



**Harnessing the Power of Digital Technologies to
Protect Plants & the Environment**

D5.1: Policy Analysis

**Responsible Authors: Anastasia Kannavou (Green & Digital)
Lazaros Kiokakis (Green & Digital)**

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Responsible Author	Anastasia Kannavou, Lazaros Kiokakis (Green & Digital)
Contributors	Séverine Coubard (IFV) Spyridoula Dimitropoulou (AUA-PL) Irmantas Čepulis (AFL) Tito Caffi, Carlotta Lomeo, Marta Corbetta (UCSC)
Reviewer(s)	Claire Ortega (ACTA), Séverine Coubard (IFV), Spyridoula Dimitropoulou (AUA-PL), Irmantas Čepulis (AFL)

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Consortium			
No.	Participants organisation name	Short name	Country
1	GEOPONIKO PANEPISTIMION ATHINON	AUA	EL
2	UNIVERSITA CATTOLICA DEL SACRO CUORE	UCSC	IT
3	EIGEN VERMOGEN VAN HET INSTITUUT VOOR LANDBOUW- EN VISSERIJONDERZOEK	EV ILVO	BE
4	UNIVERSITAET FUER BODENKULTUR WIEN	BOKU	AT
5	GREEN & DIGITAL IDIOTIKI KEFALAIOUCHIKI ETAIREIA	GREEN & DIGITAL	EL
6	REFRAME FOOD ASTIKI MI KerdoskopiKI ETAIREIA	RFF	EL
7	ACTA ASSOCIATION DE COORDINATION TECHNIQUE AGRICOLE - LES INSTITUTS TECHNIQUES AGRICOLES	ACTA	FR
8	HORTA SRL	HORTA SRL	IT
9	PESSL INSTRUMENTS GMBH	PESSL	AT
10	GREEN SUPPLY CHAIN DIGITAL INNOVATION HUB ASTIKI MI KerdoskopiKI ETAIREIA	GSC	EL
11	AgriFood Lithuania DIH	AFL	LT
12	EDENCORE TECHNOLOGIES IKE	EDENCORE	EL
13	INSTITUT FRANCAIS DE LA VIGNE ET DU VIN	IFV	FR
14	LINCOLN AGRITECH LIMITED	LincolnAgritech	NZ

Executive Summary

This deliverable, **D5.1: Policy Analysis**, compiled under Work Package 5, Task 5.1 of the **STELLA** project "Harnessing the Power of Digital Technologies to Protect Plants & the Environment", presents a comprehensive analysis of the current policy frameworks in the European Union and New Zealand regarding the **integration of digital technologies into plant health policies**. Recognising that plant pests and diseases pose significant threats that are exacerbated by climate change and global trade, the report determines the need for new, digitally facilitated solutions for effective pest monitoring and control. The primary aim is to identify the current state of play, perceived benefits and challenges, and highlight areas for future action to foster a more resilient and digitally enabled plant health system. This work contributes to informing the strategic direction for future plant health policies within the context of the Common Agricultural Policy (CAP) and the European Green Deal (EGD).

The report employed a dual **methodology** combining an integrative policy framework analysis with a thematic analysis of semi-structured interviews. The policy analysis involved reviewing relevant EU and national policy documents, including Regulation (EU) 2016/2031 and Regulation (EU) 2017/625, strategies like the [European Green Deal](#) and "[A Europe fit for the Digital Age](#)", and national frameworks from France, Greece, Italy, Lithuania, and New Zealand. This was complemented by a review of peer-reviewed literature on digital tools in plant health management and policy. The qualitative investigation involved conducting **81 interviews** with a diverse range of stakeholders, including **policymakers, agricultural/forestry advisors, farmers/foresters, and citizens**, across Greece, Italy, Lithuania, France, and at the EU level. These interviews explored their perspectives on the perception and practical implementation of digital innovations, as well as the associated needs, challenges, and benefits in plant health surveillance.

Key findings of the report show a **strong strategic commitment** of the European Union to leveraging digital technologies for plant health and sustainability goals, with policies like the Plant Health Law aligning with international frameworks such as the IPPC, One Health approach, and SDGs. EU initiatives like the Digital Europe Programme and the Data Act are building foundational infrastructure and regulatory environments for digital transformation across sectors. The objectives of the European Green Deal, including the Farm to Fork and Biodiversity strategies, implicitly rely on digital innovation for smarter pest management and enhanced surveillance. At the national level, Member States and associated countries like New Zealand are integrating digital tools into their systems, utilising platforms like TRACES

and EUROPHYT for information sharing (at the EU level), developing electronic certification, and exploring technologies in various pilot projects.

However, the interviews with the stakeholders revealed **persistent gaps between strategic ambition and practical reality**. On one hand, they recognise the potential of emerging digital technologies such as AI, remote sensing, and IoT for improved early detection, surveillance with greater efficacy, precision interventions, optimisation of resources, and enhanced efficiency, but on the other hand, they feel that significant obstacles are in the way of wide-scale adoption.

Key barriers are the cost of technology and the uncertainty of returns on investment. There is also a significant end-user digital skills gap, as well as complexity and reliability issues with new technology that need substantial training and support. Furthermore, issues related to trust and data privacy, in particular, misuse of sensitive farm information and complexities of governance models like GDPR, discourage the stakeholders from sharing information. Data fragmentation and system incompatibility among them further complicate the exchange of information. Stakeholders also reported an implementation gap, where policies may exist but fail to be effectively enforced or supported at the local level, often overlooking local realities. Overcoming these barriers requires addressing fundamental issues of trust, data governance, cost, skills, and regulatory adaptability. The study identified key **enablers**, including robust policy support, financial incentives, dedicated training and capacity building for all stakeholders, fostering strong networks and collaboration, and demonstrating the practical utility of digital solutions through real-world pilot projects.

Following these findings, the report offers several initial recommendations for future action. Plant health governance systems should be more **proactive, inclusive, and adaptable** to meet the evolving needs of agriculture and forestry. This includes updating regulatory frameworks to formally recognise and validate data and methods from new digital tools, setting clear standards for data quality, use, and privacy. A more **inclusive, multi-actor approach** should formalise the involvement of stakeholders in pest monitoring and policy co-design, building trust through transparent data governance and open communication. Sustained investment in **capacity building** across all stakeholder tiers, including digital literacy training, technical support, and resources for plant protection agencies, is essential. Finally, policymakers must undertake the effort to **demonstrate the practical application of digital technology**, prioritising making the tools accessible, affordable, and aligned with the real needs of forestry and agricultural practices. By addressing these areas, policymakers can create an environment where digital technologies become a trusted and practical component of a resilient and sustainable plant health system.

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Glossary of terms and abbreviations

List of Abbreviations and Acronyms	
AI	Artificial Intelligence
AI	Artificial Intelligence
AOC	Appellation d'Origine Contrôlée (Protected Designation of Origin in France)
BN	Bois Noir (a grapevine disease)
CAP	Common Agricultural Policy
DG AGRI	Directorate-General for Agriculture and Rural Development (European Commission)
DG CONNECT	Directorate-General for Communications Networks, Content and Technology (European Commission)
DG SANTE	Directorate-General for Health and Food Safety (European Commission)
EGD	European Green Deal
EFSA	European Food Safety Authority
ELISA	Enzyme-Linked Immunosorbent Assay
EPPO	European and Mediterranean Plant Protection Organization
EU	European Union
F2F	Farm to Fork Strategy (part of the European Green Deal)
GBF	Kunming-Montreal Global Biodiversity Framework
GLD	Grapevine Leafroll Disease
GDPR	General Data Protection Regulation (EU Regulation 2016/679)
HORIZON / HE	Horizon Europe (EU Research and Innovation Framework Programme)
IAS	Invasive Alien Species
IoT	Internet of Things
IPPC	International Plant Protection Convention
ISPM	International Standards for Phytosanitary Measures

mRNA	Messenger Ribonucleic Acid (used in molecular pest diagnostics)
MPI	Ministry for Primary Industries (New Zealand)
NPPO	National Plant Protection Organisation
One Health	A cross-sectoral approach integrating human, animal, plant, and environmental health
PSS	Pest Surveillance System
PCR	Polymerase Chain Reaction
PLRV	Potato Leafroll Virus
QPs	Quarantine Pests
RNQPs	Regulated Non-Quarantine Pests
RPAS	Remotely Piloted Aerial Systems (e.g., drones)
SDGs	Sustainable Development Goals
SUR	Sustainable Use Regulation (proposed regulation for pesticide reduction in the EU)
TRACES	Trade Control and Expert System (EU digital platform for plant/animal health certificates)
UCP	Use Case Pilot
WTO SPS Agreement	World Trade Organisation Agreement on the Application of Sanitary and Phytosanitary Measures
WP	Work Package

1 Introduction

Plant health is crucial as plants form the basis of the food chain, are part of the environment, and outbreaks can devastate livelihoods, food quality, prices, forests, and parks. The economic impact of pests like *Xylella fastidiosa* and pine wood nematode is significant, potentially causing billions in losses. Due to the movement of plants within the EU and from non-EU countries, common rules are necessary to ensure consistent phytosanitary protection and a level playing field. The new plant health policy, Regulation (EU) 2016/2031, focuses on screening, preventing entry, early detection, and eradication of devastating pests, requiring resources to be allocated early to avoid destruction of agricultural potential and the environment. The EU legislation aligns with international frameworks like the International Plant Protection Convention and World Trade Organisation principles, and the year 2020 was declared the International Year of Plant Health to raise awareness.

Pests are grouped into Union Quarantine pests, Protected Zone Quarantine Pests, Priority Pests and Regulated Non-Quarantine Pests, each subject to specific measures. Twenty Union quarantine pests with the most severe potential impacts are identified as 'priority pests' and face enhanced measures, including surveys, action plans, and contingency plans, allowing efficient resource focus. Imports of most plants and plant products from non-EU countries are allowed subject to conditions and often require a phytosanitary certificate, with few exceptions. Passengers are generally not allowed to bring living plant material from non-EU countries without a phytosanitary certificate. Plant passports are required for movement of plants for planting within the EU internal market at a business-to-business level to ensure absence of quarantine pests, compliance with regulated non-quarantine restrictions, and traceability.

[Directorate-General for Health and Food Safety](#) is responsible for EU policy on food safety and health and for monitoring the implementation of related laws, including plant health and biosecurity. Professional operators and national authorities play key roles in implementing the legislation, including notification of pest findings, registration, control, and authorization for issuing plant passports. Scientific data, pest risk analysis, and impact assessments from bodies like the [European Food Safety Authority](#) (EFSA) and the Commission's Joint Research Centre underpin the technical requirements of the rules. EFSA analyses and monitors risks to plant health to assist the European Commission and EU Member States in taking decisions to manage these risks such as through the development of preventive measures, early detection

systems, and effective control strategies. It also coordinates the Scientific Network for Risk Assessment in Plant Health and the Scientific Network on Plant Pest Surveillance¹.

Plant-health surveillance² and monitoring are important tools to detect the introduction of new pests or to monitor their status. Climate change means that there is a need for national, regional and international surveillance and monitoring activities for plant-health threats to be intensified. Consideration should be given to the development of model templates for multilateral surveillance programmes, especially for developing countries, to demonstrate how such programmes may be set up to offset phytosanitary threats (IPPC Secretariat, 2024). In the European Union (EU), it is crucial to minimise the presence of RNQPs and prevent the outbreaks of Quarantine Pests in new areas. Surveillance, response plans³ and increased public awareness could help towards that goal while providing substantial cost reductions and lowering environmental and human health risks in Europe. However, the lack of effective monitoring and surveillance systems for both QPs and RNQPs remains a significant challenge.

The [STELLA project](#) (“Harnessing the Power of Digital Technologies to Protect Plants & the Environment”), funded under Horizon Europe (Project No. 101134750), aims to design and implement an innovative digital Pest Surveillance System (PSS). It seeks to advance pest monitoring and surveillance solutions, pioneer novel methodologies, and validate efficacy in real-world agricultural systems to protect plants and the environment. The system comprises three interconnected subsystems:

- An early warning system harnessing novel pest forecasting models and Internet of Things (IoT) sensors.
- A pest detection system leveraging remotely piloted aerial systems (RPAS), remote and proximal sensing, citizen science, and traps.

¹ The Scientific Network for Risk Assessment in Plant Health, established in 2007, that facilitates the harmonisation of risk assessment practices and improves the exchange of information and data and the Scientific Network on Plant Pest Surveillance, established in 2023, that provides training to its members in pest surveillance methodologies to support the EU Member States in the planning and execution of pest surveys.

² Surveillance is an official process whereby information on pests in an area is obtained through general surveillance, specific surveillance or a combination of both (ISPM 5). Useful references on the requirements for surveillance include ISPM 6 and the IPPC Surveillance guide (IPPC, 2024).

³ A response plan sets out the phytosanitary measures that are to be applied to contain or limit the spread of invasive pests once they are officially detected and confirmed. These include delimiting surveys, preventive measures, phytosanitary measures and measures to suppress the pest population and its spread (if feasible). A response plan should be implemented immediately once a pest that is potentially affected by climate change and poses an unacceptable pest risk is officially found in a new territory. The prevention and preparedness plan should also continue to be implemented for the parts of the country where the pest is still absent (IPPC, 2024).

- A pest response system enabling data-driven decision-making for containment and mitigation measures.

The project validates its methodologies in six Use Case Pilots (UCPs) across five countries, focusing on eight key pests of economic and ecological significance. STELLA also pursues capacity building, stakeholder engagement, and policy development to support sustainable, digital pest management practices in line with EU objectives to reduce pesticide dependency and enhance resilience in agriculture.

This deliverable (D5.1), titled "**Policy Analysis**", compiled under Work Package 5, Task 5.1 of the STELLA project, presents a comprehensive analysis of the current policy frameworks in the European Union and New Zealand regarding the integration of digital technologies into plant health policies. The report gathers the perspectives of various stakeholders including policymakers, advisors, farmers/foresters, and citizens, examining existing legislation, strategies, and their lived experiences. The primary aim is to identify the state of play, perceived benefits and challenges, and highlight areas for future action to foster a more resilient and digitally-enabled plant health system.

The document is outlined in seven chapters:

Chapter 1 - Introduction: This chapter introduces the **crucial importance of plant health** for the environment, food chain, and economy, highlighting the significant economic impact of pests. It outlines the necessity for common EU rules, particularly Regulation (EU) 2016/2031, which focuses on screening, prevention, early detection, and eradication of devastating pests, aligning with international frameworks like the IPPC and WTO principles. The chapter also introduces the STELLA project and its aim to design and implement an innovative digital Pest Surveillance System (PSS) to advance pest monitoring and surveillance solutions.

Chapter 2 - Methods This chapter details the **methodology used for the policy analysis**, which was developed within Task 5.1 of the STELLA project. It describes a dual approach combining an integrative policy framework analysis (reviewing EU and national policy documents and peer-reviewed literature) and a thematic analysis of semi-structured interviews with various stakeholders. The chapter explains how these methods were used to identify gaps, enabling factors, and good practices in current policy related to digital plant health surveillance.

Chapter 3 - Results: This chapter presents the **findings of the policy analysis**, structured into two main sections, the Policy Framework and Stakeholders' perspectives. It examines the

alignment of EU and New Zealand policies with global frameworks, the integration of digital tools within EU plant health policies in the context of Green and Digital transitions, national policy frameworks in France, Greece, Italy, and Lithuania, and a review of digital tools in plant health management and policy from literature. It also details the perspectives gathered from interviews with policymakers, advisors, farmers/foresters, and citizens.

Chapter 4 - Discussion and Synthesis of Results: This chapter provides a **synthesis and discussion of the results**, integrating findings from the policy analysis and stakeholder interviews. It explores the alignment of policies with EU and global frameworks, delves into issues of data sharing and collaboration, particularly focusing on trust and governance of information, discusses the benefits and challenges associated with the adoption of digital technologies in plant health, and identifies the key barriers and enablers to both policy implementation and digital adoption. The chapter also outlines implications for plant health governance.

Chapter 5 - Conclusions: This chapter presents the **main conclusions drawn from the report**, summarising the analysis of policy frameworks and stakeholder perspectives. It reiterates the strategic commitment to leveraging digital technologies for plant health and sustainability goals at the EU level and acknowledges the persistent gaps between strategic ambition and practical reality, particularly concerning trust, data governance, cost, skills, and regulatory obstacles. It also highlights key enablers and suggests a more adaptive, inclusive, and proactive governance model for effectively integrating digital technologies.

Finally, **Chapter 6** provides a **list of all sources cited** within the document, and **Chapter 7** contains **supplementary materials** referenced in the main body of the report, such as interview questionnaires.

2 Methods

This policy analysis was developed within the scope of **Task 5.1 of the STELLA project**, which aims to provide a comprehensive assessment of the policy landscape affecting plant health surveillance, particularly with regard to the uptake and integration of digital and data-driven innovations. The overarching objective of Task 5.1 is to identify gaps, enabling factors, and good practices within current EU and national policy frameworks related to plant health, and to examine the role of digitalisation in transforming pest surveillance systems. To fulfil this purpose, the research applied a dual methodology that combined an **integrative policy framework analysis** with a **thematic analysis** of semi-structured interviews. Together, these methods allowed for an in-depth, multi-perspective evaluation of how policy and practice intersect in the field of digital plant health surveillance.

2.1 Methods for Policy Framework Analysis

To analyse the evolving policy environment relevant to pest surveillance and plant health, the research employed an integrative review methodology as outlined by Whitemore and Knafl (2005). This approach is appropriate for synthesising knowledge across diverse empirical and theoretical sources and for evaluating policy documents that cut across disciplines and governance levels. It allowed the research team to combine different types of evidence, regulatory texts, strategic policy documents, implementation plans, and evaluative studies into a coherent analytical narrative. The integrative review was essential to meeting the Task 5.1 objective of identifying how current policies enable or constrain the implementation of a digitally enhanced pest surveillance system.

The integrative component consisted of two analytical streams: a policy document analysis and a literature review of peer-reviewed academic articles.

The policy document analysis focused on key EU legislative and strategic instruments relevant to plant health and digital innovation, including Regulation (EU) 2016/2031 on protective measures against pests of plants, the European Green Deal and its Farm to Fork and Biodiversity Strategies and the EU's Digital Strategy and its related digital, data and AI legal acts. National-level policy documents from four EU Member States, France, Greece, Italy, and Lithuania, were also examined, along with relevant frameworks from New Zealand as a benchmark third country. Selection criteria for documents included thematic relevance to plant

health, digitalisation, early warning, pest detection, response strategies, sustainability, digital transition, and governance innovation.

The literature review focused on peer-reviewed scientific articles that provided empirical evidence and theoretical frameworks related to EU plant health policy, pest surveillance, early warning systems, response strategies, digital plant health tools, biosecurity systems, policy innovation, and stakeholder engagement in plant protection contexts. The search was conducted in major academic databases using predefined keywords relevant to the STELLA objectives, such as plant health policy, Regulation (EU) 2016/2031, surveillance, digital, or electronic tools, Italy, Greece, France, Lithuania, New Zealand, early warning, pest detection, disease detection, phytosanitary rules, pest response.

The study included twenty-two papers published between 2013 and 2024, covering various geographic regions with a primary focus on the European Union. Articles were screened based on their relevance, focus areas, geographic scope, digital technologies examined, and policy frameworks addressed. The literature review aimed to complement the policy analysis by capturing scientific perspectives on digital surveillance technologies, risk analysis, early warning systems, and institutional readiness, as well as identifying knowledge gaps and areas for improvement in practice.

All sources were analysed through a structured coding framework developed in alignment with the research questions of Task 5.1. Codes and categories were developed inductively and iteratively refined during the process. Key themes identified in the integrative analysis included the fragmentation of plant health governance, the variability in national digital readiness, inconsistencies in cross-border data sharing, the potential of citizen engagement, and the critical role of institutional trust and coordination.

The combined use of policy and scholarly sources allowed for a multidimensional evaluation of regulatory ambition, implementation practice, and innovation opportunity. Specific attention was paid to identifying policy instruments that either directly support or indirectly affect the adoption of digital technologies in pest monitoring, including those associated with the Common Agricultural Policy (CAP), national innovation strategies, and biosecurity frameworks.

2.2 Thematic Analysis of Stakeholder Interviews

To complement the integrative analysis and capture experiential knowledge, a qualitative investigation was carried out through semi-structured interviews with stakeholders engaged

in various aspects of plant health, biosecurity, and agricultural or forestry innovation. These stakeholders included policymakers (at EU and national levels), agricultural/forestry advisors, farmers/foresters, and civil society representatives across the case study countries. The interviews were designed to explore lived experiences, institutional challenges, policy perceptions, and expectations concerning the deployment of digital tools in pest surveillance and related plant health policies.

Policymakers from the European Parliament and the European Commission (DG AGRI, DG CONNECT, and EFSA) were invited to participate in interviews to explore their perspectives on integrating digital tools into plant health policies to aid in the early warning and detection of regulated pests and address climate change and biodiversity loss. The project team sent them personalised emails, introducing STELLA's goals and explaining the value of their insights in shaping practical and effective policy recommendations.

Participants were given the interview questionnaire (APPENDIX) in advance and given the flexibility to either respond at their convenience or schedule a full interview. All participants were informed about confidentiality measures and data handling protocols, and their consent was requested for audio recording. This outreach approach was essential in gathering high-quality input to inform research and policy design.

Between November 2024 and June 2025, 81 interviews were conducted with policymakers, farmers, foresters, advisors, and citizens. This exceeded the expected key performance indicators (KPI = 65) and provided a robust evidence base to advance the objectives of Task 5.1. Six in-depth interviews were conducted with EU policymakers from DG AGRI, DG CONNECT, EFSA and the European Parliament. Each interview lasted approximately one hour, was recorded with consent, and subsequently transcribed for analysis. In parallel, 75 interviews were conducted with national and regional policymakers, farmers and foresters, advisors, and citizens across the Use Case Pilots in France, Greece (both agriculture and forestry), Italy, and Lithuania. Tailored interview guides (APPENDIX) were provided in English, along with machine-translated versions in the relevant local languages, accompanied by clear instructions and a submission deadline of February 15th, 2025.

