comparative analysis shows that agricultural digitalization in the studied territories is not limited by a lack of technology, but rather by a combination of uneven infrastructure, training gaps, insufficient accompaniment and organizational difficulties. The most advanced territories are not necessarily the most technologically equipped, but those that have successfully articulated collective ecosystems, practical training and solutions adapted to farmers' realities. Digitalization thrives when it is useful, understandable, gradual and clearly profitable, and when it is supported by collective structures that reduce risks and costs.

9. ANEXOS