Each partner had to identify and interview at least five policymakers, from their regional networks, involved in the plant health sector and related policy initiatives, as well as five farmers or foresters (in the case of Greece), three advisors and two citizens engaged in or receptive to plant health management. The goal was to collect insights into the potential role of digital technologies in the plant health sector. Detailed guidance was offered on interview

preparation, consent procedures, and data management to ensure consistency and quality across all contributions.

The interview data were analysed using the **reflexive thematic analysis method** proposed by Braun and Clarke (2021). The method was selected because it is suitable for exploring diverse, subjective experiences and is flexible enough to address both direct and latent meanings. The process is rooted in a constructivist epistemology, acknowledging that themes are actively developed through the researcher's interpretation and reflection, rather than simply being discovered.

Transcripts were subjected to a six-phase analytic process. In the first phase, the research team conducted repeated readings of the transcripts to achieve deep familiarity with the material. The second phase involved generating initial codes across the dataset, with a focus on segments that illustrated stakeholder concerns, strategies, and reflections on digital plant health innovation. Coding was conducted inductively and refined iteratively to remain sensitive to the data. In the third and fourth phases, the codes were clustered into preliminary themes and reviewed against the data to ensure consistency and analytical value. Phase five involved naming and defining the final themes in relation to the project's analytical goals. In the final phase, the themes were synthesised into a narrative interpretation that was cross-validated through peer review within the project team.

The main themes that appeared from the interviews included perceptions of regulatory complexity, a disconnect between high-level policy goals and local capacities, concerns over data privacy and trust, scepticism about the practical value of digital tools, and the demand for inclusive and adaptive policy mechanisms. They also provided the essential context to better understand the implementation challenges and opportunities revealed through the integrative analysis.

Together, the integrative review and reflexive thematic analysis form a coherent, robust methodology to explore the landscape of digital innovation in plant health governance. The former provides a broad structural and conceptual map, while the latter offers grounded, practice-based insights from those navigating this complex terrain of plant health management. This dual approach was crucial for fulfilling the aims of Task 5.1—to develop a rich, evidence-based understanding of how policy can support or hinder the implementation of a digitally enabled pest surveillance system across diverse European Union (EU) contexts.

3 Results

3.1 Policy Framework

3.1.1 Alignment of EU and New Zealand Plant Health Policies with Global Frameworks

This chapter examines the alignment of the European Union and New Zealand's plant health policies, particularly those integrating digital technologies for prevention, early detection, surveillance, and eradication of phytosanitary risks, with key international frameworks. It focuses on their compliance with the International Plant Protection Convention (IPPC), the One Health approach, the Kunming-Montreal Global Biodiversity Framework (GBF), the United Nations Sustainable Development Goals (SDGs), and other relevant international instruments. The analysis identifies both explicit references and inferred alignment based on legal provisions, strategic plans, and implemented practices. As global trade, climate change, and biodiversity loss increase phytosanitary threats, understanding how national and regional frameworks connect with international standards is essential for building resilient, future-proof plant health systems.

3.1.1.1 European Union (EU)

Plants are traded internationally, and pests and diseases know no borders. The EU is a member of the [International Plant Protection Convention](#) (IPPC), where it actively participates in setting international quality standards for plants and plant products ([EC, Plant Health and Biosecurity](#)). The IPPC is an intergovernmental treaty established to protect the world's plants, agricultural products and natural resources from plant pests and diseases. Adopted in 1951 and ratified by 185 contracting parties, the IPPC aims to secure global cooperation in safeguarding plant resources from the introduction and spread of harmful organisms, which is essential for maintaining global food security, preserving biodiversity, and supporting the safe trade of plants and plant products (IPPC, n.d.). It operates within the framework of the World Trade Organisation's (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (WTO, 1994), making it one of the key pillars alongside the [Codex Alimentarius](#) International Food Standards⁴ (FAO, n/d).

⁴ The *C O D E X A L I M E N T A R I U S* international food standards, guidelines and codes of practice contribute to the safety, quality and fairness of this international food trade. Consumers can trust the safety and

The IPPC plays a crucial role in plant health by providing a foundation for countries to develop national laws, guidelines, and measures that protect plant resources based on scientific evidence through the application of [International Standards for Phytosanitary Measures \(ISPMs\)](#) (Table 1). These standards protect sustainable agriculture and enhance global food security, protect the environment, forests and biodiversity and facilitate economic and trade development.

Table 1: International Standards for Phytosanitary Measures (ISPMs) related to detection, surveillance and inspection, address and management of outbreaks and risk assessment (Roukos et al., 2023).

ISPMs related to the pest detection, surveillance and inspection	ISPM 06	Surveillance
	ISPM 07	Phytosanitary certification system
	ISPM 08	Determination of pest status in an area
	ISPM 20	Guidelines for a phytosanitary import regulatory system
	ISPM 23	Guidelines for inspection
	ISPM 27	Diagnostic protocols for regulated pests
	ISPM 28	Phytosanitary treatments for regulated pests
	ISPM 31	Methodologies for sampling of consignments
ISPMs related to addressing pests and managing outbreaks	ISPM 09	Guidelines for pest eradication programmes
	ISPM 13	Guidelines for the notification of non-compliance and emergency action
	ISPM 14	The use of integrated measures in a systems approach for pest risk management
	ISPM 17	Pest reporting

Each contracting party to the IPPC is required to designate a [National Plant Protection Organisation \(NPPO\)](#), tasked with managing plant health surveillance, conducting inspections, issuing phytosanitary certificates, and maintaining pest-free areas. The IPPC also emphasises international cooperation and the exchange of phytosanitary information among its contracting parties to ensure a coordinated global response to plant health challenges. The IPPC Secretariat continues to expand its outreach, with milestones such as the International Day of

quality of the food products they buy and importers can trust that the food they ordered will be in accordance with their specifications.

Plant Health (IDPH) and the International Plant Health Conference (IPHC) raising global awareness on plant health.

[Regulation \(EU\) 2016/2031](#)⁵ on protective measures against pests of plants, the cornerstone EU Plant Health Law that took effect in December 2019, *“takes into account the International Plant Protection Convention (IPPC), the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement), and the guidelines set out under them.”*. This law acknowledges that the Union and all Member States are contracting parties to the IPPC, and it requires EU phytosanitary measures, such as pest risk analysis and phytosanitary certificates, to conform to IPPC standards. For example, the Regulation mandates that phytosanitary certificates comply with the IPPC’s model and content requirements. Moreover, European authorities have also implemented electronic systems for surveillance and trade controls that inherently facilitate international alignment. The European Commission’s [TRACES](#) system⁶ has been connected to the IPPC [ePhyto Hub](#)⁷ to exchange electronic phytosanitary certificates, a “forward-thinking” step welcomed by the IPPC Secretariat in 2020. Likewise, the EU’s internal notification networks for plant pest outbreaks, [EUROPHYT](#)⁸, facilitate rapid information sharing among countries, echoing the cooperative spirit of the IPPC. This demonstrates explicit support for IPPC-led modernisation of phytosanitary practices. These digital and data-driven enhancements also improve the EU’s ability to implement the One Health approach, for example, by swiftly addressing plant pest outbreaks that could have economic, environmental, or even public health knock-on effects.

⁵ Regulation (EU) 2016/2031 of the European Parliament of the Council of 26 October 2016 on protective measures against pests of plants, amending Regulations (EU) No 228/2013, (EU) No 652/2014 and (EU) No 1143/2014 of the European Parliament and of the Council and repealing Council Directives 69/464/EEC, 74/647/EEC, 93/85/EEC, 98/57/EC, 2000/29/EC, 2006/91/EC and 2007/33/EC, OJ L 317, 23.11.2016, p. 4–104, : <http://data.europa.eu/eli/reg/2016/2031/oj>

⁶ TRACES is the European Commission's online platform for animal and plant health certification required for the importation of animals, animal products, food and feed of non-animal origin and plants into the European Union, and the intra-EU trade and EU exports of animals and certain animal products.

⁷ ePhyto is short for “electronic phytosanitary certificate”. The IPPC ePhyto Solution is a tool that transition paper phytosanitary certificate information into a digital phytosanitary certificate or “ePhyto”. This electronic exchange between countries makes trade safer, faster and cheaper.

⁸ EUROPHYT brings together the words 'European' and 'Phytosanitary' and describes a notification and rapid alert system dealing with Interceptions for plant health reasons of consignments of plants and plant products imported into the EU or being traded within the EU itself. EUROPHYT is established and run by the Directorate General for Health and Food Safety of the European Commission.

The EU also explicitly endorses the **One Health** approach in its strategies. In 2022, the European Commission adopted an EU Global Health Strategy⁹ that frames One Health¹⁰ as “an integrated, unifying approach that aims to sustainably balance and optimise the health of people, animals, and ecosystems”. Likewise, a 2024 joint statement by five EU agencies (EFSA, ECDC, EMA, EEA, ECHA)¹¹ emphasises that One Health recognises the complex interplay between human, animal, and plant health, food safety, climate, and the environment, and that implementing this approach is key to better prevention, detection, and response to health threats. While these statements are high-level (often focusing on zoonoses and food safety), they explicitly include *plant health* as part of One Health thinking in the EU (Figure 1). This cross-sectoral vision is formally embraced to ensure plant pest threats are addressed alongside human and animal health threats in an integrated manner.

The EU has also made clear commitments to global biodiversity frameworks. It was an active party in negotiating the [2022 Kunming–Montreal Global Biodiversity Framework \(GBF\)](#) and has committed to the full and swift implementation of the GBF. The European Commission announced the 2022 GBF as “a historic deal” when 196 countries agreed on a roadmap to halt and reverse nature loss by 2030. Although EU plant health policy documents (e.g., the Plant Health Law) predate the GBF, the [EU Biodiversity Strategy for 2030](#) and the comprehensive [Nature Restoration Law](#), with its binding targets to restore degraded ecosystems, provide a strong basis for delivering on international commitments. Notably, the GBF’s target 7, which aims to reduce pesticide risk by 50% by 2030, mirrors the EU’s own Farm to Fork strategy goal of a 50% reduction in pesticide use, indicating alignment. Similarly, EU measures on invasive alien species support the GBF’s invasive species target 6 (the EU has a dedicated Invasive Alien Species (IAS) Regulation (EU) 1143/2014).

⁹ COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS EU Global Health Strategy Better Health for All in a Changing World, COM/2022/675 final, <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52022DC0675>

¹⁰ A full definition of One Health is provided by OHLEP under <https://www.who.int/news/item/01-12-2021-tripartite-and-unep-support-ohhlep-s-definition-of-one-health>

In the context of the Consultation on the Future of Europe, citizens proposed a One Health Approach: “Adopt a holistic approach to health, addressing, beyond diseases and cures, health literacy and prevention, and fostering a shared understanding of the challenges faced by those who are ill or disabled, in line with the “One Health Approach”, which should be emphasized as a horizontal and fundamental principle encompassing all EU policies”.

¹¹ European Food Safety Authority (EFSA), European Centre for Disease Prevention and Control (ECDC), European Medicines Agency (EMA), European Environment Agency (EEA), European Chemicals Agency (ECHA).

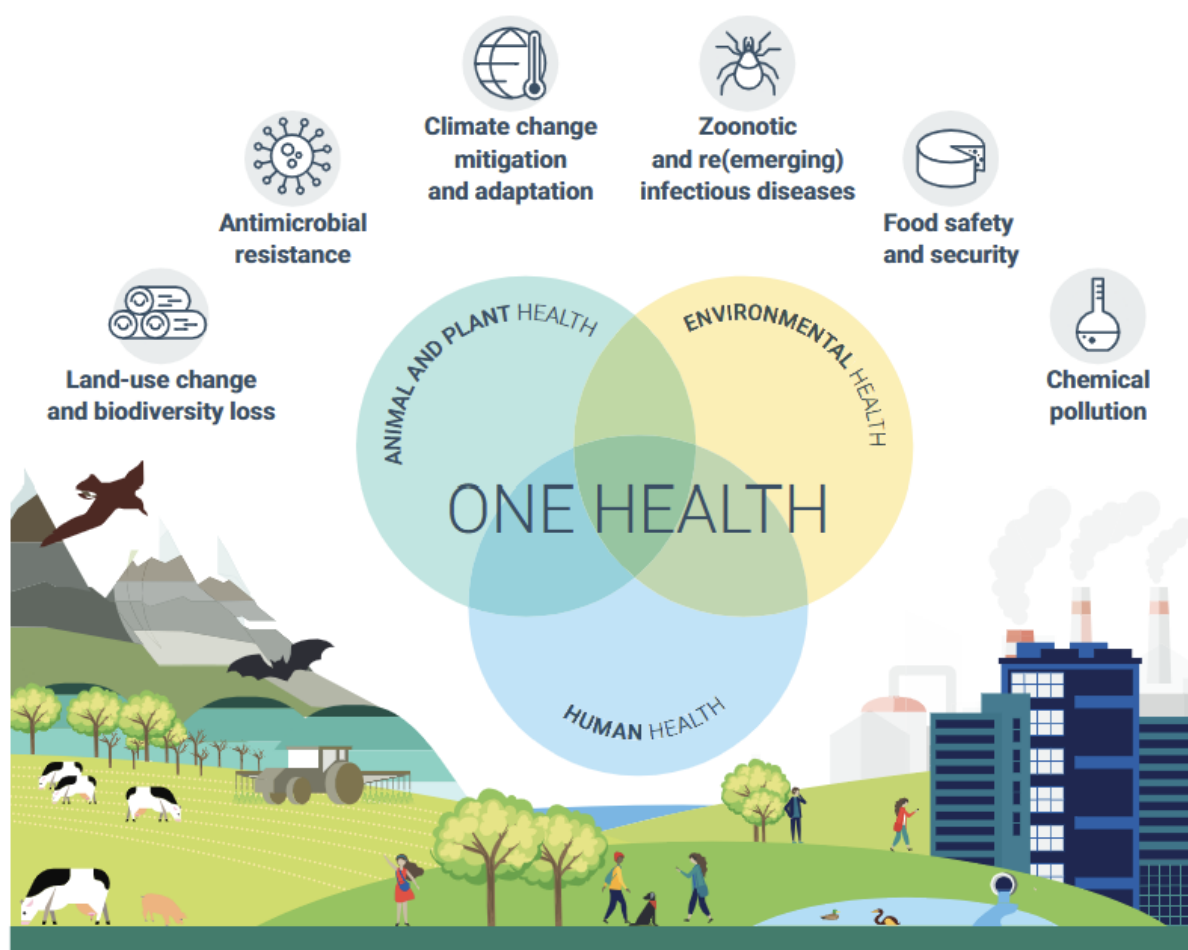


Figure 1: Examples of issues that can be addressed through a One Health approach, (the EU Cross-Agency One Health Task Force), 2023.

EU policies also recognise the [United Nations Sustainable Development Goals \(SDGs\)](#) in the context of plant health. Promoting plant health is essential for achieving the UN Sustainable Development Goals, which aim to reduce hunger and malnutrition, poverty, and the effects of climate change. Protecting plants from pests contributes directly to **SDG 2** (zero hunger) by safeguarding food crops and to **SDG 1** (poverty reduction) by protecting farmer livelihoods. It also supports **SDG 15**, which focuses on life on land. SDG Target 15.8 calls for measures to prevent invasive species introductions, which is part of the EU's biosecurity measures.



Source: [UN, the 17 Goals](#).

While the EU's plant health legislation may not cite the SDGs textually, the Commission continues to focus on delivering concrete actions that will bring tangible progress towards the SDGs. The President's political guidelines for 2024-2029 constitute this Commission's strategy to implement the SDGs. It integrates the SDGs into all Commission proposals, policies and strategies. All of the 17 SDGs feature in one or more of the six headline ambitions announced in [President von der Leyen's Political Guidelines](#).

Even where not stated outright, the EU's plant health strategies since 2019 reflect the principles of these international frameworks. For instance, the EU uniformly applies IPPC International Standards for Phytosanitary Measures (ISPMs) in practice, from pest risk analysis to surveillance protocols, showing de facto compliance. The EU law expanded pest surveillance and reporting obligations across Member States, embodying the IPPC's emphasis on early warning and cooperation. The EU also champions digital innovation in plant health, which aligns with IPPC and One Health calls for modernised approaches. The EU has invested in advanced digital technologies for pest detection and reporting. For example, EU HORIZON-funded projects, such as [STELLA](#), [CERBERUS](#) and [FORSÄID](#) aim to modernise pest surveillance by utilising remote sensing, drones, IoT sensors, and AI analytics, enabling predictive and real-time pest management.

3.1.1.2 New Zealand (NZ)

New Zealand's plant health and biosecurity policies are closely tied to international conventions, often by formal declaration. NZ is a long-standing contracting party to the International Plant Protection Convention, and this is reflected in its policy documents. The Ministry for Primary Industries (MPI) directly acknowledges that the IPPC "*sets standards for the safe movement of plants and related products to prevent the spread of pests and diseases*" (MPI, n.d.), and MPI serves as [NZ's NPPO](#) (National Plant Protection Organisation) in implementing those standards. New Zealand actively participates in IPPC standard-setting, signalling an explicit commitment to align national measures with IPPC benchmarks. At a strategic level, MPI published "[New Zealand's Strategic Objectives for the IPPC 2019–2023](#)", underscoring NZ's intent to support and influence the IPPC's work (e.g. contributing expertise in plant pest control). In practical terms, [New Zealand's Biosecurity Act](#) and regulations are designed to fulfil WTO SPS Agreement obligations as well. For instance, import health standards are science-based and adhere to international guidelines, satisfying NZ's SPS commitments.

New Zealand is also **party to global biodiversity agreements**, and it explicitly links these to its domestic strategies. NZ joined nearly 200 parties in adopting the **Kunming-Montreal Global Biodiversity Framework** in December 2022. The government has openly endorsed the GBF's goals – including protecting 30% of land and sea by 2030 – and confirmed that NZ will implement its GBF commitments *“through Te Mana o te Taiao, our national biodiversity strategy, wherever possible.”*. The [NZ Biodiversity Strategy 2020–2050 \(“Te Mana o te Taiao”\)](#) is positioned as the vehicle to fulfil global targets under the Convention on Biological Diversity (CBD) and the GBF. In line with this, New Zealand's policies on invasive species and ecosystem protection contribute to the objectives of the CBD. For example, [NZ's Predator Free 2050 initiative](#) and pest eradication programs on islands link with the GBF aim to reduce or eliminate the impact of invasive alien species. While plant health, per se, is often under the broader “biosecurity” umbrella, the biodiversity strategy explicitly identifies invasive pests and diseases as a significant threat to New Zealand's native flora and fauna, and calls for strengthened biosecurity as a key action area, implicitly tying plant health measures to international biodiversity goals.

On the **One Health** front, New Zealand's official plant health strategies seldom use the term “One Health” explicitly, but the ethos of One Health is increasingly acknowledged in its biosecurity discourse. NZ researchers and advisors promote a “**One Biosecurity**” concept that extends One Health to include plant and environmental health more explicitly. For instance, New Zealand's Bio-Protection Research Centre describes *One Biosecurity* as “*an interdisciplinary approach to biosecurity policy and research that builds on the interconnections between human, animal, plant, and environmental health to prevent and mitigate the impacts of invasive alien species effectively.*” (Hulme, 2020). While not a formal policy term, NZ's integrated biosecurity system (covering plant, animal, and human health under MPI and other agencies) inherently follows One Health principles. NZ also has [One Health Aotearoa](#), a national consortium focusing on infectious diseases, indicating high-level endorsement of One Health thinking that indirectly benefits plant health through environmental health.

New Zealand is committed to implementing the Sustainable Development Goals (SDGs), with a focus on building a productive, sustainable, and inclusive economy that improves the well-being of all New Zealanders (MFAT, 2019). The Ministry of Foreign Affairs and Trade coordinates efforts across agencies to align the SDGs with national priorities and engages with the private sector and civil society to advance progress. New Zealand's commitment extends to areas directly related to plant health, primarily through initiatives focused on land

use, agriculture, forestry, and biosecurity, aligning with **SDG 2 (Zero Hunger)**, **SDG 12 (Responsible Consumption and Production)**, and **SDG 15 (Life on Land)**. The health and sustainable management of plants and land resources are crucial because New Zealand's economy relies heavily on primary production sectors. The country is addressing challenges such as reducing nutrient pollution from farming activities, which impacts soil and water health. Policies are also being developed to manage the environmental effects of plantation forestry through National Environmental Standards. Furthermore, biosecurity measures are being strengthened to protect the primary sector from pests and diseases, which is fundamental to plant health and maintaining the economy's reliance on these sectors (MFAT, 2019).

3.1.2 EU Plant Health Policies in the context of Green and Digital transition

3.1.2.1 Green Transition

The [European Green Deal \(EGD\)](#)¹² is the European Union's ambitious strategic and transformative agenda designed to tackle climate and environmental-related challenges and achieve climate neutrality by 2050, aiming to make Europe the first climate-neutral continent. It is the EU's growth strategy intended to transform the EU into a fair and prosperous society with a modern, resource-efficient, and competitive economy where there are no net greenhouse gas emissions by 2050 and where economic growth is decoupled from resource use. The EGD also aims to protect, conserve, and enhance the EU's natural capital and protect the health and well-being of citizens from environment-related risks and impacts. It serves as the EU's compass and is an integral part of the European Commission's strategy to implement the United Nations' 2030 Agenda and the Sustainable Development Goals (SDGs). The EGD encompasses an unprecedented suite of new policies and amended legislation across seven thematic areas, including a binding target set by the EU Climate Law in July 2021 to reduce net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels. In the [Commission's 2024-2029 priorities](#), from defence and security to sustainable prosperity, democracy, and social fairness, it is stated that “*we must and will stay the course on the goals set out in the European Green Deal*” (EC, 2024).

¹² COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS The European Green Deal. COM/2019/640 final. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2019:640:FIN>

All policy areas are included in the EGD's objective of achieving climate neutrality by 2050, which explicitly requires that sectoral strategies, including those pertaining to agriculture and food systems, be informed by environmental considerations. The Plant Health Law¹³, modernised in 2019 and further updated in 2024, recognises that climate change creates new conditions for pest survival and spread across European territories. Forest health protection under the Plant Health Law directly supports Green Deal objectives related to carbon sequestration and climate mitigation. The EU Plant Health Law's mandate to protect forest ecosystems from harmful pests contributes to maintaining forest cover and ecosystem services essential for climate regulation. Healthy forests serve as carbon sinks, biodiversity refuges, and sources of renewable materials that support the circular economy objectives embedded within the Green Deal framework.

The EGD objectives and implementation efforts are closely linked to plant health policies, primarily through the [Farm to Fork \(F2F\) Strategy](#)¹⁴. The F2F Strategy is central to the EGD's goal of transitioning to a more sustainable and resilient EU food system and achieving climate neutrality. It aims to ensure that the food system has a neutral or positive environmental impact, helps mitigate and adapt to climate change, and contributes to reversing biodiversity loss (Figure 2). The F2F strategy directly addresses plant health through its intention to reduce the use and risk of chemical pesticides significantly. The F2F Strategy also aims to address the use of fertilisers as part of preserving and restoring Europe's natural capital. These objectives fundamentally reshape plant protection approaches, requiring agricultural systems to adopt integrated pest management strategies that emphasise the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourage natural pest control mechanisms over chemical interventions. The transition supports broader Green Deal objectives of reducing environmental pollution while maintaining agricultural productivity and food security.

¹³ Regulation (EU) 2016/2031 of the European Parliament of the Council of 26 October 2016 on protective measures against pests of plants, amending Regulations (EU) No 228/2013, (EU) No 652/2014 and (EU) No 1143/2014 of the European Parliament and of the Council and repealing Council Directives 69/464/EEC, 74/647/EEC, 93/85/EEC, 98/57/EC, 2000/29/EC, 2006/91/EC and 2007/33/EC, OJ L 317, 23.11.2016, p. 4–104. <http://data.europa.eu/eli/reg/2016/2031/oj>

¹⁴ COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system. COM/2020/381 final. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0381>

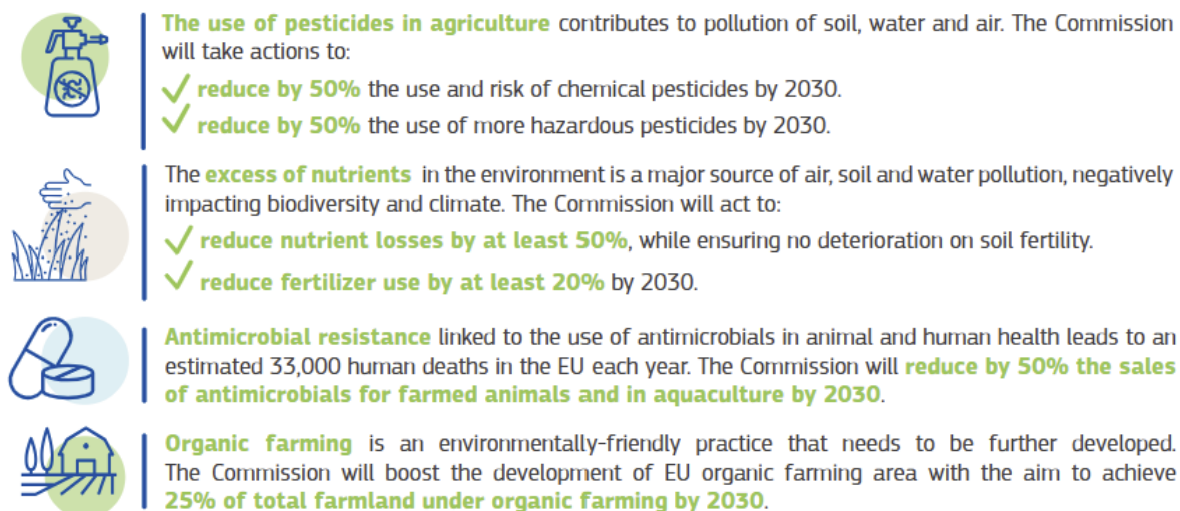


Figure 2: F2F Strategy targets (EC, 2020).

The [EU Biodiversity Strategy](#)¹⁵ for 2030 aligns with the F2F Strategy in sharing targets, including those related to reducing the use of pesticides, and increasing organic farming and agro-ecological practices (Figure 3).

The strategy also considers the potential role of new, innovative techniques to protect harvests from pests and diseases, contributing to food system sustainability while ensuring safety. Proposals for new rules concerning certain new genomic techniques have been made to ensure health protection while promoting sustainability and innovation. While progress is being made in reducing the use and risk of chemical pesticides, with data suggesting the 50% reduction target might be achievable by 2030, the robustness of the current indicator is debated (Marelli et al., 2025). Achieving the 50% reduction target for *more hazardous* pesticides is considered challenging based on available data. The proposed Regulation on the Sustainable Use of Plant Protection Products, mentioned as part of a July 2023 package of proposals for the sustainable use of natural resources, was later withdrawn in February 2024 (Marelli et al., 2025). The Common Agricultural Policy (CAP) Strategic Plans implemented by Member States are intended to align with CAP legislation and support the goals of the EGD, including those outlined in the F2F and Biodiversity strategies, contributing to GHG emissions mitigation targets for the primary sector. However, the analysis indicates

¹⁵ COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS EU Biodiversity Strategy for 2030 Bringing nature back into our lives. COM/2020/380 final. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0380>

that the impact of implementing these plans has been limited so far due to timing (Marelli et al., 2025).

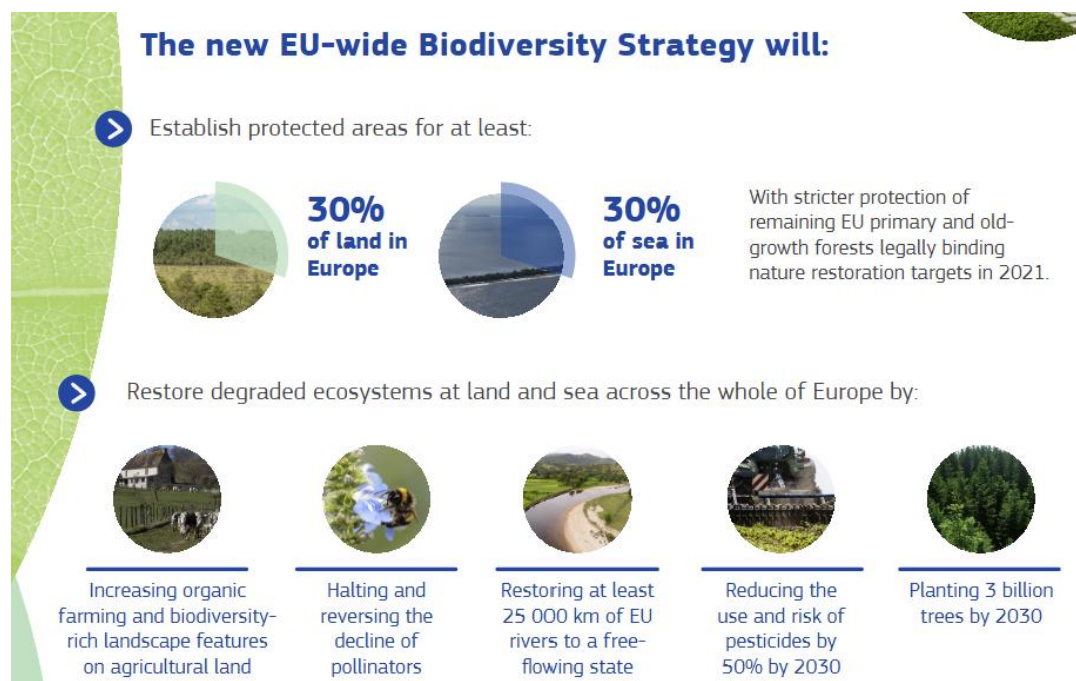


Figure 3: Biodiversity Strategy for 2030 targets (EC, 2020)

The Farm to Fork Strategy¹⁶ and the EU Biodiversity Strategy for 2030¹⁷ set targets that implicitly rely on digital innovation. Their common target to reduce chemical pesticide use by 50% by 2030 will require smarter pest management and early-warning tools. Likewise, the Biodiversity Strategy calls for curbing invasive alien species, emphasising improved surveillance and rapid response. Among the others, the Council Decision on the Horizon Europe Framework Programme¹⁸ refers to the importance of plant health and the integrated approaches needed to tackle plant pests and diseases. In line with these broad lines of activities to be carried out, the EU has funded research and innovation projects to “digitalise” plant health surveillance. For example, Horizon Europe’s 2023 call “*Digital technologies supporting plant health early detection, territory surveillance and phytosanitary measures*”

¹⁶ COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system. COM/2020/381 final. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0381>

¹⁷ COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS EU Biodiversity Strategy for 2030 Bringing nature back into our lives. COM/2020/380 final.

¹⁸ [Council Decision \(EU\) 2021/764](#) of 10 May 2021 establishing the Specific Programme implementing Horizon Europe – the Framework Programme for Research and Innovation, and repealing Decision 2013/743/EU.

explicitly supports Regulation (EU) 2016/2031 and Green Deal goals. Projects, such as STELLA, funded under this call, are expected to integrate remote sensing, networks of sensor-equipped traps (IoT), drones, and artificial intelligence to monitor regulated pests at a large scale. The expected outcomes include robust large-scale plant scanning methods for quicker detection and mapping of infestations, and cost-efficient combinations of technologies to assist official surveillance and timely eradication efforts. There is a strong push for interoperable data platforms and “early warning” systems that compile field observations, lab diagnostics, and sensor data for real-time pest risk analysis.

EU institutions have also fostered multi-actor networks. For instance, [EUPHRESKO](#), hosted within the European and Mediterranean Plant Protection Organisation (EPPO), is a network of organisations that fund research projects and coordinate national research in the phytosanitary area. Meanwhile, the European Food Safety Authority (EFSA) uses automated [tools for horizon scanning](#) to detect emerging plant pests, including global media and scientific literature monitoring and to provide timely scientific advice and inform EU risk assessments and policies. The monitoring system is based on the automatic public health surveillance platform [MEDISYS \(Medical Information System\)](#), scanning more than 25.000 sources in 79 languages from 204 countries, covering all the world's regions (EFSA, 2022). The EU's regulatory and funding landscape since 2019 encourages the adoption of digital technologies, mainly electronic certification and databases for prevention.

The new Vision for Agriculture and Food¹⁹ highlights the fundamental link between the resilience of farming and its long-term food production capacity, and the health of ecosystems, including the fight against pests and diseases. Animal and plant diseases are specifically identified among the significant shocks the agri-food sector has recently faced. A core aspect of this vision regarding plant health and pest management is the ambition to reduce the use of harmful pesticides, which is considered important for the long-term resilience of farming, as well as for protecting nature and health. The sources acknowledge the challenge that the introduction of alternatives, such as biological or innovative low-risk plant protection products, has not kept pace with the withdrawal of active substances from the market, potentially affecting the EU's ability to ensure food production. Addressing this, the Commission states it

¹⁹ COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A Vision for Agriculture and Food Shaping together an attractive farming and agri-food sector for future generations. COM/2025/75 final. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52025DC0075>

will carefully consider any further ban of pesticides if alternatives are not yet available, unless the pesticide presents a clear threat to human health or the environment that agriculture relies upon. To accelerate access for biopesticides, the Commission plans a proposal in Q4 2025, which will include defining biocontrol active substances, allowing provisional authorisations by Member States while evaluation is ongoing, and creating a fast-track procedure for approval and authorisation. Reinforcement of EFSA with additional resources is also deemed necessary to speed up risk assessment procedures for innovative plant protection products, while maintaining a high level of protection.

Furthermore, plant health is listed as one of the universal objectives that the EU defends with high global standards, particularly in the context of trade. The vision aims for a stronger alignment of production standards on imported products, notably concerning pesticides, establishing a principle that most hazardous pesticides banned in the EU for health and environmental reasons should not be allowed back through imported products. An Impact Assessment on this and the assessment of the export of hazardous chemicals, including banned pesticides, are planned for 2025. Strengthening controls on imports, including on plant health, is also a stated priority, and animal/plant health issues are identified as specific crises of significant magnitude for which the agricultural reserve could potentially be refocused.

3.1.2.2 Digital Transition

The digital transition in agriculture is positioned within a broader EU strategic direction, particularly aligning with EU priorities in the Green Deal and a Europe Fit for the Digital Age²⁰. Digitalisation is a key priority of the EU's agricultural policy, supporting the adoption of advanced technologies, data-driven approaches, and improved infrastructure to benefit both farmers and rural communities. The Common Agricultural Policy (CAP) 2023–27 plays a central role, requiring EU countries to develop digital strategies tailored to their specific needs, focusing on investments in broadband, precision farming, training, and advisory services. The EU is committed to supporting the adoption of cutting-edge digital tools, such as the Internet of Things (IoT), artificial intelligence, robotics, and big data analytics, to enable more precise, resource-efficient, and climate-smart farming practices. It is also important to digitalise public services, including CAP administration, through online applications, satellite monitoring, and geotagged photos, which reduce bureaucracy and make support more accessible to farmers.

²⁰ https://commission.europa.eu/publications/factsheets-europe-fit-digital-age_en

A key component of digitalisation is the creation of a common agricultural data space, which aims to facilitate secure and fair data sharing among stakeholders, fostering innovation and transparency across the agri-food value chain. Funding from Horizon Europe and the Digital Europe Programme²¹ is supporting research, innovation, and capacity-building projects that drive the digital transition. The challenges to overcome are digital divides, the need for inclusive digital ecosystems, and the importance of tailored solutions for small and medium-sized farms. Overall, the EU is committed to a human-centred, inclusive digital transition in agriculture (EC, n.d.).

A central component of the EU's ambition to become a global leader in the digital economy is the European Data Strategy²². The strategy aims to create a single European data space, fostering a genuine single market for data that benefits businesses, researchers, public administrations, and citizens throughout the European Union. It emphasises the development of sector-specific data spaces, such as those in health, agriculture, manufacturing, and public administration, to facilitate secure and trustworthy data sharing and access across sectors and Member States. The strategy is supported by regulatory frameworks, including the Data Governance Act²³, the Data Act²⁴, and the Interoperable Europe Act²⁵, which establish clear rules for data sharing, access, and reuse while prioritising privacy and security. A key objective is to empower individuals with greater control over their data and to provide businesses, particularly small and medium-sized enterprises, with fair access to data, thereby promoting innovation and competition. The strategy also calls for significant investment in advanced data infrastructure, such as cloud and edge computing, as well as in digital skills and literacy. Trust, security, and ethical data use are foundational principles, ensuring compliance with EU values and fundamental rights, including data protection under the General Data Protection Regulation (GDPR). By leveraging data-driven innovation, the strategy supports the EU's twin transitions to a greener and more digital economy, contributing to initiatives like the European

²¹ Regulation (EU) 2021/694 of the European Parliament and of the Council of 29 April 2021 establishing the Digital Europe Programme and repealing Decision (EU) 2015/2240. *OJ L 166*, 11.5.2021, p. 1–34 . <http://data.europa.eu/eli/reg/2021/694/oj>

²² COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A European strategy for data. COM/2020/66 final. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52020DC0066>

²³ Regulation (EU) 2022/868 of the European Parliament and of the Council of 30 May 2022 on European data governance and amending Regulation (EU) 2018/1724 (Data Governance Act). *OJ L 152*, 3.6.2022, p. 1–44 . <http://data.europa.eu/eli/reg/2022/868/oj>

²⁴ Regulation (EU) 2023/2854 of the European Parliament and of the Council of 13 December 2023 on harmonised rules on fair access to and use of data and amending Regulation (EU) 2017/2394 and Directive (EU) 2020/1828 (Data Act). *OJ L*, 2023/2854, 22.12.2023, <http://data.europa.eu/eli/reg/2023/2854/oj>

²⁵ Regulation (EU) 2024/903 of the European Parliament and of the Council of 13 March 2024 laying down measures for a high level of public sector interoperability across the Union (Interoperable Europe Act). *OJ L*, 2024/903, 22.3.2024, <http://data.europa.eu/eli/reg/2024/903/oj>

Green Deal and the digital transformation of public services and policy-making. Ultimately, the European Data Strategy seeks to boost Europe's competitiveness, enhance the availability and use of high-quality data, accelerate the adoption of artificial intelligence and digital services, and ensure that data is used in ways that respect fundamental rights and foster societal progress.

The Vision for Agriculture and Food outlines that the digital transition is moving at an unprecedented speed and holds significant potential to improve farm economic performance, resilience, and sustainability. Advanced digital technologies, including artificial intelligence, when combined with data from the Internet of Things and other sources, are seen as being able to enhance operations, drive innovation, and revolutionise how food is produced, while also taking care of the environment, climate, and people. Examples of how digitalisation can help include enabling e-commerce, digital marketing, and online marketplaces to reach a wider customer base, and leveraging precision farming and data-based solutions to increase profitability through optimising inputs. Furthermore, new technologies like earth observation satellites can help reduce on-the-spot controls and reporting by providing real-time, actionable data at farm level, a benefit also fostered by EU space assets like Copernicus and Galileo. Data-sharing technologies are also expected to cut red tape through more streamlined and automated reporting. Despite these potentials, the adoption of digital tools lags due to high costs, lack of digital skills and trust, absence of tailored solutions, and connectivity issues. The Commission plans to address these challenges by launching an EU digital strategy for agriculture to enable the transition to a digital-ready sector, prioritising connectivity in rural areas, investing in lifelong digital skills training and advice, and integrating digital systems for data collection using a 'collect once, use multiple times' principle.

Regarding the relationship to plant health and pest management, the vision identifies the fight against pests and diseases as fundamental to the long-term ability of farming to produce food and be resilient. Animal and plant diseases are listed as significant shocks the agri-food sector has faced. While the vision aims to reduce the use of harmful pesticides and addresses the slow introduction of alternatives like biological or innovative low-risk plant protection products, and plans to accelerate market access for biopesticides, it does not explicitly state that the broader digitalisation strategy or specific digital technologies like AI are primarily intended to revolutionise plant health or pest management directly. The link is primarily indirect with digitalisation supporting the overall resilience and efficiency of farming, which includes managing inputs, and the vision mentions reinforcing EFSA to speed up risk assessment for innovative plant protection products, which could potentially be technology-enabled.

The plant health rules move towards greater reliance on digital tools and systems for communication, reporting, and data management within the EU plant health regime. Digital tools and precision farming technologies can improve the environmental resilience of agriculture. This is achieved by collecting and analysing data on elements such as weather conditions, soil quality, and crop health, allowing farmers to make more informed decisions regarding pest control. This capability contributes to better resource management, optimised production, and a reduced environmental impact. There is also significant potential of remote sensing and underlying digital platforms for revolutionising early warning capabilities across various fields, and digital technologies can support biosecurity measures. Furthermore, cybersecurity is important, as agricultural businesses store significant data, including on crop yields, and unauthorised access could lead to misuse (Barabanova et al., 2023).

Digital solutions are also playing a crucial role in the transition to zero-pollution, sustainable farming²⁶ by leveraging technological, digital, and space-based innovations. Digital technologies are applicable across all farming subsectors and can benefit farms of various sizes and types, including both organic and conventional operations. Specifically, focusing on plant health and pest management, technologies like drones can be utilised for online monitoring of crop yields, soil health, and plant nutrient needs. They can also integrate weather forecasts to identify existing or predictable plant health issues. This allows for targeted interventions, such as spot spraying of crops, reducing the need for widespread application. Sensors on farms can collect near real-time data and monitor soil, air, and water properties, as well as specific crop characteristics. This data provides essential information for making informed decisions regarding the optimal amount, place, and time for the use of fertilisers or pesticides. By optimising the application of these inputs, digital solutions can lead to a reduction in unwarranted pesticide use and lessen pollution caused by excess nutrients.

Sensor technology, when combined with Internet of Things (IoT) applications, can automatically detect infestation events, which allows for reduced-scale pesticide application. EU space technologies, such as Copernicus and Galileo, also support these efforts. For example, the [EU-funded Fatima project](#) developed methods for assessing crop nutrient and water requirements using these technologies. An example of an eco-innovative approach to

²⁶ COMMISSION STAFF WORKING DOCUMENT Digital Solutions for Zero Pollution Accompanying the document Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Pathway to a Healthy Planet for All EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil'. SWD/2021/140 final. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021SC0140>

pest management highlighted is the [WeLASER project](#). This project aims to eliminate the use of herbicides by employing high-power lasers, autonomous mobile systems, and a smart controller based on AI, IoT, and cloud computing for weeding, which also seeks to improve productivity.

Moreover, the Commission's proposal for the post-2020 Common Agriculture Policy (CAP) included the [Farm Sustainability Tool \(FaST\)](#). This digital tool offers advice on fertiliser use via mobile and web applications and assists farmers in meeting legal requirements for nutrient management. This helps to reduce nutrient pollution. The FaST tool uses space data from [Copernicus](#) and [Galileo](#) and allows for the reuse and interoperability of data from various sources.

Digital platforms, such as STELLA-PSS platform that will be developed to aid in the early warning and detection of regulated pests and provide a response strategy, are considered vital for Europe's AgriTech sector and play a key role in achieving the EU green and digital transition. They function as the digital backbone that enables seamless data exchange and collaboration across the agricultural value chain. This capability is fundamental for collecting and integrating diverse data streams from sources like IoT devices and satellite imagery, which is necessary for monitoring aspects relevant to plant health and identifying pest presence. Platforms facilitate communication between different systems and data sources, supporting collaboration among stakeholders like farmers, technology providers, and researchers, which is important for developing effective plant health and pest management strategies (Doolin, 2024).

Digital platforms are central to implementing and adopting both formal and quasi-standards, which significantly enhances interoperability. When platforms respect and use existing standards, they allow various technologies and systems pertinent to plant health and pest management, such as sensors, weather stations, and analytical software, to communicate effectively and share data, thereby overcoming fragmentation. Platforms are also most important for driving digitalisation, efficiency, and innovation in agriculture. By providing a common framework, digital platforms can simplify the integration of new tools and solutions relevant to monitoring and managing plant health and pests (Doolin, 2024).

Platforms are also crucial for managing and structuring the data collected in agriculture, using IT standards like XML, JSON, and SQL. High-quality, standardised data, which digital platforms help establish, is essential for the analytics and research and development needed

in data-driven plant health and pest management. Platforms also enable the use of technologies like IoT for monitoring and AI/Big Data for analysis, which are applicable to tasks such as identifying plant diseases, predicting pest outbreaks, and optimising resource use. Standards specific to precision agriculture (ISO 22006) and biodiversity protection, supported by these platforms, are also relevant as they guide practices impacting ecosystem health and resource use in pest control (Doolin, 2024).

The digital activities in agriculture generate a vast amount of data. This holds great potential for economic growth and for addressing societal challenges. The [European data strategy](#)²⁷ aims to establish a single market for data, promoting competitiveness and data sovereignty. In the agricultural sector, it focuses on the creation of a Common European agricultural data space. The primary goal of this data space is to enhance the sustainability performance and competitiveness of the agricultural sector.

Data is seen as a crucial element for improving both the sustainability and competitiveness of the sector. By processing and analysing production data, particularly when combined with other types of data like earth observation, meteorological data, and supply chain information, it becomes possible to implement precise and tailored production approaches at the farm level. The establishment of a common data space, building on existing data sharing models, could create a neutral platform for sharing and pooling agricultural data, including both private and public data. Such a platform is expected to foster the emergence of an innovative data-driven ecosystem founded on fair contractual relationships. Furthermore, this initiative could strengthen the capacity for monitoring and implementing common agricultural policies and has the potential to reduce administrative burden for both government bodies and beneficiaries. Existing efforts, such as a stakeholder code of conduct for data sharing by contractual agreement developed in 2018, and a declaration signed by Member States in 2019 supporting the setup of data spaces, underpin this strategy.

The European Data Strategy will encourage data altruism, particularly in Internet-of-Things-generated data, which is crucial for advanced farming technologies, such as precision farming.

²⁷ COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A European strategy for data. COM/2020/66 final. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52020DC0066>

The Open Data Directive²⁸ and Act on High-Value Datasets²⁹ also support data reuse. These regulations affect data sharing in agriculture and the development of a common data space for agricultural data.

3.1.3 Digital Tools in EU Plant Health Policies

The EU has established a robust legal framework and supportive policies to integrate digital tools into plant health policies. The cornerstone is **Regulation (EU) 2016/2031** (the “EU Plant Health Law”), in force since December 14, 2019, which replaced five Directives of plant health law and provides for a risk-based and more proactive approach to the phytosanitary protection of Union territory. It aims to help fight plant pests and diseases, with more effective measures to protect the European Union (EU) and its plants, ensuring safe trade and mitigating the impact of climate change, including:

- better protection of landscapes, forests and other green spaces, and reducing the need for pesticides;
- simpler and more transparent documentation for growers and farmers, and better protection for crops;
- financial support for surveillance, eradication and containment.

It provides for surveys for the presence of Union Quarantine Pests, Priority Pests and Protected Zones Quarantine Pests, timely detection and notification of outbreaks and interceptions, detailed rules for eradication and containment, definitions of pests (Figure 4), contingency planning and simulation exercises (EC, 2021). The regulation also seeks to level the playing field for EU producers and traders in plant and plant products on the EU internal market and sets out measures on imports to the EU from third countries (Karamfilova, 2024). The Implementing Regulation (EU) [2019/2072](#)³⁰ sets out the listing of Union quarantine pests, protected zone quarantine pests, and Union regulated non-quarantine pests.

²⁸ Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and the re-use of public sector information (recast), OJ L 172, 26.6.2019, <http://data.europa.eu/eli/dir/2019/1024/oj>

²⁹ Commission Implementing Regulation (EU) 2023/138 of 21 December 2022 laying down a list of specific high-value datasets and the arrangements for their publication and re-use, OJ L 19, 20.1.2023, p. 43–75, http://data.europa.eu/eli/reg_impl/2023/138/oj

³⁰ Commission Implementing Regulation (EU) 2019/2072 of 28 November 2019 establishing uniform conditions for the implementation of Regulation (EU) 2016/2031 of the European Parliament and the Council, as regards protective measures against pests of plants, and repealing Commission Regulation (EC) No 690/2008 and amending Commission Implementing Regulation (EU) 2018/2019. OJ L 319, 10.12.2019, p. 1–279, http://data.europa.eu/eli/reg_impl/2019/2072/oj

Since 2014, the European Union has been providing funding (Regulation (EU) 652/2014 replaced by [Regulation \(EU\) 2021/690](#)³¹) to support Member States for the costs incurred in surveillance activities. Regulation (EU) 2021/690 established a funding programme relating, inter alia, to the plants sector, which aims to contribute to a high level of protection of the health and safety of humans, animals and plants in the plants, animals, food and feed sectors, through the prevention, detection and eradication of animal diseases and plant pests as well as by stimulating the exchange of best practices between stakeholders in these sectors. To obtain co-funding, Member States must submit their survey programmes to the Commission for prior approval. As part of the surveillance measures under the Single Market Programme (SMP), the EC co-finances sampling, testing and other activities related to plant health (Sánchez et al., 2021).

Regulation (EU) 2016/2031 incorporates key provisions regarding the use of electronic and digital tools to enhance the efficiency, speed, and traceability of the plant health regime within the EU:

1. The Commission is required to establish an electronic system for the submission of notifications by the Member States. This system is intended to be connected to and compatible with a computerised information management system for official controls at the Union level. Member States are obliged to use this system for various notifications, such as:
 - Officially confirmed presence of Union quarantine pests.
 - Cases of non-compliance with Union measures adopted against specific pests or temporary measures, particularly when creating a risk of spread of Union Quarantine pests.
 - Presence of pests not yet listed as Union quarantine pests.
 - Violations of import prohibitions or special requirements for introduction or movement within the Union.
 - Violations concerning frontier zones.
 - Findings of pests after applying temporary import measures or refusal of introduction/movement due to violations of temporary prohibitions.
 - Invalidation of phytosanitary certificates.

³¹ Regulation (EU) 2021/690 of the European Parliament and of the Council of 28 April 2021 establishing a programme for the internal market, competitiveness of enterprises, including small and medium-sized enterprises, the area of plants, animals, food and feed, and European statistics (Single Market Programme) and repealing Regulations (EU) No 99/2013, (EU) No 1287/2013, (EU) No 254/2014 and (EU) No 652/2014. OJ L 153, 3.5.2021, p. 1–47. <http://data.europa.eu/eli/reg/2021/690/oj>

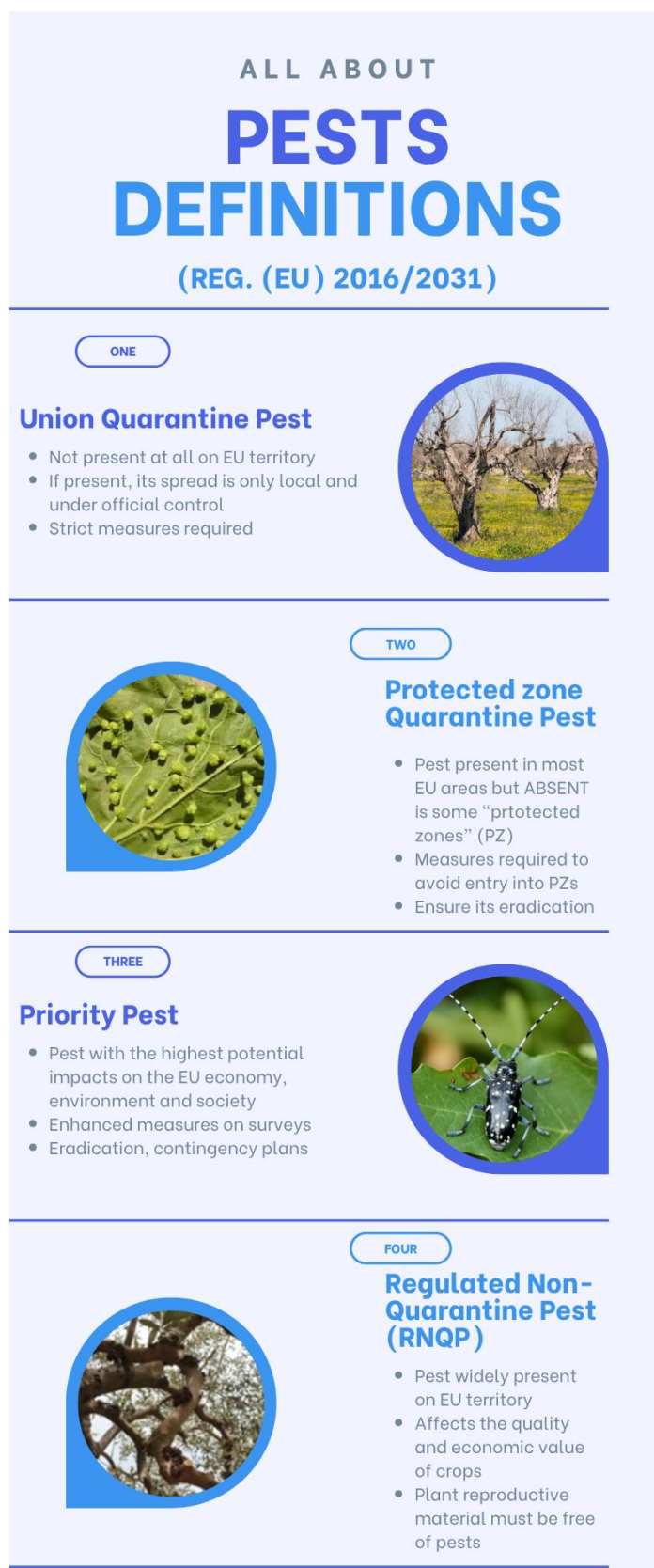


Figure 4: Pests Definitions, Reg. (EU) 2016/2031 (Photos: 1. *Xylella fastidiosa* in olive trees in Apulia, [BEXYL](#), 2. Grapevine phylloxera, by Ilias Antonopoulos / 24 July 2018, 3. *Anoplophora chinensis* (from [malasiaca](#))_July 2010_ Photo Matteo Maspero ([Web](#)), 4. The formation of hard galls on olive twigs and branches, AUA, Greece)

- Removal and invalidation of plant passports.
 - The Commission can also lay down specific rules for these notifications, including information items, format, deadlines, and when a suspected presence or non-compliance needs notification.
2. The Regulation anticipates the use of electronic phytosanitary certificates. These certificates, required for the introduction of certain plants, plant products, and other objects into the Union from third countries, shall only be accepted when provided through, or in electronic exchange with, a computerised information management system for official controls at Union level. Similar provisions apply to electronic phytosanitary certificates for export and re-export. Implementing acts may set out technical arrangements for the invalidation of electronic phytosanitary certificates.
 3. The Regulation explicitly allows for plant passports to be issued in an electronic form, '**electronic plant passport**'. An electronic plant passport must contain all the required elements of a physical plant passport. Implementing acts may set out technical arrangements for the issuance of electronic plant passports to ensure compliance, credibility, and effectiveness.
 4. It also includes provisions for digital traceability and record keeping:
 - Plant passports may include a traceability code that may also be supplemented by a reference to a unique traceability barcode, hologram, chip or other data carrier.
 - Professional operators are required to keep records for traceability, identifying suppliers and recipients of regulated items. While not explicitly requiring digital format for *all* records, the text mentions that *the retention of information contained in a replaced/invalidated plant passport... may take the form of storage... in a computerised database*, provided it includes information from any traceability barcode, hologram, chip or other data carrier. Similarly, *retention of phytosanitary certificate information may take the form of storage... in a computerised database*.
 - Professional operators must also have traceability systems or procedures to allow identification of the movements of those plants, plant products and other objects within and between their own premises. The information from these systems must be available to the competent authority on request.
 5. The electronic notification system, connected to a computerised information management system, facilitates information exchange. Regarding the pre-export

certificates (used for internal movement before export), the information may be exchanged between the Member States concerned through, or in electronic exchange with, a computerised information management system for official controls at Union level, unless the physical document accompanies the items.

6. Competent authorities are required to inform professional operators of contingency plans, and this includes informing all relevant professional operators through publication on the internet. Postal services and operators involved in distance contracts must also make information about import restrictions available to their clients at least through the internet. The Commission is to keep a publicly available, updated list of notifications concerning emerging pests in third countries, which may be part of the electronic system.

Regulation (EU) 2016/2031 is complemented and supported by the rules on official controls introduced by Regulation (EU) 2017/625³², which modernised phytosanitary import inspections and internal controls. Applied from 2019, it introduced **risk-based electronic controls** across the agrifood chain, and created an **Integrated Management System for Official Controls (IMSOC)**³³, to manage, handle and automatically exchange data, information and documents in relation to official controls. The IMSOC includes the four existing information systems managed by the Commission (Figure 5), namely:

- the rapid alert system for food and feed (**RASFF**) established by General Food law;
- the animal diseases information system (**ADIS**) to be established by the Animal Health Law;
- the system for notifying and reporting the presence of pests (**EUROPHYT**) established by the Plant Health Law; and
- the **TRACES** system (referred to in the Official Controls Regulation).

³² Regulation (EU) 2017/625 of the European Parliament and of the Council of 15 March 2017 on official controls and other official activities performed to ensure the application of food and feed law, rules on animal health and welfare, plant health and plant protection products, amending Regulations (EC) No 999/2001, (EC) No 396/2005, (EC) No 1069/2009, (EC) No 1107/2009, (EU) No 1151/2012, (EU) No 652/2014, (EU) 2016/429 and (EU) 2016/2031 of the European Parliament and of the Council, Council Regulations (EC) No 1/2005 and (EC) No 1099/2009 and Council Directives 98/58/EC, 1999/74/EC, 2007/43/EC, 2008/119/EC and 2008/120/EC, and repealing Regulations (EC) No 854/2004 and (EC) No 882/2004 of the European Parliament and of the Council, Council Directives 89/608/EEC, 89/662/EEC, 90/425/EEC, 91/496/EEC, 96/23/EC, 96/93/EC and 97/78/EC and Council Decision 92/438/EEC (Official Controls Regulation). OJ L 95, 7.4.2017, <http://data.europa.eu/eli/reg/2017/625/oj>

³³ Commission Implementing Regulation (EU) 2019/1715 of 30 September 2019 laying down rules for the functioning of the information management system for official controls and its system components (the IMSOC Regulation), C/2019/7005, OJ L 261, 14.10.2019, http://data.europa.eu/eli/reg_impl/2019/1715/oj

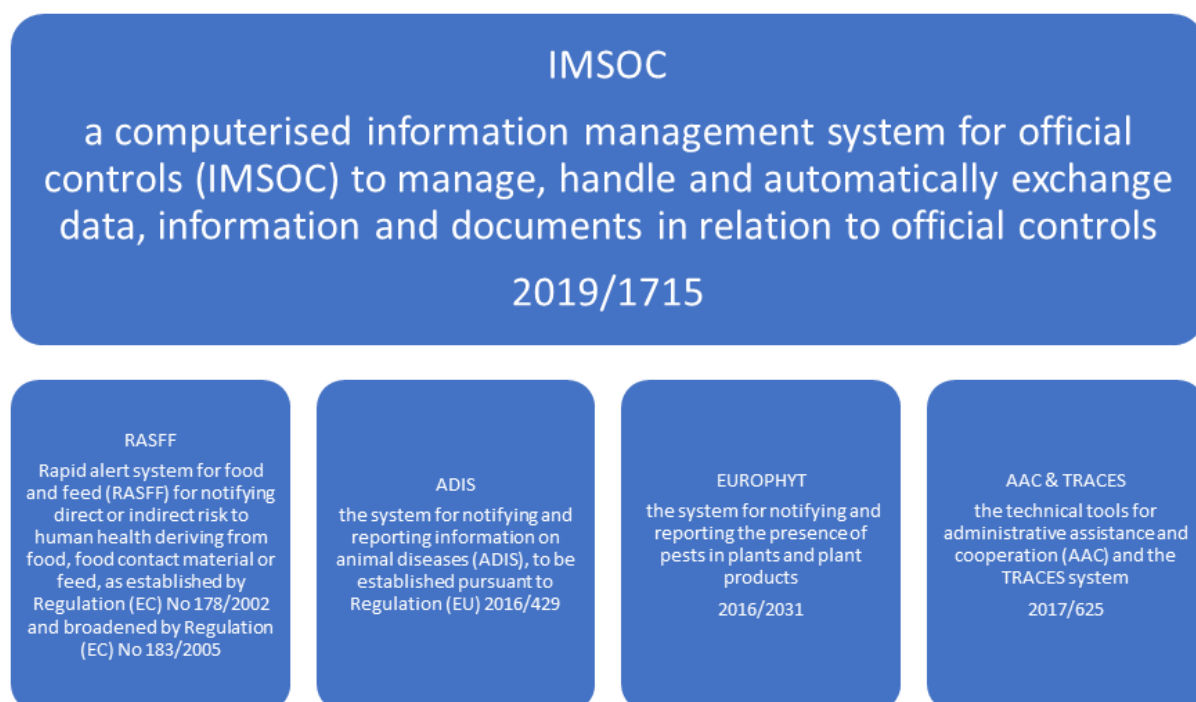


Figure 5: IMSOC information systems

Regarding plant health, IMSOC includes [EUROPHYT](#), the EU notification system for submitting EUROPHYT outbreak notifications, in accordance with Article 103 of Regulation (EU) 2016/2031 and [TRACES](#), the computerised system which digitises sanitary and phytosanitary certificates. Since 2019, TRACES has been linked with the IPPC ePhyto Hub, enabling seamless exchange of electronic phytosanitary certificates with trading partners. This digital shift speeds up border checks and helps prevent pest entry by reducing errors and delays in phytosanitary documentation.

The 2024 revision ([Regulation \(EU\) 2024/3115](#)³⁴ amending Regulation (EU) 2016/2031 and Regulation (EU) 2017/625), which entered into force on 5 January 2025, introduced the following additional elements to the EU plant health regime (EC, n.d.):

³⁴ Regulation (EU) 2024/3115 of the European Parliament and of the Council of 27 November 2024 amending Regulation (EU) 2016/2031 as regards multiannual survey programmes, notifications concerning the presence of regulated non-quarantine pests, temporary derogations from import prohibitions and special import requirements and establishment of procedures for granting them, temporary import requirements for high-risk plants, plant products and other objects, the establishment of procedures for the listing of high-risk plants, the content of phytosanitary certificates and the use of plant passports, and as regards certain reporting requirements for demarcated areas and surveys of pests and amending Regulation (EU) 2017/625 as regards certain notifications of non-compliance. PE/66/2024/REV/1, OJ L, 2024/3115, 16.12.2024, <http://data.europa.eu/eli/reg/2024/3115/oj>

- The creation of the Union's Plant Health Emergency Team, aiming at providing Member States, upon their request, with urgent assistance, technical scientific and managerial, in case of an outbreak of a union quarantine pest.
- The obligation for third countries to declare the measures they applied against regulated non-quarantine pests on the phytosanitary certificate in case of imported plant reproductive material.
- The establishment of procedures for third countries' requests for market access and for the Union's listing of plants as high risk.
- The facilitation of internal EU trade as regards different rules on internal movement of plants (attachment of plant passport, distance sales for consumers, digitalisation of post-import controls).
- The digitalisation of several reporting and notification obligations for EU Member States.

The amendments regarding digitalisation aim to promote harmonised, standardised, and digitalised procedures to streamline requirements and reduce administrative burden. The key new provisions regarding the digitalisation of reporting and notification obligations through EUROPHYT include:

- Member States must now notify the Commission and other Member States of demarcated areas immediately after their establishment, along with the pests concerned and measures taken. This replaces the previous annual reporting requirement for demarcated areas.
- The finding of a pest presence in the buffer zone of a demarcated area and the abolition of demarcated areas.
- Member States must now submit their annual reports on the results of surveys for Union quarantine pests, pests that provisionally qualify as Union quarantine pests (Articles 29 and 30), and priority pests (Articles 22(3) and 24(2)). This applies to surveys carried out in the preceding calendar year. Similarly, reports on surveys for protected zone quarantine pests (Article 34(2)) must also be submitted.
- Member States, upon request from the Commission, must notify their multiannual survey programmes.

- In the event that plants for planting are introduced into or moved within the Union territory in non-compliance with the rules on Union regulated non-quarantine pests (RNQPs) (Article 37(1)), Member States must notify that non-compliance and the measures taken to the Commission and other Member States. Notification must also be made to the third country of origin.
- Article 103 of Regulation (EU) 2016/2031, which established the electronic system for notifications, is amended to state that the system is for the submission of notifications *and reports* by the Member States. This formalises the use of the system for the various reporting obligations mentioned above and strengthens the process of digitalisation of phytosanitary measures. Article 104, concerning the rules for submitting notifications, is also updated to include the new notification types mandated for submission through the electronic system.

There are also provisions regarding plant health in the Common Agricultural Policy (CAP). The CAP aims to support the EU's agricultural sector while also addressing environmental concerns and promoting plant health. The provisions regarding plant health within the framework of the Common Agricultural Policy (CAP) Strategic Plans³⁵ are addressed through several integrated mechanisms. Primarily, plant health concerns are incorporated into the conditionality system, requiring farmers and other beneficiaries of CAP support to comply with basic standards, which include Statutory Management Requirements (SMRs) and standards of good agricultural and environmental conditions of land (GAEC standards). The aim is to make the CAP more compatible with societal expectations, including plant health objectives, and includes administrative penalties for non-compliance. Specifically, SMRs must fully implement the main Union legislation on plant health, such as obligations under Directive 2009/128/EC establishing a framework for the sustainable use of pesticides (including restrictions in protected areas, handling, and storage), and Regulation (EC) No 1107/2009 concerning the placing of plant protection products on the market.

Furthermore, plant health aspects are addressed through support for types of intervention in certain sectors, such as fruit and vegetables, hops, olive oil and table olives, and other sectors, where objectives include research into, and development of, sustainable production methods

³⁵ Regulation (EU) 2021/2115 of the European Parliament and of the Council of 2 December 2021 establishing rules on support for strategic plans to be drawn up by Member States under the common agricultural policy (CAP Strategic Plans) and financed by the European Agricultural Guarantee Fund (EAGF) and by the European Agricultural Fund for Rural Development (EAFRD) and repealing Regulations (EU) No 1305/2013 and (EU) No 1307/2013. OJ L 435, 6.12.2021, p. 1–186. <http://data.europa.eu/eli/reg/2021/2115/oj>

like pest resilience, and promoting pest and disease resilient production practices. Interventions can involve investments to improve resilience against pests and reduce pesticide risks, including the implementation of Integrated Pest Management techniques, as well as replanting necessitated by phytosanitary reasons, and harvest insurance covering losses due to pest infestations or diseases.

Lastly, farm advisory services must be established by Member States to advise farmers and other CAP beneficiaries. These services cover economic, environmental, and social dimensions and must deliver up-to-date technological and scientific information, including advice on sustainable pest and disease control techniques and sustainable use of plant protection and animal health products. Farm advisory services are required to cover the requirements laid down for implementing Regulation (EC) No 1107/2009, Directive 2009/128/EC, and Regulation (EU) 2016/2031 (protective measures against pests of plants) regarding plant health. Member States must set objectives in their CAP Strategic Plans, which include fostering sustainable development and efficient management of natural resources by reducing chemical dependency, taking into account relevant environmental and climate legislation, such as Directive 2009/128/EC on the sustainable use of pesticides.

Digitalisation is a cross-cutting objective of the CAP. Member States are encouraged to invest in technological development and digitalisation, improving the uptake and effective deployment of digital technologies. This includes supporting investments in the installation of digital technologies in agriculture, forestry, and rural areas, such as investments in precision farming, smart villages, rural businesses, and information and communications technology infrastructures. Furthermore, Member States must establish a strategy for the development of digital technologies and their use to boost digitalisation in agriculture and rural areas and improve the effectiveness and efficiency of CAP Strategic Plan interventions. Farm advisory services, which are integrated within the Agricultural Knowledge and Innovation Systems (AKIS), are intended to deliver up-to-date technological and scientific information and explicitly cover advice on digital technologies in agriculture and rural areas. While a specific digital *Farm Sustainability Tool* is mentioned for nutrient management, highlighting the role of digital applications, the regulation does not provide for a dedicated digital tool specifically for plant health or pest management.

3.1.4 National Policy Framework for Plant Health

Member States' competent authorities play a key role in the implementation of the EU plant health rules. They are responsible for a great array of activities such as surveys, notification of pest occurrences, eradication of outbreaks, contingency plans, simulation exercises, controls at import, registration of professional operators, authorisation of professional operators to issue plant passports and other attestations.

This chapter examines how France, Lithuania, Greece, Italy, and New Zealand are integrating digital technologies into their national plant health policies and systems. It discusses the legal, strategic, and operational measures these countries have adopted since 2019 to enhance the prevention, early detection, surveillance, and eradication of plant pests and diseases, with a particular focus on the use of remote sensing, sensor networks, data platforms, and artificial intelligence. The analysis highlights both government-led initiatives and collaborative efforts involving research institutions, industry stakeholders, and international partnerships. The aim is to showcase the evolving landscape of digital innovation in phytosanitary policy and its contribution to creating resilient, sustainable, and science-driven plant health systems.

3.1.4.1 France

Introduction

The French Use Case Pilot (UCP 1) in the Alsace region focuses on managing pests in **vineyards** (*Vitis vinifera*). The primary pest challenges targeted by STELLA in this region are **Grapevine Leafroll Disease (GLD)**, caused by no fewer than eight different viruses from Grapevine Leaf Roll associated Virus (GLRaVs), and **“Bois Noir” (BN)**, caused by *Candidatus Phytoplasma solani*. Both are classified as regulated non-quarantine pests (RNQPs). GLD significantly impacts grapevines globally, causing foliage discolouration, reducing photosynthesis and yield by 15% to 30%, and up to 60% in severe cases, while also diminishing vigour and impacting grape quality. BN causes direct crop losses due to the sterility of symptomatic branches and complicates disease management by masking other yellowing diseases, such as Flavescence Dorée (FD), which is a quarantine pest, leading to increased survey costs and the impact of FD. The Alsace region faces a growing prevalence of vine diseases, with an annual progression rate of 0.5% to 1%, partly attributed to climate change (Dujakovic et al., 2024). Conventional monitoring methods are often reactive, relying on periodic scouting and manual inspections, which result in delayed responses and limited surveillance coverage. Identifying GLD is particularly challenging due to symptom variation,

and the absence of integrated data management systems further hampers effective practices. Despite some stakeholder involvement in pest monitoring initiatives, notably for BN, which often coincides with monitoring for FD, a significant portion of respondents in a survey (75%) had never participated in GLD surveillance (Dujakovic et al., 2024).

The STELLA project aims to enhance pest management in the French UCP by leveraging digital technologies to enable early detection, provide comprehensive surveillance, and integrate data for improved decision support. The planned technologies include Drones, Satellites, Connected traps, EDEN Viewer, Weather stations, and Soil temperature sensors across six selected plots. Deployment of these sensors is already underway in the first year of the project. A survey conducted among stakeholders in the Alsace region indicated strong interest (86%) in participating in workshops to test and provide feedback on the STELLA platform. Perceived benefits of the STELLA platform include improved pest management, optimisation of pesticide use, and plant disease prevention. Stakeholders prioritise a user-friendly interface, integration with existing tools, and ease of learning. While many obstacles to adopting new technologies are considered easy to overcome, the financial cost stands out as a particularly difficult barrier. Stakeholders also value digital data on specific pest populations, meteorological data, and numerical data on disease intensity for decision-making, and expect the PSS to provide recommendations for appropriate control methods and procedures to follow. High engagement levels suggest a positive outlook, with a majority interested in following project progress (92%) and some willing to offer vineyards for testing (33%) (Dujakovic et al., 2024).

France's Plant Health Policy Framework

In France, priority is given to protection against the most important regulated organisms harmful to plants designated under Regulation (EU) 2016/2031 as regulated quarantine pests (RQP) or non-quarantine regulated pests (RNQP). France has supplemented the implementation of this regulation through national legislative and regulatory measures, primarily via the Rural and Maritime Fishing Code ([Code rural et de la pêche maritime](#)), especially Book II (Alimentation, santé publique, vétérinaire et protection des végétaux), Title V (La protection des végétaux), which concerns plant health. The French Ministry of Agriculture and Food Sovereignty (Ministère de l'Agriculture et de la Souveraineté Alimentaire) and its General Directorate for Food (DGAL) are responsible for enforcing these provisions and adapting national procedures to comply with Regulation (EU) 2016/2031. Over 200 plant pests are covered by official surveillance plans organised by individual sectors for the purpose

of detecting their appearance on national territory as early as possible. Where applicable, control measures will be required in the event of an outbreak (DGAL, 2023).

The [General Directorate for Food \(DGAL\)](#), in its capacity as government department responsible for the safeguarding of plant health, is the National Plant Protection Organisation (NPPO). Controls and official missions are placed under the responsibility of four competent authorities (MANCP, 2022):

- DGAL, the competent authority acting as “point of contact” for the European Commission for plant health.
- [SEMAE](#) is in charge, through its official control and certification service, of authorising operators to issue plant passports. The scope of its competence is seeds of agricultural and vegetable species, seed potatoes, and vegetable and strawberry planting material. It carries out this mission at the same time as the compulsory certification of these plants. SEMAE works with laboratories approved by the DGAL for quarantine pests and seed potatoes and with the national reference laboratory (GEVES) for non-quarantine regulated pests.
- [FranceAgriMer](#) for controls for the issuing of plant passports for vine propagating material (vine cuttings and plants). It carries out this mission at the same time as the compulsory certification of these plants imposed by Directive 68/193/EEC.

Dedicated regional sanitary bodies (FREDON) may be delegated tasks by the competent authorities based on organizational and operational factors specific to each region.

The epidemiological surveillance in France is directed by the DGAL, aiming to obtain information on the phytosanitary situation across the country with regard to non-regulated pests responsible for impacts that are major in terms of the quantities and quality of plant crops on national territory (i.e. Metropolitan France and its overseas territories). It involves some 4,000 observers providing the surveillance with weekly observations of over 15,000 designated plots. A network of 220 specialist observer correspondents also carries out this surveillance work for forests. Since the surveillance also involves certain regulated or emerging pests, it provides important underpinning for the DGAL’s official surveillance plans. This surveillance effort as a whole helps to determine the current status of the country with regard to regulated and emerging organisms, and additionally to define appropriate methods for combating pests and observing the unintentional effects of farming methods.

Where surveillance specifically targeting regulated pests is concerned, nearly 15,000 official inspections are performed (each of which may cover more than one plot) under more than 30 national surveillance plans (concerning for example the Asian longhorn beetles *Anoplophora chinensis* and *Anoplophora glabripennis*, the bacterium *Xylella fastidiosa*, the pine wood nematode *Bursaphelenchus xylophilus*, grapevine Flavescence Dorée phytoplasma, the *Bactrocera dorsalis* fruit fly, *Geosmithia morbida* fungus and its beetle vector *Pityophthorus juglandis*, in addition to the surveillance specifically targeted on French protected areas (in Brittany, Corsica and North-eastern France).

In the event of detection of a quarantine pest, government agencies are alerted and, once it has been officially confirmed, a notification is sent by the NPPO (i.e. DGAL) to the European Commission and the international authorities (EPPO, IPPC). Where a pest considered to be particularly dangerous is detected, mandatory control measures are ordered by the government in order to ensure its eradication or containment. Emergency plans are drawn up for the pests of most concern (cf. Part One, point 4-5). The application of mandatory measures to combat the pest is the responsibility of the owner of the plants and their execution will be subject to DGAL verification (MANCP, 2022).

France formalised a multi-partner approach to surveillance. In July 2018, it launched the [Plateforme d'Epidémiosurveillance en Santé Végétale \(ESV\)](#) (Plant Health Epidemiological Surveillance Platform). This is France's national platform for plant health epidemiological surveillance. It supports public policy and stakeholders involved in plant health monitoring by providing methodological and operational assistance to better understand, detect, and manage plant diseases. The platform centralises data, develops detection tools, informs the public, and facilitates communication among professionals, enabling informed decision-making.

ESV is a multi-partner initiative led by the General Directorate for Food (DGAL), INRAE, and Anses, in collaboration with ACTA, Chambre d'Agriculture France, FREDON France, and Cirad. It is part of a broader network that also includes platforms for animal health and food chain safety. INRAE contributes expertise in epidemiology, ecology, plant pathology, population biology, microbiology, data analysis, modelling, and information systems, promoting interdisciplinary collaboration and technology transfer among partners. The platform systematically collects and analyses data from official surveillance networks and other sources to monitor the health status of French territory, detect emerging diseases early, and develop tailored methods for diverse plant health challenges.

The ESV employs several digital tools to enhance plant health surveillance and data management:

- [EPPO \(European and Mediterranean Plant Protection Organisation\) codes](#) to standardise information on harmful organisms, host plants, and commodities. It retrieves names, taxonomy, and categorisation of organisms via the EPPO API, and uses the EPPO online Excel tool to access and analyse their geographic distribution. This facilitates the inclusion of up-to-date and harmonised data in official plant health surveys and reporting.
- Digital information systems that centralise surveillance data, allowing for efficient collection, storage, and analysis. These systems support the real-time monitoring of plant health and the generation of automated surveillance reports.
- Operates International Health Watch, partly based on computer procedures such as web scraping and text mining to collect and pre-sort information deemed relevant within a defined corpus of sources, to provide [international health monitoring bulletins](#) on disease outbreaks and emerging plant health threats
- Information mapping based on the static and dynamic visualisation of results. This allows the communication of monitoring results in a privileged way ([ToBRFV](#), [Pinewood nematode](#), [Xylella fastidiosa](#)) (Figure 6)

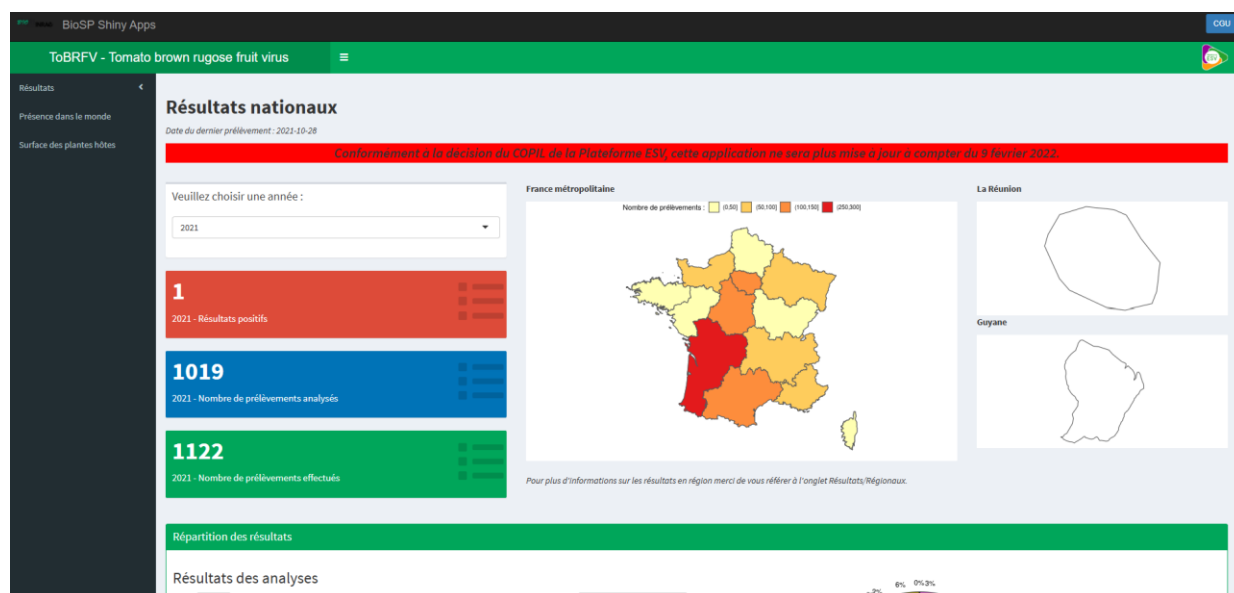


Figure 6: Representations in space and time achieved through information mapping for ToBRFV, (source: [ESV platform](#))

These digital tools collectively enable ESV to provide robust, real-time surveillance, facilitate data-driven decision-making, and support collaboration among plant health stakeholders in France and internationally.

In terms of national strategy, France does not have a standalone “digital plant health” policy document, but related strategies incorporate these themes. The [Ecophyto II+ Plan \(2018–2025\)](#), France’s pesticide reduction plan, emphasises the Integrated Pest Management (IPM) principles, which are central to the plan's strategy for reducing plant protection product use, risks, and impacts. It aims to reinforce and disseminate IPM by establishing a reference document on IPM, supporting farmers in adopting low-Plant Protection Products (PPP) systems that integrate practices like diversification, alternative weeding techniques, and bio-control solutions, and leveraging networks like [DEPHY FERME](#) as references.

The plan also emphasises the development and enhanced use of decision-making tools (DSTs) for farmers, recognising their potential to reduce PPP use and offer savings. This includes supporting investment in high-performance agro-equipment and tools, focusing on system-based DSTs and tools for adjusting doses. Key to this is improving the crop health newsletter to provide reliable monitoring information and enhancing its forecasting capabilities, including supporting the development and use of epidemiological models for bio-pest development forecasting. The [ÉcophytoPIC](#) integrated pest management portal serves as a digital tool for information sharing and supporting IPM implementation. Research priorities also include developing tools for farmers and advisors to optimise methods.

Another practical program under the [Ecophyto II+ Plan \(2018–2025\)](#) is the “[Bulletin de Santé du Végétal](#)” (BSV). The “Bulletins de santé du végétal” (Plant Health Bulletins) are official reports that provide an overview of crop health across France. Each bulletin presents:

- The current health status of crops, including development stages, pest and disease observations, and symptom presence.
- An assessment of phytosanitary risks based on crop sensitivity periods and pest or disease thresholds.
- Regulatory updates relevant to plant health.

The bulletins are compiled using mainly the dedicated national data-collection platform **Vigicultures®** plays a pivotal role in feeding these plant-health bulletins with high-quality surveillance data. Established under the authority of the French Ministry of Agriculture and co-managed with ACTA, Vigicultures® enables regional advisory networks (including agricultural

chambers, technical institutes, cooperatives) and participating farmers to record real-time phytosanitary observations via both web and mobile interfaces. Contributors' log captures of insect pests (trap counts), crop phenological stages, emergent or recurring disease outbreaks, and details of phytosanitary treatments applied. Once validated, each record is geolocated and aggregated into a harmonized national database, providing a detailed, up-to-date view of pest population dynamics and sanitary pressure at the departmental and regional levels.

The bulletins are also compiled using epidemiological modelling developed by technical institutes and research organisations (such as IFV or INRAE), as well as laboratory biological monitoring. These bulletins are freely available to all stakeholders on the websites of regional agricultural chambers and regional directorates for food, agriculture, and forestry (DRAAF). They are published for various crops and regions throughout France, supporting informed decision-making and sustainable crop protection practices.

France also boasts innovative pilot projects and tech initiatives led by research institutes. INRAE and partners have developed the [e-Phytia](#) portal and mobile apps, a suite of digital tools that “revolutionise plant health” by aiding diagnosis and public vigilance. The e-phytia hosts several plant health applications, allowing in particular:

- to identify the diseases and pests of various cultivated plants, to know their biology, and finally to choose relevant protection methods;
- to put into practice biological and/or alternative protection methods in full knowledge of the facts;
- to carry out epidemiological surveillance, or even to contribute to participatory sciences.

Launched over the past decade and continuously expanded, e-Phytia apps allow users (farmers, gardeners or even citizen scientists) to identify plant diseases or pests via smartphone by consulting symptom images and decision trees, and suggesting management solutions.

Furthermore, France's CAP Strategic Plan (PSN) addresses digitalisation in agriculture, although its primary focus isn't on large-scale digital infrastructure, which is handled by other national policies like the "Plan France Très Haut Débit" aiming to improve very high-speed broadband coverage in rural areas. Within the PSN, support for digitalisation is approached mainly through on-farm adoption and capacity building. Investments in agricultural holdings (Interventions 73.01 for Hexagone and 73.09 for Corsica) can finance digital tools like decision

support tools or precision equipment. The specific types of digital tools supported depend on regional calls for projects. The PSN also supports digitalisation through training, advice, and knowledge exchange (Intervention 78.01), which aims to enhance skills related to the digitalisation of agriculture. Furthermore, the PSN incorporates digital tools for administrative simplification, such as the mandatory use of online platforms like [Telepac](#) for aid declarations, photo-interpretation, and a dedicated application for sending geolocalised photos to interact with the administration, intended to support farmers' "right to error". These tools contribute to improving the efficiency of input use and the prevention/management of sanitary risks.

Regarding plant health and pest protection, the French PSN places a strong emphasis on reducing the use of synthetic plant protection products and associated risks. This aligns with national goals set by the "Plan Ecophyto II+". Key interventions supporting this objective include the Eco-regime (31.01), which incentivises practices like crop diversification (which can help control pests and diseases), vegetal cover in perennial crops (reducing herbicide use), and the maintenance of ecological infrastructures that foster biological control. The Eco-regime also supports farms certified in organic farming or High Environmental Value, modes of production recognised for significantly reducing or eliminating synthetic pesticides.

Agro-Environmental and Climate Measures (e.g., 70.06-70.25, 70.27, 70.32) provide targeted support for practices such as reducing phytosanitary products and nitrogen fertilisers, promoting biological control, and preserving habitats important for biodiversity and pollinators. Support for conversion to Organic Farming (70.01-70.04) is a major focus, aiming to double AB surfaces by 2027, primarily due to the prohibition of synthetic phytosanitary products. Investments (73.01, 73.09, 73.17) can finance equipment that reduces the need for phytosanitary inputs and supports agro-ecological practices.

Sectoral programs for fruits and vegetables, olives, and vitiviniculture include measures promoting sustainable practices, technical support, and research related to pest and disease management and input reduction, such as demonstrations for controlling the olive fly. The apicultural sector support (55.01-55.06) specifically includes actions for fighting bio-aggressors and diseases affecting bees. Some investments and Agro-Environmental and Climate Measures also target the prevention of sanitary risks in livestock and the development of integrated pest management. The connection between digitalisation and plant health is evident where investments support digital tools (decision support tools, precision agriculture) that enable more efficient input use, thus reducing pesticides and fertilisers, and help manage sanitary risks.

3.1.4.2 Greece

Introduction

The STELLA project includes two distinct Use Case Pilots (UCPs) in Greece, one focusing on agriculture and the other one on forestry. The Greek Use Case focusing on **olive orchards** (UCP 6) is centered in the Attica and Atalanti regions of Greece, targeting two significant diseases: i) Verticillium wilt caused by ***Verticillium dahliae***, and ii) olive knot disease caused by ***Pseudomonas savastanoi* pv. *savastanoi***. ***V. dahliae*** is described as one of the most devastating olive tree pathogens worldwide, causing significant economic losses through tree mortality, yield reduction, and negative impacts on olive oil quality. *P. savastanoi* pv. *savastanoi* causes tumorous galls and can spread rapidly, potentially infecting an entire orchard within a year. Both diseases are prevalent where olives are grown in Greece, but neither has ongoing official surveys, leading to a lack of monitored data, which complicates management.

Current detection methods for *V. dahliae* involve morphological identification, while *P. savastanoi* pv. *savastanoi* relies on symptoms, pathogenicity tests, and PCR. These methods are described as labor-intensive, time-consuming, and lacking specificity. The Mediterranean climate, characterised by hot, dry summers and mild, wet winters, significantly influences agricultural practices, including olive cultivation, and can contribute to rapid growth of insect populations and fungal infections, creating unique environmental challenges.

STELLA aims to significantly enhance pest management in this UCP by leveraging digital technologies to overcome the limitations of conventional methods. The UCP includes a 0.01-hectare experimental plot on the Agricultural University of Athens (AUA) campus, which will be artificially infected with *V. dahliae* to increase infestation levels and test both targeted diseases. Additionally, three larger commercial plots (1.2 ha, 2.2 ha, 1.1 ha) are situated in the Atalanti region, in collaboration with a local producer who has previously experienced high infection levels. Technologies currently deployed include drones, satellite imagery, EDEN Viewer, weather stations, and soil temperature sensors, among others.

Stakeholder surveys in this UCP revealed that while there are mixed views on the effectiveness of current monitoring methods, participants are strongly interested in testing the STELLA PSS platform. Perceived potential benefits include optimising pesticide use, reducing harvest losses, improving pest management, increasing quality, lowering costs, and enhancing environmental sustainability. Key obstacles to adoption include financial cost, technology reliability, and the average age of users, many of whom are unfamiliar with new

technologies. Users highly value meteorological data and data on specific pest populations for decision-making. They expect the PSS response system to provide recommendations for appropriate control methods and a step-by-step guide on what to do next. Precision data (per-tree basis, tailored recommendations) and forecasting are also highly valued. Ensuring profitability, ease of use, and demonstrating successful examples from other producers are seen as crucial for acceptance (Dujakovic et al., 2024).

The Greek Use Case Pilot (UCP 2), focusing on plane trees (*Platanus* spp.) on **Evia Island**, addresses the significant challenge posed by the dangerous fungus, *Ceratocystis platani*. This pathogen causes canker stain and is lethal to infected trees within 3-7 years. It spreads through various means, including water, wind, insects, and particularly via infected plant material and contaminated tools, making containment difficult. Once inside, it colonises the tree's vascular system. Cankers may not be visible on the dominant Greek plane tree species, *Platanus orientalis*, due to their rough and thick bark. The disease has caused an ecological disaster on Evia Island since 2017, killing hundreds of trees, including those of great aesthetic and historical value. It poses a threat to both natural forest ecosystems and trees in urban areas.

The Mediterranean climate of Evia, with hot, dry summers and mild, wet winters, influences the conditions affecting tree development and susceptibility. *Ceratocystis platani* is a Union quarantine pest (QP) with limited distribution within the EU (France, Italy and Greece), but with potential for further introduction and spread. The fungus is expected to be able to become established in all parts of the EU due to the widespread use of plane trees as ornamental plants. The pathogen can be detected visually from May to September (canopy symptoms) or year-round (canker stains), and identification should be confirmed in the field or in the laboratory using molecular methods (EFSA, 2021). *C. platani* undergoes annual surveys nationwide aimed at substantiating pest freedom or at delimiting infested areas. However, conventional methods like visual inspections and sampling are labour-intensive, time-consuming, costly, and difficult in remote forest areas where plane trees often grow, hindering timely detection and response. Eradication is impossible in areas where the disease has reached epidemic proportions, making prevention the only control method.

STELLA aims to improve the management of *C. platani* by focusing on tracking disease dispersal patterns to prevent further spread to new areas. The UCP involves **three pilot plots** situated along riverbanks, making them highly vulnerable to pathogen dispersal via water. Their proximity to two major villages, however, supports active community engagement

through citizen science initiatives. Continuous STELLA deployment is planned; however, due to the quarantine status, the pest-infected trees must be eradicated, which might require relocating the monitoring plots. STELLA technologies, such as IoT devices, will provide real-time monitoring of environmental conditions and pest activity, replacing labour-intensive traditional methods with automation for enhanced efficiency and accuracy. Drones and satellite imagery will be used for comprehensive spatial monitoring, addressing accessibility challenges in remote forest areas. Citizen science activities are intended to enhance surveillance through symptom reporting.

Stakeholder surveys, although with limited responses, indicated that perceived benefits of the PSS platform include improved pest management, enhanced environmental sustainability, and plant disease prevention. Valued data types for decision-making include meteorological data and data on specific pest populations. Stakeholders expect the PSS response system to provide recommendations for appropriate control methods, and believe that data, especially concerning quarantine organisms, should be incorporated into the national database and shared with authorities. They also highlighted the need for precise location and habitat information for accurate mapping. Overall, there is interest in following the project's progress and testing the platform (Dujakovic et al., 2024).

Greece's Plant Health Policy Framework

Greece's plant health policy framework has been updated in line with EU Plant health rules and is gradually incorporating digital technology, often through EU-funded programs and projects. Plant health control is carried out on imported, produced and traded plants, plant products and other objects in accordance with Regulation (EU) 2016/2031, Regulation (EU) 2017/625, Decree 37/10-6-2021 (A 94) and Regulation 12681/352685/16-12-2021 (B 5931), and aims to reduce the risk of introduction and spread of harmful pests in the country.

The Competent Authorities for phytosanitary control of the Country in accordance with the P.D. 37/10-6-2021 (A 94) and with the MD No. 12681/352685/16-12-2021 (B 5931) are the following:

- The Directorates of Agricultural Economy and Veterinary of the Regional Units,
- The Regional Centres for Plant Protection and Quality and Phytosanitary Control of the Ministry of Rural Development and Food,

- The Departments of Rural Development and Control of the Ministry of Rural Development and Food and
- The Directorates of Forestry, Forestry of the Ministry of Environment and Energy.

Phytosanitary control is carried out at the border phytosanitary control stations of the Country, at the approved control points for imported plants, plant products and other objects and at the premises of producers, exporters, packers for plants, plant products exported and moved to other Member States of the Union and within the Country (HMRDF, 2025).

The main legislative acts are the following:

[Presidential Decree 37/2021](#) (Government Gazette A' 94/10.06.2021): 'Additional measures for the implementation of Regulations (EU) 2017/625 on official inspections and other official activities carried out to ensure the enforcement of plant health rules and (EU) 2016/2031 on protective measures against organisms harmful to plants'. It details the organisation and conduct of official checks aimed at preventing the introduction and spread of plant pests and diseases. The decree designates responsible authorities within Greece, including the Ministry of Rural Development and Food and various regional services, and establishes requirements for a registry of businesses and individuals involved in plant-related activities. It also specifies the Benaki Phytopathological Institute (BPI) as the national reference laboratory and procedures for designating official laboratories, while outlining penalties for non-compliance with the regulations. The decree repeals previous national legislation to align with the EU framework.

[Ministerial Decision 12681/352685](#) (Government Gazette B' 5931/16.12. 2021): 'Specification of the division of responsibilities of the competent plant health control authorities, designation of official plant health officials and establishment of procedures for carrying out official plant health checks and other official activities under Regulation (EU) 2017/625 of the European Parliament and of the Council of 15 March 2017 (L 095 and corrigendum L 137), carried out to verify compliance with plant health legislation'.

[Ministerial Decision 5579/158054](#) (Government Gazette B' 3114/20.06.2022): 'Determination of fees for official controls and other official activities under Regulation (EU) 2017/625 of the European Parliament and of the Council of 15 March 2017 (L 095), carried out to verify compliance with plant health legislation'.

[Ministerial Decision 5560/146601](#) (Government Gazette B 3384/19.05. 2023): 'Specification of the division of responsibilities in the forest plant health control services, designation of the official officials of forest plant health services of the forest plant health control services and definition of procedures for carrying out official plant health checks and other official activities under Regulation (EU) 2017/625 of the European Parliament and of the Council of 15 March 2017 (L 095 and corrigendum L 137), carried out to verify compliance with plant health legislation'.

Under the new regime, Greece intensified surveys for EU “priority pests” (such as *Xylella fastidiosa* and Pinewood nematode) and updated its contingency plans accordingly. Greece has drawn up contingency plans for the following priority pests:

- *Anastrepha ludens*, *Bactrocera dorsalis*, *Bactrocera zonata* and *Rhagoletis pomonella*
- *Phyllosticta citricarpa*
- *Thaumatotibia leucotreta*
- *Candidatus Liberibacter* spp
- *Anthonomus eugenii*
- *Aromia bungii*
- *Xylella fastidiosa*

Regarding the Union Quarantine pest, *Ceratocystis platani*, which causes canker stain disease in plane trees (*Platanus* spp.) in Greece, specific measures are being implemented to limit and eradicate it. These measures are detailed in the Ministerial Decision [4757/123205](#) (Gazette B' 2842/27.04.23). The overall purpose is to prevent the spread, limit the presence, and eliminate this harmful pest.

Annual macroscopic phytosanitary surveys are conducted throughout Greece to detect the organism, with sampling for laboratory analysis as part of official survey programs. These surveys cover *Platanus* spp. plants and all batches of *Platanus* spp. plants intended for planting that are produced, moved, or imported within Greece. If the presence of the organism is confirmed in an area, delimited zones are established, consisting of a 100-meter "focal zone" around the detected location and a 1-kilometre "safety zone" surrounding the focal zone.

Local action plans are developed for these zones, outlining official measures, including preventive logging, roles of involved services, communication rules, protocols for examination, sampling, and testing, personnel training, intervention methods, and resource allocation. An intensive annual survey plan is applied in these delimited zones to monitor the spread and

assess the effectiveness of measures. If the organism is not detected for ten consecutive years, the delimited zones are no longer in effect, although the responsible forest service can extend measures if necessary.

Logging and pruning of plane trees require permission from the competent forest service. If the organism is found in plane trees on public or private forest land, immediate cutting and destruction (by burning, sanitary burial, or thermal treatment) of the affected trees and wood must occur under supervision. These actions are prioritised in residential areas, around infrastructure, and along roads. The transport of infected wood for thermal processing must be officially controlled using closed vehicles to prevent the dispersal of the disease. Approved plant protection products are used to kill healthy neighbouring trees and stumps within a radius of 15 meters, extendable up to 50 meters if deemed necessary.

Owners or landholders are responsible for interventions on private land, while the responsible local government (OTA) oversee trees within city plans or settlements, all under the supervision of the forest service. Batches of infected plants for planting must be immediately destroyed by burning, with the owner/holder responsible under official supervision. All logging residues from cut plane trees must be collected and destroyed by burning. Crucially, cutting tools and excavation machinery must be cleaned and disinfected with approved chemical substances before and after use, especially when working near plane trees or in areas with confirmed or suspected infection.

Movement of plane tree plants for planting, firewood, or wood from the focal and safety zones to areas outside these zones is prohibited. For construction projects or activities in areas with plane trees, a forest service inspection and opinion on the trees' health are required before environmental approval. If the organism is present, additional urgent measures like eradication and extensive disinfection are mandated. If a contractor fails to implement necessary preventive measures and the organism spreads, they face administrative penalties and are liable for future control costs. The cost of implementing measures due to violations typically falls on the owner or landholder. These administrative fines are imposed by the relevant Forest Directorate and deposited into the Green Fund. Funding for implementing local action plans and emergency measures comes from the budgets of involved services, operational programs, regional programs, and the Green Fund. This decision repeals a previous joint ministerial decision from 2004 concerning measures against *Ceratocystis fimbriata* f. sp. *platani*.

On the digital front, Greece has begun leveraging technology through both government initiatives and private sector innovation. The Benaki Phytopathological Institute has developed a [dashboard application](#) (Figure 7) designed to present survey results regarding the Union quarantine pest *Spodoptera frugiperda* for the year 2024 and onwards, specifically covering the period from March 1st onwards. The application displays trap locations on a map of Greece, indicating whether a trap is positive (red) or negative (green) for the insect, with weekly data updates. Users can filter data by regional unit or inspection dates, and the dashboard includes various charts and tables summarising the findings, such as the total number of insects captured per inspection date and a table of positive traps.

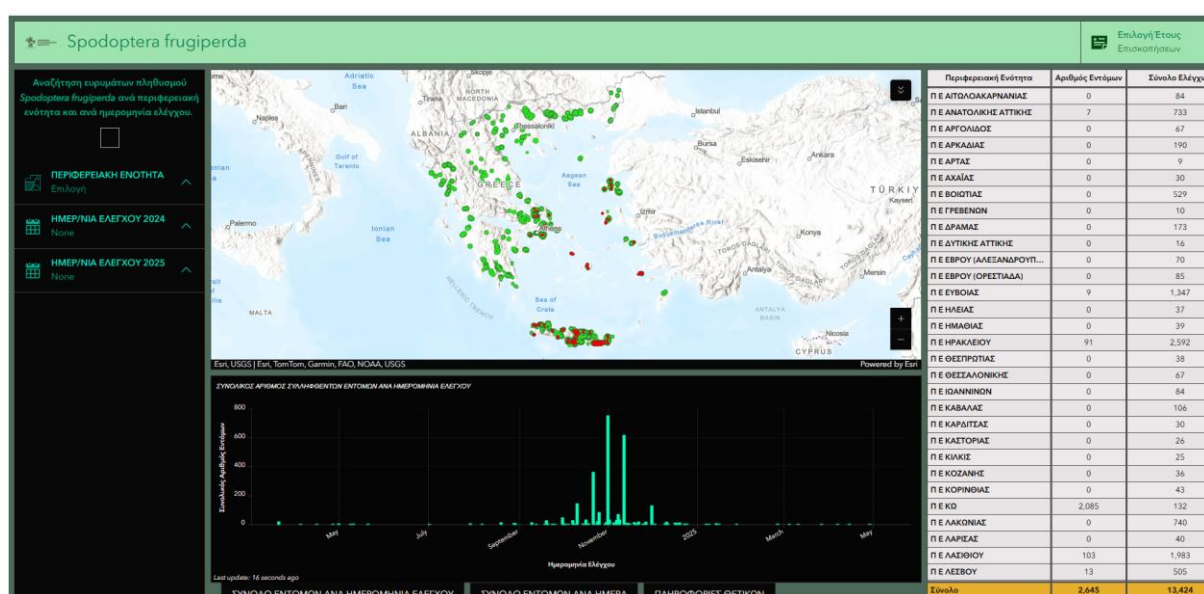


Figure 7: Population of *Spodoptera frugiperda* by regional unit and by control date, BPI.

The [Greek CAP Strategic Plan \(2023–2027\)](#) includes several interventions designed to support plant health, primarily by promoting sustainable practices and reducing reliance on chemical inputs and highlights “digital transformation” as a priority for agriculture. One key approach involves promoting sustainable techniques for combating pests and diseases. This is facilitated through various advisory services and technical assistance offered within sectoral programs for fruits, vegetables, and olive oil and table olives, as well as through general training and advisory services. These services cover topics such as the rational use of plant protection products, sustainable pest and disease control, and adaptation to climate change. A specific intervention (Π3-70-1.3) directly supports the application of alternative methods of plant protection with the aim of reducing pesticides. This includes measures like alternative weed control in rice fields (stale seedbed technique and use of weed-free certified seeds) and applying the mating disruption method ("ΚΟΜΦΟΥΖΙΟ") against insect pests in various crops.

The plan also supports the use of resistant and adapted species and varieties, including local ones, which are better suited to local conditions and pests, thereby reducing the need for plant protection products. Furthermore, the use of certified seeds for cereals (hard wheat, soft wheat, barley) is promoted as a prerequisite for receiving coupled support, ensuring seeds are phytosanitary checked and certified, which limits the use of plant protection products like fungicides. Support is also provided for protecting and preserving local plant genetic material threatened by genetic erosion.

Additional interventions support plant health through indirect or technological means. The Eco-scheme Π1-31.6 encourages producers to use a digital application for input management and monitoring environmental parameters. This application is intended to help optimise the use of inputs like plant protection products. Investments on farms (Π3-73.2.1) prioritise the use of advanced technology, including automation, digitalisation, and precision agriculture, which can improve the efficiency and targeting of plant protection applications. The plan supports investments in general agricultural farm improvements (Π3-73.2.1) which can include technological equipment for plant protection. Investments in sectoral programs (fruits, vegetables, olive oil, wine) also encompass material and intangible assets, research, and innovative methods, which can cover plant health technologies. Furthermore, the plan includes investments for protection against natural disasters and adverse climatic events (Π3-73.2.5), such as frost, hail, rain, floods, drought, and fires, which can damage plants and make them more susceptible to diseases. Practices that improve soil health, such as improved plant cover (Eco-scheme Π1-31.3) and maintaining organic farming methods (Eco-scheme Π1-31.9), contribute to overall resilient agriculture.

With EU Recovery and Resilience funding, Greece approved a [National Digital Agriculture project](#) in 2022, aiming to install a nationwide network of smart farming infrastructure. This includes hundreds of weather and soil stations and a central data platform to provide farmers with real-time advice on irrigation, fertilisation, and pest risks. The [gaiasense project](#) (funded by national funds and EU LIFE program), implemented a smart farming system on Greek farms that collects microclimate data and uses decision support software for pest management recommendations. By 2022, gaiasense and similar systems were advising wine, grape and olive growers on when and where to spray by analysing sensor data, thus improving targeted pest control and early warning of disease conducive conditions. The Bodossaki Foundation and American Farm School's "[Smart Farming Initiative](#)" (launched 2020) also introduced digital tools to small-scale farmers in various Greek regions, including smartphone apps for pest identification and direct communication with agronomists.

3.1.4.3 Italy

Introduction

The Italian Use Case Pilot (UCP 4) focuses on **tomato** (*Solanum lycopersicum*) processing in the **Emilia-Romagna region** of Italy, particularly near Parma and Piacenza. This region is a significant global producer of processing tomatoes. It has a humid subtropical climate with hot, humid summers (peaking sometimes above 38°C) and cool to mild winters (averaging -1/2°C lows), with rainfall concentrated in spring and autumn.

The primary pest challenge is ***Ralstonia solanacearum***, a bacterium that infects the plant's vascular system, causing wilting, yellowing, and ultimately, the plant's death. *Ralstonia solanacearum* is regulated as a Union quarantine pest in Annex II, Part B of [Commission Implementing Regulation \(EU\) 2019/2072](#) (pests known to occur in the Union territory). The general requirements for survey of the EU territory are laid down in [Regulation \(EU\) 2016/2031](#).

In addition to the general requirements, detailed measures to be taken within the EU against *R. solanacearum* are listed in [Council Directive 98/57/EC](#) (amended by [Commission Directive 2006/63/CE](#)) on the control of *R solanacearum*. These measures include the conduct of annual systematic official surveys for the organism. Member States should design a targeted survey plan based on a risk assessment for the pest. The Directive includes detailed protocols for detection and identification of the pathogen. It also requires the conduct of a survey of tomato (EFSA, 2019). In Italy infected fields must be destroyed according to regional law ([DPG/2021/9524](#)), and the bacterium's ability to persist in soil and plant debris makes control difficult.

Conventional pest monitoring for *R. solanacearum* involves inspections and sampling by designated experts and technicians between flowering and harvest, with preliminary laboratory tests and formal procedures triggered by confirmed symptoms. A simple diagnostic method involves observing a white, milky stream of bacteria from a freshly cut stem placed in water. These traditional methods are described as having high costs and requiring long periods for monitoring and identification, potentially delaying response and allowing the pest to spread.

The STELLA project aims to enhance pest management in this UCP by leveraging digital technologies. UCP plots are selected based on confirmed *R. solanacearum* cases identified

by the Regional Plant Protection Organization (RPPO), with satellite images acquired for affected areas. While proximal sensing is not applicable due to the nature of official inspections, remote sensing technologies, IoT devices, and crowdsourcing activities are considered potentially useful for obtaining large-scale data on disease epidemiology and spread after symptoms are confirmed. Technologies planned for use include satellites, EDEN viewer, weather stations, and soil temperature sensors.

This approach seeks to enable earlier detection and timely intervention by reducing the reporting period, thereby diminishing the potential spread of the pest. Stakeholders surveyed in this UCP identified potential benefits of the STELLA platform, such as improved crop protection management, enhanced environmental sustainability, and better plant disease control. They prioritised a user-friendly design, compatibility with mobile devices, and a customisable interface. Perceived obstacles to adopting new technologies include GDPR-related issues, financial costs, and concerns about technology reliability. Stakeholders highly value digital data like numerical disease intensity, meteorological data, and specific pest population data for decision-making, and see economic profitability and ease of use as key factors for the platform's acceptance. They expect the PSS to provide recommendations for appropriate control methods (Dujakovic et al., 2024).

Italy's Plant Health Policy Framework

Italy has significantly updated its plant health governance since 2019 and is pioneering the use of digital tools in response to high-profile pest threats. In Italy, the organisation of the National Plant Health Service and its areas of competence, in accordance with European plant health legislation, is defined by [Legislative Decree 2 February 2021, n. 19](#). 'Rules for the protection of plants from harmful organisms in implementation of art. 11 of Law 4 October 2019, n. 117, for the adaptation of national legislation to the provisions of Regulation (EU) 2016/2031 and Regulation (EU) 2017/625' (effective April 2022) which repealed the old plant protection law from 2005.

The Legislative Decree 2 February 2021, n.19, redesigns many organisational aspects, including the structures and competences of the Central and Regional Authority, the establishment of a central Secretariat unit for phytosanitary emergencies, the creation of a national information system, the rationalisation of entry points, as well as the definition of uniform control procedures at national level and the training and permanent updating of phytosanitary personnel. Particular importance is given to the scientific and diagnostic aspects with the establishment of the national reference institute, identified in CREA DC - Defense and

Certification, which is already a European reference laboratory (Faraglia et al., 2021). Specific mandatory control plans are the tools used to eradicate or contain quarantine pests. Italy's national legislation established the structure and functions of the National Phytosanitary Service (SFN), as the Italian NPPO, comprising a central service (SFC) and regional services (SFR), along with a National Reference Institute (Figure 8).



Figure 8: National Plant Health Service (source: [Servizio fitosanitario nazionale](http://www.serviziiofitosanitario.nazionale.it))

The decree outlines plant protection activities, including prediction, prevention, mitigation, and emergency management of harmful organisms, supported by national surveillance programs and emergency plans. It mandates the Official Register of Professional Operators and regulates the authorisation and use of plant passports for the movement of plants and plant products. It details official controls, including import checks at border control posts, export certifications, and controls throughout the production and distribution chain, supported by a network of official laboratories. Procedures for notifying of the discovery of harmful organisms and implementing urgent measures are specified. Enforcement mechanisms include administrative sanctions for various violations and mandatory fees for official controls and authorisations. A national fund is also established to finance plant protection activities.

All EU Member States are required (Articles 22, 23 and 24 of Regulation (EU) 2016/2031) to carry out an investigation on their territory and draw up a multi-annual investigation programme, which defines the relevant harmful organisms (Regulation (EU) 2019/2072) to be monitored over a period of 5-7 years on the basis of a risk assessment.

In Italy, surveillance activity is planned by drawing up a [National Investigation Program \(PNI\) of plant pests](#) in pest-free areas, pursuant to art. 27 of Legislative Decree no. 19 of 2 February 2021. The risk assessment takes into account the climatic-productive peculiarities of the different Italian regions, the host species present, and the specific diffusion paths of the pests, also linked to import and export activities. The surveillance activity is planned taking into account the investigation methodologies defined in the Investigation Sheets of harmful organisms, in compliance with what is planned in the PNI. By 30 April of the following year, the results of the investigation are processed, analysed and presented to the European Commission. It is carried out by technically and professionally qualified personnel of each regional phytosanitary service and by phytosanitary assistants operating in other structures or organisations other than the regional phytosanitary services (articles 18, 19 and 20 of the legislative decree of 2 February 2021 n. 19).

The strategies for each harmful organism at the different survey sites (nurseries, tree crops, herbaceous crops, hedges and groves, forests, public sites, warehouses for fruit or wood processing, etc.) take into account the protocols defined in the survey sheets and consist of visual observations, collection of symptomatic and asymptomatic plant samples, positioning of entomological traps and diagnostic activity at official laboratories for the identification of the organisms.

The Italian legislation on plant health includes provisions for the use of digital and electronic tools to support plant protection activities. A central element is the establishment of the Sistema Informativo per la Protezione delle Piante (SIPP) at the Central Phytosanitary Service. The SIPP is designed for the integrated processing, treatment, and automatic exchange of data, information, and documents related to plant protection activities, facilitating communication between the Central and Regional Phytosanitary Services and with the European Commission and other entities. It aims to integrate existing IT systems for rapid data exchange.

The SIPP has a section for official controls, part of the National Agricultural Information System, which enables the quick exchange of data concerning professional operators, plants during import and export, and official controls, and is structured to integrate with the European Commission's Information Management System for Official Controls (IMSOC). It also has a website section used for sharing data and information internally within the National Phytosanitary Service and making them available to professional operators and the public.

Furthermore, the regulation mandates the immediate communication of the discovery of harmful organisms by anyone, including professional operators, "anche con modalità di tipo telematico" (also electronically), to the competent authorities. [M.ORGANA](#) (Monitoraggio ORGANismi Novici in Agricoltura) is an application available to the National Phytosanitary Service for the collection and archiving of data in real time during land surveillance activities. The application allows users, both professionals and citizens, to send photos and information about new or harmful organisms directly to the National Phytosanitary Service. It was developed by CREA-Difesa e Certificazione at the request of the Central Phytosanitary Service of the Ministry of Agriculture (MIPAAF), specifically to support surveillance and monitoring activities across the national territory.

The Italian CAP Strategic Plan supports digitalisation both through infrastructural interventions and actions at the farm level, as well as through knowledge transfer and innovation. Support for digitalisation is included in interventions aimed at increasing the profitability and competitiveness of agricultural, agri-food, and forestry businesses. It is also seen as essential for improving the quality and accessibility of material and digital infrastructure networks serving these businesses. Digitalisation is considered a transversal objective, including promoting and sharing knowledge, innovation, and digitalisation in agriculture. The AKIS (Agricultural Knowledge and Innovation System) is a key part of this, supporting the introduction of new technologies and digitalisation to help businesses adopt more sustainable and innovative production techniques. AKIS interventions, including training and consultation, are expected to focus on sustainability and new digital technologies. Improvements in data usage, open data, interoperability of databases, and systematised collection of agricultural and environmental data are planned, using EU tools like Copernicus and FADN.

Regarding plant health and pest management, the Italian CSP supports investments in farm businesses (SRD01) that contribute to the digitalisation of agriculture (R.3), aiming to enhance

productivity and support more environmentally sustainable production. Precision agriculture techniques, which often rely on digital tools, are mentioned as being supported by investments. These techniques are linked to optimising input use and reducing environmental impact.

Advisory and technical assistance services (ADVI1) and training (TRAINCO) interventions, particularly within sectoral programs (such as potatoes, olive oil), include topics related to sustainable pest and disease control techniques and the sustainable use of plant protection products. AKIS interventions will also provide training and consultation on managing risks, including those related to plant health. Another important objective (E2.5) is strengthening agrometeorological services and developing monitoring and alert systems (early warning) for plant diseases and invasive species. This is partially supported by the CSP (via AKIS) and complemented by the Italian Recovery and Resilient Plan (PNRR) investments in Earth observation systems.

Eco-schemes and environmental, climate-related and other management commitments (ACA) are also planned to support digitalisation in plant health:

- The eco-scheme "Specific measures for pollinators" (PD04-ES5) involves commitments including the prohibition or limitation of the use of chemical herbicides and other plant protection products during flowering periods to protect pollinators. This contributes to the objective of reduced and sustainable use of pesticides. The control of this eco-scheme is ensured through the Integrated Management and Control System (SIGC), using satellite monitoring (Sentinel data) and field visits.
- The ACA 1 (Integrated Production) intervention promotes practices, including pest defence strategies, that reduce chemical inputs. Precision techniques are noted as relevant in this context. Adopting instrumental regulation of spraying machines is mentioned, which creates the premise for using precision techniques aimed at reducing the quantity of plant protection products used. Monitoring of phytosanitary issues is part of the commitments for integrated production.
- ACA 22 (Specific commitments for rice fields) involves prohibiting the use of fertilisers and herbicides in specific areas.
- ACA 24 promotes precision agriculture practices.

Sectoral interventions, specifically targeting areas like wine, fruit and vegetables, potatoes, olive oil, and bees, include support for investments in tangible and intangible assets, research, and innovative production methods, as well as services such as technical assistance and advisory services, training, and the exchange of good practices, particularly concerning sustainable pest and disease control techniques and the sustainable use of plant protection products.

3.1.4.4 Lithuania

Introduction

The Lithuanian Use Case Pilot (UCP 3) is focused on **potato crops** (*Solanum tuberosum*) in the **Vilkaviškis region** of Lithuania. This area is important for potato farming, with 500 ha cultivated annually, contributing significantly to the local community and economy. The main pest targeted is the **Potato leafroll virus (PLRV)**, which can cause up to a **50% yield loss** by under certain conditions reducing both the quality and quantity of the harvest. PLRV is transmitted by aphids, making effective control dependent on understanding their life cycles. Conventional methods for managing pests in Lithuania primarily involve general agricultural technical principles like crop rotation, seedbed preparation, the use of plant protection products and variety selection. For pests like the Colorado beetle, mechanical collection is used as well as the spreading of insecticides, but for aphids, which transmit PLRV, there are reportedly no alternative means of control besides insecticides, especially for seed crops. According to stakeholder surveys, the current pest monitoring methods in the region are considered "not satisfactory", and most respondents (75%) have not participated in monitoring initiatives. Notably, none of the surveyed individuals in this UCP have experience using digital tools in their fields (Dujakovic et al., 2024). The region experiences four distinct seasons, with cold winters and warm summers, and has soils of very good economic value, providing good conditions for vegetable growers.

STELLA aims to bring improvements by deploying digital technologies to enhance pest management. For the Lithuanian UCP, the plan involves using pest traps and satellite imaging across selected plots. The project has identified 10 plots for potential use, with initial deployment involving four pest traps and two meteorological stations that will be relocated after initial data collection. Based on stakeholder feedback, the potential benefits of the

STELLA platform include reducing yield losses, improving pest control and potato quality, optimising the use of plant protection products, and preventing plant diseases. Stakeholders are particularly interested in features like compatibility with other tools, ease of use, and adaptability to their specific needs. They highly value data on specific pest populations and meteorological data for decision-making and expect the PSS response system to provide recommendations for appropriate control methods and consistent steps on what to do next. However, challenges to adoption include a perceived lack of technical skills, concerns about technology reliability and financial cost, and fears regarding smartphone limitations like GPS accuracy and reliability of results. Despite limited prior experience with digital tools, there is clear interest in testing the STELLA platform and addressing pest issues, with a strong desire for precise data and customised recommendations (Dujakovic et al., 2024).

Lithuania's Plant Health Policy Framework

The primary Lithuanian legislation on plant health is the [Phytosanitary Law of the Republic of Lithuania](#) Nr. VIII-1481, 1999 amended by Law Nr. XI-653 in 2010, aiming to establish measures to prevent the import and spread of organisms harmful to plants and plant products into the territories of the Republic of Lithuania and the European Union. The law regulates mandatory phytosanitary requirements and the basis for phytosanitary control for individuals and legal entities engaged in growing, propagating, importing, exporting, transporting (within Lithuania/EU and in transit), storing, buying, and selling plants, plant products, and other objects. It implements relevant European Union legal acts and defines key concepts such as plants, plant products, harmful organisms, and phytosanitary measures.

The State Plant Service under the Ministry of Agriculture (SPS) is tasked with state control over the phytosanitary status of these objects, including officially identifying and evaluating harmful organisms, establishing eradication measures, and enforcing requirements. The law also outlines the requirement for registration in the Phytosanitary Register for many entities involved in these activities, specifies procedures for phytosanitary control of goods being imported, exported, or transported in transit, mandates inspections by SPS officials at border control points, details the decisions SPS officials can make based on inspection results (such as allowing entry, detaining, disinfecting, destroying, or returning shipments), addresses international cooperation, and the recognition of phytosanitary measures from third countries. Expenses related to phytosanitary control activities are covered by the importer, exporter, carrier, or their representatives.

In 2020, the Lithuanian Republic Minister of Agriculture Decision "[Order of the Minister of Agriculture of the Republic of Lithuania No. 3D-564 "On approval of the description of the procedure for phytosanitary inspection of plants, plant products, and other objects, phytosanitary monitoring and application of phytosanitary measures"](#)" demonstrates compliance with Regulation (EU) 2016/2031 on protective measures against plant pests and Regulation (EU) 2017/625 on official controls and other official activities. It also considers the Lithuanian Republic Phytosanitary Law and International Standards for Phytosanitary Measures.

Its main provisions focus on phytosanitary inspection and phytosanitary surveillance, activities carried out by the State Plant Service (SPS). Phytosanitary surveillance (PhS) is defined as an official procedure performed periodically to detect specific pests, determine pest populations or characteristics, or assess which pest species are present in Lithuania or specific locations. Surveillance and inspections are conducted for plants, plant products, and other objects at various stages, including planting, production, import, transport, export, storage, packaging, dispatch, processing, and marketing. These activities take place at various locations, including agricultural, forest, water, conservation, and other land plots, marketplaces, trade buildings, quarantine points, storage facilities, ports, airports, border control points, and other locations where plants or plant products are kept or produced. Inspections and surveillance involve physical, identity, and/or documentary checks, including physical checks of operational sites, transport, equipment, and packaging. Checks on the registration of professional operators in the Lithuanian Phytosanitary Register are also performed.

A crucial part of surveillance and monitoring involves sampling for laboratory testing if there is suspicion that plants or products may be infected with specific pests. These targeted pests include Union quarantine pests, Lithuanian Republic protected zone quarantine pests, pests not currently on the Union list but potentially Quarantine Pests, and Union Regulated Non-Quarantine pests. Sampling and testing are conducted according to EU law and SPS-approved methodologies. If suspicion arises, movement or marketing from the potentially infected zone is prohibited until official laboratory results are obtained.

Phytosanitary surveillance can also be performed for other pests to determine their presence in Lithuania. Based on the results of inspections and surveillance, the SPS is responsible for collecting, storing, and systemising information, analysing and summarising results, assessing the risk and extent of pest spread, preparing reports for EU and national institutions, planning

future inspections, and informing the public annually about the results. The SPS can also establish pest-free areas and demarcation zones based on pest spread and risk assessment. Furthermore, if a pest is confirmed, particularly a priority pest, the SPS approves an action plan that includes a surveillance model and procedure to monitor the situation. Post-eradication, surveillance continues for a specified period to ensure the pest has not re-infested the area. Professional operators are also required to take measures to prevent pest spread and comply with SPS's instructions, which may include actions related to monitoring or managing the affected area.

The [Order of the Minister of Agriculture of the Republic of Lithuania regarding the approval of contingency plan for preventing the spread of priority pests in the Republic of Lithuania, 3D-576/2022](#) primarily outlines the steps taken to manage the spread of priority pests once they are confirmed through laboratory testing following phytosanitary inspections and surveillance.

While the plan's actions are largely reactive to a confirmed detection, several provisions contribute to the broader goal of preventing widespread infestation. The State Plant Service conducts phytosanitary inspections and/or surveillance. These activities serve as the initial detection mechanism to identify potential issues before they become widespread. During inspections and surveillance, samples are taken for laboratory testing, based on the potential phytosanitary risk posed by priority pests. The SPS's Phytosanitary Research Laboratory conducts laboratory tests. Confirmation of a priority pest through these tests triggers the subsequent actions outlined in the plan.

The plan establishes a risk level for priority pests. If a pest's risk level is assessed as medium or high, a specific contingency plan is prepared for that pest. If the risk is low, a specific plan is not prepared. This allows for targeted preparedness based on potential threats. Once a priority pest is confirmed in a plant, plant product, or other object, the SPS instructs professional operators to apply phytosanitary measures. The purpose of these measures is specifically to limit the spread of the priority pest and destroy the outbreak. The SPS organises necessary public procurement for goods, services, or works required to destroy the priority pest further and stop its spread. This ensures resources are available for eradication efforts.

Following detection, the SPS conducts repeated phytosanitary inspections and surveillance in the priority pest outbreak area and designated buffer zones. This is crucial for monitoring the effectiveness of control measures and detecting any further spread. If infested plants, products, or objects are found outside the initial outbreak area or buffer zone during repeated

checks, the boundaries of the outbreak and buffer zones are expanded. This action is taken to contain the pest within a larger defined area, preventing unchecked expansion. When the State Plant Service confirms that a plant, plant product, or other object is infested with a priority pest, it is required to inform European Union member states and the European Commission. This reporting is conducted in accordance with the procedure established in Commission Implementing Regulation 2019/1715, through the information management system for official controls and its components (IMSOC Regulation).

Aside from this specific reference to the IMSOC regulation for international reporting, the plan does not mention the use of digital or electronic tools for other activities described, such as conducting inspections, surveillance, laboratory testing, applying phytosanitary measures, organising procurement, or coordinating with other national institutions. Regarding border controls, Lithuania uses the EU's TRACES system. In 2020, Lithuania connected to the ePhyto Hub via TRACES, enabling fully electronic phytosanitary certificates for imports and exports (reducing paperwork and speeding up quarantine checks). Another informational and service portal for Lithuania's State Plant Service, is the [VATIS system](#), operated under the Ministry of Agriculture. The VATIS system allows users to submit queries, search for information by name, and access descriptions of services provided by the State Plant Service. It is designed to facilitate access to plant-related regulatory and service information for individuals and organisations involved in agriculture and plant health in Lithuania.

Lithuania's CAP Strategic Plan also includes some interventions aimed at promoting digitalisation in agriculture, specifically focusing on plant health and pest protection. It supports Digital Innovation Hubs, such as "AgriFood Lithuania DIH" and "Agro Space DIH", which are integral in supporting the adoption of new digital technologies in agriculture. They offer infrastructure and expertise to help farmers implement modern technologies for better farm management and pest control. The plan also encourages the use of integrated pest management practices, promoting the use of biological plant protection methods such as pheromones, pheromone traps, and beneficial insects to reduce reliance on chemical pesticides. Financial support is available for the adoption of innovative technologies in the fruit and vegetable sector. This includes investments in new plant protection equipment and technologies aimed at reducing the environmental impact and improving pest management. Finally, the plan mentions the creation of a digital platform for agricultural knowledge and innovation ([ŽŪŽIS](#)), which will help farmers access consultations, training, and digital tools for better pest control and plant health management .

3.1.4.5 New Zealand

Introduction

The New Zealand Use Case Pilot (UCP 5) in the STELLA project focuses on **apple orchards in the Hawkes Bay region**, led by Lincoln Agritech. The primary challenge targeted in this UCP is **Bull's eye rot disease**, caused by the fungus *Neofabraea alba*, which is a significant postharvest issue for the apple export industry. While the infection occurs in the orchard, symptoms often appear late, during cool storage or after the fruit reaches importing markets, posing risks to export quality and value. Hawkes Bay is New Zealand's largest apple-growing region, characterised by a climate favourable for apple cultivation, including high sunshine hours, moderate temperatures, and fertile soils. However, the intensive growing systems in the region face challenges related to orchard hygiene, which is crucial for managing the spread of *N. alba*, primarily dispersed by splashing water containing spores. The region has also been impacted by weather extremes, such as Cyclone Gabriel in 2023.

Current conventional pest monitoring in NZ struggles with predicting where latent infections of *N. alba* might be high, and existing lab methods and models are not always spatially explicit or require substantial input for calibration. STELLA's approach aims to complement these efforts by developing models and digital solutions to create 'risk hot spots' or 'risk maps' for detecting and managing disease risks. UCP 5 will utilise technologies such as UAV/RPAS, Satellites, EDEN Viewer, Spore Samplers, Weather stations, and Raman Spectroscopy. This UCP is working closely with key industry bodies like [New Zealand Apple and Pears Inc \(NZAPI\)](#) and research organisations like Plant and Food Research (PFR), integrating with existing R&D programs such as [NZAPI's 'Smart & Sustainable' project](#). Site selection involves a minimum of three plots on commercial farms, chosen in diverse zones to investigate pest presence and outbreak levels, with access managed under strict health and safety protocols. The goal is for STELLA to enhance the tools available to the NZ apple industry for improved disease management.

New Zealand's plant health policy framework

New Zealand is a key associated country to the EU in the context of global plant health and has a world-renowned biosecurity system that increasingly leverages digital technologies. Plant health in New Zealand falls under the broader biosecurity system, which prevents or manages risks from harmful organisms, like pests and diseases, led by the [Ministry for Primary Industries \(MPI\)](#). MPI is New Zealand's National Plant Protection Organisation (NPPO) and

serves as the lead for agriculture, biosecurity, forestry, fisheries, and food safety in New Zealand. In its role as the NPPO, MPI develops policy, regulates, and manages imports and exports, as well as the surveillance and control programmes for pests of national importance. MPI provides inspectors at the border who manage risks from people, planes, vessels and goods coming into the country and maintains a system for rapidly responding to detections of new, harmful pests and diseases. Other groups that play a role in NZ's biosecurity system are other government departments when needed, regional councils, industry organisations, iwi³⁶ or community groups, landowners, and occupiers who have a responsibility to manage pests on their properties.

The principal legislation is the [Biosecurity Act 1993](#), which provides the legal basis for keeping out and managing pests and diseases. This Act establishes New Zealand's biosecurity system, covering pre-border risk management and standard setting, border management, readiness and response and long-term pest management. It remains in force (with amendments) and has been hailed as a world-leading model. The Minister of Biosecurity announced an overhaul of the Act in July 2019, but it has not yet amended the Biosecurity Act 1993. The most recent developments include a public consultation on proposed amendments, which closed on December 13, 2024, and the subsequent release of a [summary of submissions](#) in March 2025.

In 2016, New Zealand launched a forward-looking strategy, "[Biosecurity 2025 Direction Statement](#)", a partnership between people, organisations, Māori, and central, local and regional government, to make NZ's biosecurity system more resilient and future-focused. The Biosecurity 2025 Direction Statement is a high-level roadmap updating the 2003 Biosecurity Strategy, designed to strengthen New Zealand's biosecurity system through to 2025 and beyond. It acknowledges that the system faces increasing pressures and that biosecurity is fundamental to the nation's primary sector, tourism, environment, and way of life, emphasising that everyone in New Zealand has a role to play and benefits from it. The statement outlines five key strategic directions developed through wide participation (MPI, 2016):

- a biosecurity team of 4.7 million,
- a toolbox for tomorrow,
- smart, free-flowing information,

³⁶ *Iwi* are the largest social units in New Zealand [Māori society](#). In [Māori](#), *iwi* roughly means 'people' or 'nation', and is often translated as "[tribe](#)". *Iwi* groups trace their ancestry to the original [Polynesian](#) migrants who, according to tradition, arrived from [Hawaiki](#). In modern-day New Zealand, *iwi* can exercise significant [political power](#) in the management of land and other assets. ([wikipedia](#)).

- effective leadership and governance, and
- Tomorrow's skills and assets.

These directions aim to drive necessary change, reinforce successful aspects, and prepare the system to leverage opportunities and manage threats through a collaborative effort involving central and regional government. Ultimately, the statement guides efforts to protect New Zealand's environmental, economic, cultural, and social values from the risks posed by pests and diseases.

The Biosecurity 2025 emphasises the critical role of advanced tools, information, and digital technologies in strengthening New Zealand's biosecurity system. This is reflected in two of its five key strategic directions: "A toolbox for tomorrow" and "Smart, free-flowing information". The goal is to harness science and technology to transform the way biosecurity is conducted, accelerating innovation for smarter, better, and more efficient detection and management of risks. This includes improving existing tools with new technologies, developing breakthrough solutions for challenges like predator control, and ensuring everyone working in biosecurity has smart biological and digital tools readily available. There is also a target to halve the cost of managing significant established pests through innovative science and new tools. Initial actions include prioritising system-wide biosecurity science needs and upgrading a Biosecurity Toolbox platform for sharing information on pest management tools (MPI, 2016).

Information is identified as a critical biosecurity system asset, with a focus on tapping into data, building intelligence, and using powerful data analysis to support risk management. The aim is for the right information to be rapidly available to everyone across the system. This involves coordinating data collection, facilitating sharing through common standards, and using analytics to transform data into useful information and intelligence for risk assessment and resource allocation. Making effective use of emerging information technologies and their transformational aspects is also a key goal. Specific outcomes include identifying system-wide information needs, establishing national data standards and procedures for sharing organism information, creating a publicly-accessible network for organism data, and providing automated, targeted alerts about emerging risks. Digital tools like the [CatchIT online platform](#) for data management and analysis for community pest control agents, demonstrate how data management and analysis can engage participants and support pest control efforts (Figure 9), (MPI, 2016).

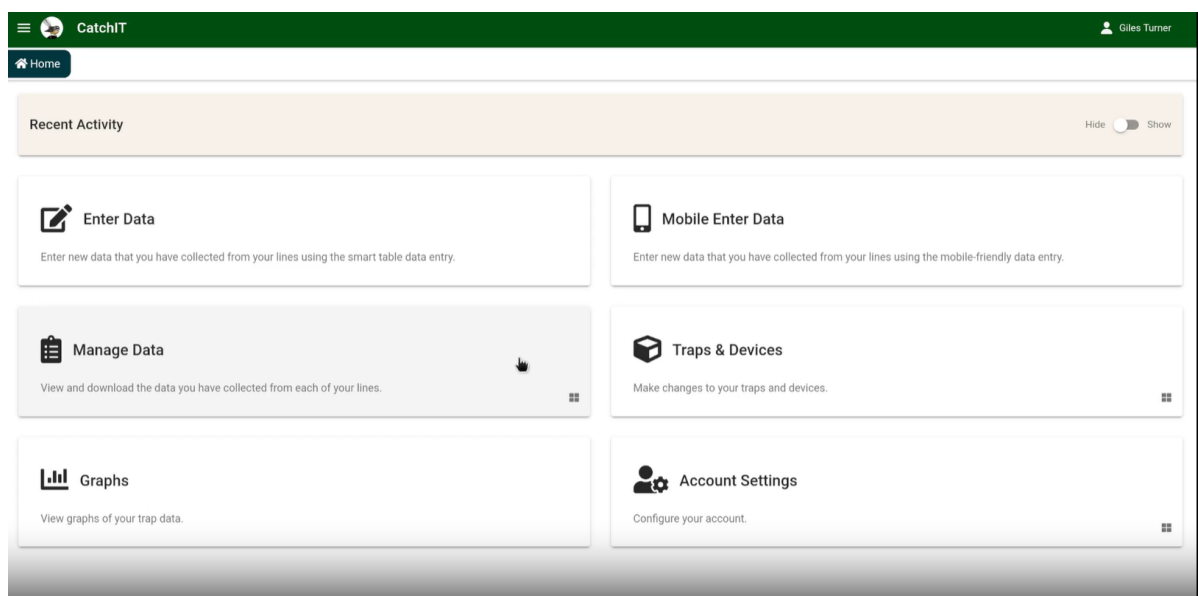


Figure 9: CatchIT is data-management software for conservation projects in New Zealand, coordinated by University of Auckland, (<https://catchit.co.nz/catchit/#/login>)

Under this strategy, MPI and partners have pursued a range of digital innovations. New Zealand has been a pioneer in engaging the public (citizen science) with technology for early detection. The flagship tool is the [“Find-A-Pest” mobile app](#), introduced around 2018 and continually expanded. This free app allows anyone to report suspected pests or diseases with geo-tagged photos (Figure 10). It includes AI-assisted identification and connects users to experts who verify reports. Find-A-Pest has proven invaluable in recent incursions, helping detect the spread of fall armyworm and invasive gold clams early, which improved response outcomes. It is a collaborative project based at the University of Canterbury between DOC, MPI, Regional Councils, Te Tira Whakamataki and primary industry groups including NZ Wine, KVH, NZ Forest Owners Association, Summerfruit NZ, Horticulture NZ, and Apples & Pears NZ. The app forms part of New Zealand’s broader biosecurity social network, turning citizens, farmers, and tourists into the “eyes” for unwanted organisms. In parallel, NZ has a strong presence on [iNaturalistNZ](#), an online social network of people sharing biodiversity information to help each other learn about nature, integrating that citizen science platform data into biosecurity monitoring.

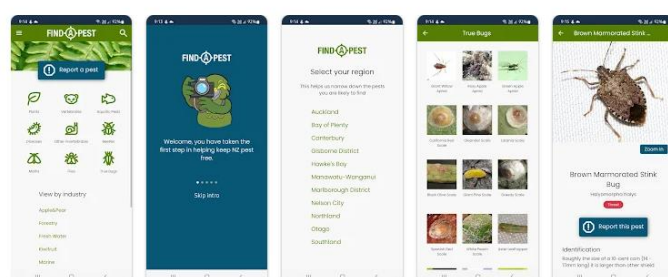
Find-A-Pest

Find-A-Pest

1K+ Downloads PEGI 3

Share Add to wishlist

This app is not available for any of your devices



App support

Similar apps



Figure 10: Find-A-Pest application on Google Play.

All surveillance and detection data feed into MPI's central biosecurity databases. MPI has built a [Plant Pest Information Network](#), a national database for the collection, management, and dissemination of plant pest surveillance information. This supports modelling the spread of an incursion under different scenarios to prioritise actions. New Zealand has also developed a powerful tool for horizon scanning, the [Biosecurity Organisms register for imported commodities \(BORIC\)](#), a searchable database of pests and pathogens relevant to New Zealand, and includes general information about each pest, as well as specific details for researchers, importers, exporters and the general public. While not “digital tech for detection” per se, it's a data-driven policy tool that guides where surveillance should focus.

Another significant partnership is the [Government-Industry Agreement \(GIA\)](#) on biosecurity, established mid-2010s, which formalises partnerships with industry groups for pest readiness and response. Under GIA, Signatories share the decision-making, responsibilities and costs of preparing for – and responding to – biosecurity incursions. By working in partnership, industry and government can achieve better biosecurity outcomes. This agreement has urged industry investment in digital solutions tailored to specific sectors. For example, a new biosecurity initiative started in New Zealand involving a six-month trial of an online traceability programme called Onside Intelligence. This initiative is a collaboration between Biosecurity New Zealand, several primary industry sector groups (including Kiwifruit Vine Health, New Zealand Winegrowers, NZ Pork, Aquaculture New Zealand, New Zealand Avocado, and New Zealand Apples and Pears), and the agri-tech company Onside. The goal of the trial is to

assess whether the Onside Intelligence platform can make it easier and faster to detect and respond to pest and disease outbreaks. The programme offers tools for data collection, traceability, privacy, and user support, aiming to enhance biosecurity readiness and response across New Zealand's primary industries. The trial will evaluate the effectiveness of the Onside platform, with the potential for long-term adoption if successful. The kiwifruit industry (KVH) recently partnered with Onside to implement technology that will power its Plant Pathway Plan, a programme designed to protect the \$4 billion kiwifruit sector from incursions.

In practice, New Zealand's plant health and biosecurity system demonstrates strong compliance with international frameworks, leveraging digital technology and innovative approaches.

3.1.5 Digital Tools in Plant Health Management and Policy: A Review of Peer-Reviewed Literature

3.1.5.1 Geographical Scope

The research covered policies and governance frameworks related to plant health from an EU-level perspective and also included a specific examination of New Zealand's biosecurity system, which involves aspects of technology governance (Grant et al., 2019). While other mentioned countries (France, Lithuania, Greece, Italy) appear in the sources, they are generally discussed within the context of EU regulations, pest prevalence, or stakeholder participation rather than focusing specifically on their national digital technology policies or governance frameworks for plant health.

France, Lithuania, Greece and Italy are mentioned in various contexts, such as locations for pest outbreaks such as *Xylella fastidiosa* in Italy, Greece, France (Michi et al., 2023; Ferilli et al., 2019), Asian Longhorn Beetle in Italy, France, Germany (Michi et al., 2023; Green et al., 2023), countries participating in stakeholder surveys (Green et al., 2023), having low plant health awareness (Lithuania, Belgium, Romania), (Michi et al., 2023), having high numbers of vegetable plots (Belgium, The Netherlands, Lithuania, Estonia, Poland, Czech Republic, Slovakia, Germany) (Michi et al., 2023), or being identified as high-risk regions for pest introductions (Italy, Portugal, southern Spain, Netherlands, Germany, Greece), (Rosace, et al., 2025).

Italy is also specifically examined in a study on the socio-economic impacts of EU climate-driven agricultural regulations (including those related to pests and diseases) on vineyard farmers in Northern Italy (Fishman, K. N., 2024). While these countries are part of the broader European picture or are locations for specific pest studies or stakeholder input, the sources do not present a concentrated focus on their *national* policies or governance structures *specifically* concerning digital technology use in plant health, distinct from or in addition to the overarching EU framework.

3.1.5.2 Digital Technologies Examined

The studies examined and discussed a diverse range of digital technologies relevant to plant health, biosecurity, and related areas such as forest protection and tackling the trade in illegal pesticides. These technologies are explored for detecting, monitoring, managing, and communicating about plant pests and diseases, as well as for related activities like trade control and policy analysis within different governance contexts, particularly at the EU level and in New Zealand.

For monitoring and detection, electronic traps or e-traps are explored as tools to integrate with traditional methods, offering real-time data on insect pest captures through digital cameras and recognition systems that count target pests and can record environmental data like temperature and humidity (Ascolese et al., 2022). While promising, these require further development to address dysfunctions and data transmission issues.

Beyond traps, various sensors are discussed for monitoring environmental parameters crucial for pest and disease development, such as temperature and humidity. Low-cost IoT sensor meshes powered by solar energy and using LoRaWAN technology can enable real-time remote measurement in large areas like orchards (Varandas et al., 2020). Electronic nose (e-nose) sensors are highlighted for their ability to detect plant diseases and pests through analysing emitted volatile organic compounds (VOCs), representing an indirect, non-invasive method with advancements in sensing, data analysis, real-time monitoring, and portability, though challenges remain in open field use and data interpretation (Buja, et al., 2021; Fundurulic, et al., 2023). Other advanced diagnostic tools include biosensors and microfluidic-based devices (Lab-on-a-Chip) capable of rapid, sensitive, and specific detection of pathogens, sometimes directly on-field or with smartphone connectivity (Buja, et al., 2021).

Wearable plant sensors are also being explored for real-time monitoring of plant physiological responses (Buja, et al., 2021). Broad-area surveillance is enhanced by remote sensing technologies, utilising data from satellites, aircraft, and unmanned aerial vehicles (UAVs or drones) to capture optical canopy measurements, spectral signatures, or thermal imagery that can indicate plant stress or pest presence (Michi et al., 2023; Trigkas, et al., 2024; Buja, et al., 2021). Drones can also be equipped with sensors and sprayers for management (Michi et al., 2023). Camera traps are mentioned for monitoring animals like squirrels (De Groot, et al., 2020).

The vast amounts of data collected necessitate sophisticated data analysis and processing techniques. Artificial intelligence (AI) and machine learning (ML) are mentioned for tasks such as counting target pests from trap images (Ascolese, et al., 2022), analysing sensor data for plant disease/pest detection (Fundurulic, et al., 2023; Buja, et al., 2021), predicting tree mortality or bark beetle infestations (Hartmann, et al., 2025), and refining predictive models (Grobert, et al., 2024; Rosace, et al., 2025). The integration of AI with process-based models is also discussed to improve simulations (Hartmann, et al., 2025). Big data analytics plays a role in handling large datasets from various sources (Buja, et al., 2021; Frezal and Garsous, 2020; Grobert, et al., 2024).

Geographic Information Systems (GIS) and spatial analysis tools are used for mapping treatment areas and analysing spatial patterns of pest introductions (Hartmann, et al., 2025; Rosace, et al., 2025). Statistical tools, such as RiBESS+, RiPEST and OptiPest, are available for designing and analysing plant pest surveillance (EFSA, 2025). Digital twins are noted as a future direction for adjusting forest dynamics simulations based on ML-based mortality detections during model runtime (Hartmann, et al., 2025).

Connecting these sensors and processing the data relies on communication and information systems. The Internet of Things (IoT) and Wireless Sensor Networks (WSN) provide frameworks for interconnected devices that enable real-time remote monitoring and data transmission (Buja, et al., 2021; Varandas, et al., 2020; Trigkas, et al., 2024). Technologies like LoRaWAN and 5G facilitate long-range, low-power, or high-speed data transfer (Varandas, et al., 2020; Trigkas, et al., 2024). Data access is often provided via web interfaces and mobile applications, allowing users to view monitored information and interact with the system from various devices (Varandas, et al., 2020; Buja, et al., 2021).

These apps can also serve for identification, reporting, and engaging the public in citizen science (Grant et al., 2019; Michi et al., 2023; Green et al., 2023; Buja, et al., 2021). Social media platforms like Facebook and Twitter are used for detection, identification, horizon scanning, and raising public awareness (Michi et al., 2023; Green et al., 2023; Trigkas, et al., 2024; De Groot, et al., 2020). Online platforms also host knowledge tools, databases, and information systems such as ARTEMIS and EUROPHYT, providing facts, maps, data, and guidance on plant health issues (Michi et al., 2023; Hartmann, et al., 2025). Media monitoring tools are also used for the early identification and reporting of plant health issues. They can help understand the impacts of plant pests and the societal response to new plant health threats (Ferilli, et al., 2019).

In the realm of trade control and policy, blockchain technology is explored for its potential to ensure end-to-end traceability and authentication along complex supply chains, such as for pesticides, reducing opportunities for fraud (Frezal & Garsous, 2020). Official IT systems like IMSOC/TRACES are used for recording and tracking the movement and import of plant material within the EU (Kaminski, et al., 2020). RFID microchips can be used for identifying, storing, and tracking individual plants for sanitary certification and traceability (Buja, et al., 2021).

Digital tools also support policy analysis through online surveys for data collection and access to regulatory databases like EUR-Lex (Green et al., 2023; Fishman, K. N., 2024). Analytical frameworks like PEST analysis and SWOT analysis are methodologies applied to assess the context and potential of implementing technologies and strategies (Michi et al., 2023; Trigkas, et al., 2024). Economic analyses, such as cost-benefit studies, are also conducted, often drawing on data facilitated by these technologies (Hartmann, et al., 2025; Kammenou, et al., 2021; Grobert, et al., 2024).

Finally, digital technologies support management actions and education/awareness. Drones equipped with sprayers offer targeted application of control measures (Michi et al., 2023; Green et al., 2023). Robotics combined with video processing and cloud computing can enable automated pest detection and pesticide spraying (Buja, et al., 2021). For education and public engagement, tools like e-learning packages, games, and the use of virtual reality are mentioned to facilitate learning and communication about plant health and biosecurity (Michi et al., 2023; Grobert, et al., 2024).

3.1.5.3 Digital Technology Integration in Regulatory Frameworks

The studies and reports analysed, examine how digital technologies interact with or are supported by the established policies and governance frameworks related to plant health, particularly within the European Union context. They discuss the regulations that require or enable digital tools, analyse the use of specific IT systems for official controls and information exchange, and explore the potential and challenges of integrating new digital technologies into plant health management strategies and policy implementation.

The Plant Health Regulation (EU) 2016/2031 and the Control Regulation (EU) 2017/625 are fundamental pieces of legislation that prescribe detailed procedures, such as reporting, testing, and monitoring, that farms must implement for quarantine organisms (Kammenou, et al., 2021; Filiptseva, et al., 2022). Regulation (EU) 2016/2031 aims to protect the Union's territory, plants, and forests, ensuring safe trade and serving as a main foundation for other EU plant health mitigations (Fishman, K. N., 2024; Grobert, et al., 2024; Herrera, et al., 2024). The Control Regulation (EU) 2017/625 sets out Member States' obligations regarding official controls and other official activities. These regulations are described as setting the framework for measures against pests (Buja, et al., 2021), reducing risks from foreign pest invasions and within the EU (Fishman, K. N., 2024), and strengthening the early warning system (Kaminski, et al., 2020).

The EU plant health regime, which took effect in December 2019, strengthened the established early warning system by utilising EU-wide IT systems like EUROPHYT and TRACES for information flow (Kaminski, et al., 2020). These systems are used to inform relevant authorities about pests found in imported consignments and the occurrence of quarantine pests within the EU (Kaminski, et al., 2020). EUROPHYT is described as a web-based network and database for notification and rapid alert concerning interceptions of plants and plant products imported into or traded within the EU. It connects EU Member States' plant health authorities, EFSA, and DG SANTE and provides essential support for implementing preventative measures by ensuring data on risks is up-to-date and accurate (Michi et al., 2023; Kaminski, et al., 2020). TRACES is also mentioned in this context (Michi et al., 2023). EUROPHYT also provides information and guidance to producers, importers, and exporters to ensure compliance with plant health regulations (Michi et al., 2023).

A study on enhancing biosecurity general surveillance discusses the challenges of integrating new Information and Communications Technology (ICT) tools and citizen science into the existing socio-technical system and the resulting changes in stakeholder relationships (Grant

et al., 2019). It highlights the need for coordinating among regulatory authorities and levels of government, as well as clear roles and data sharing agreements, for effective Early Detection Rapid Response (EDRR) systems for invasive alien species (IAS) in forests, suggesting lessons can be learned from plant health regulations (De Groot, et al., 2020). Stakeholders surveyed in another study on pests and pathogens detection and management reported using "plant health policies" and "websites" for detection and identification (Green et al., 2023), and suggested better integration of citizen science into official monitoring programmes (Green et al., 2023).

A report on a plant health campaign strategy includes a PEST analysis (Political, Economic, Social, Technological), which examines the political/legislative environment and technological factors relevant to plant health in Europe (Michi et al., 2023). It references EU policies like Regulation (EU) 2016/2031 and Regulation (EU) 2017/625 as the "European PH regulatory framework" and discusses the role of technological advances like mobile apps and pest reporting tools (including EUROPHYT) within this context (Michi et al., 2023).

A study evaluating legal, political, and cooperative frameworks for forest pest management in the EU-27 used a SWOT analysis to explore opportunities like emerging technologies (IoT, AI, 5G) (Trigkas et al., 2024) within the existing regulatory strengths. It advocates for a unified, technologically advanced approach and the strategic implementation of innovative solutions, emphasising strengthened international cooperation and legal frameworks.

A report on One Health governance in the EU includes plant health (Grobert, et al., 2024), and discusses integrating new technologies like AI and Virtual Reality into surveillance and risk assessment techniques at regulatory levels as a policy recommendation. It notes that the evidence review supporting the opinion includes a SWOT analysis of policies in relation to One Health governance, identifying areas like plant health that would benefit from transdisciplinary collaboration and the application of new technologies.

Policy harmonisation is also discussed in the examined studies, where it is presented both as an explicit goal of regulatory measures (Kammenou et al., 2021) and as a challenge in their practical implementation across different levels and Member States. Digital technologies are also examined for their role in supporting harmonisation efforts. Despite common EU rules, Member States often implement and enforce regulations with variations, sometimes adapting measures to local risks and conditions or complementing EU legislation with national laws

(Michi et al., 2023). Differences exist in national surveillance and monitoring programs for detecting harmful organisms (Michi et al., 2023).

Difficulties in enforcing rules and obtaining data from Member States are mentioned as challenges to achieving harmonised implementation (Fishman, K. N., 2024). Furthermore, surveillance is often designed on a threat-by-threat basis, which is less efficient than a more integrated, harmonised view of multiple threats (Herrera, et al., 2024). The studies also note challenges in standardisation or obtaining evidence for the efficacy of biosecurity practices across different countries (Green et al., 2023). The need for coordination among EU member states and at the global level is highlighted to address the increasing speed and complexity of crises.

The role of digital technologies in supporting harmonisation is also mentioned. Integrated IT systems like TRACES are presented as essential for rapid and standardised data exchange among authorities, supporting the operationalisation of regulations (Kammenou, et al., 2021). The development of standardised methodologies and data formats is seen as crucial for integrating data and knowledge across different sectors and disciplines, especially within the One Health framework (De Groot, et al., 2020). Integrated surveillance systems and the development of integrated models and Key Performance Indicators (KPIs) are proposed to enhance the monitoring and evaluation of policies, contributing to harmonised assessment and response (Grobert, et al., 2024).

Despite these potential benefits, technical challenges in areas like e-trap data transmission can hinder the widespread adoption and effectiveness of such technologies (Ascolese, et al., 2022). The broader context driving harmonisation efforts includes the framework of EU regulations, international standards, and the One Health concept itself, which inherently requires integrated, coordinated, and coherent policies and governance across diverse sectors and levels (Grobert, et al., 2024).

3.1.5.4 Barriers and Enablers to Digital Adoption

The studies discuss several significant barriers and enablers to the adoption of digital technologies in regulatory frameworks, particularly within plant health, biosecurity, and related agricultural and environmental contexts.

Barriers to Digital Adoption

A major challenge is the substantial upfront cost associated with IT development, infrastructure, and the deployment of digital solutions like blockchain, big data, and AI (Frezal & Garsous, 2020). This barrier is more acute in developing countries due to limited financial resources for equipment and skilled staff, as well as lower quality IT infrastructure. Grant et al., 2019 support that the cost of change itself is an important consideration for users in a system. Concerns about who bears the financial costs of surveillance and trapping technologies are also raised (Green et al., 2023). There can be a bottleneck to productivity due to the limited availability and high costs of laboratory testing (Green et al., 2023).

Existing digital tools may have technical limitations that hinder their effectiveness. Examples include problems with data transmission and errors in recognition systems in electronic traps, requiring further development before they can fully replace traditional monitoring (Ascolese, et al., 2022). The complexity of managing the quality of raw data, which big data and AI rely on, presents another challenge (Frezal & Garsous, 2020). There can be difficulties linking different model worlds (e.g., detailed pest models and landscape models) due to differing spatial and temporal scales (Hartmann, et al., 2025), and important factors like forest microclimate may not be fully integrated into models (Hartmann, et al., 2025). Some model's spatial resolution might not capture fine-scale variations (Rosace, et al., 2025). There can be concerns about the unspecified limitations of drones (Green et al., 2023).

The complexity of new digital technologies like blockchain, big data, and AI hinders their widespread deployment (Frezal & Garsous, 2020). A lack of education and understanding of these technologies means integrating all actors into a system (like a blockchain) is challenging and time-consuming (Frezal & Garsous, 2020).

There is also a lack of interoperability between different digital platforms, particularly a challenge for supply chain cooperation through blockchain (Frezal & Garsous, 2020). The data landscape for One Health is fragmented, and integrating existing infrastructures for surveillance and risk assessment is necessary (Grobert, et al., 2024). Standardising data collection, sharing, and analysis across different health domains is needed.

The development of some digital tools, like plant health mobile apps, may not be subjected to the same regulations as medical or veterinary apps, highlighting a need for clarity and informed choice (Michi et al., 2023). There is a lack of robust evidence for the widespread use and efficacy of certain methods, such as citizen science for pest reporting (Michi et al., 2023;

Green et al., 2023). Many invasive alien species are not regulated, and contingency plans are not yet developed, meaning digital support for managing them is lacking (De Groot, et al., 2020). There can be a lack of prioritising issues within the EU (Trigkas, et al., 2024).

The absence of an adequate legal and regulatory framework for some digital applications hinders widespread deployment (Frezal & Garsous, 2020). There is a noted absence of legal regulations for critical activities like quarantining contaminated sites (Trigkas, et al., 2024). Socio-political structures of information control may be a limiting factor for incorporating new information processing systems into surveillance networks (Grant et al., 2019). Climate-related enforcements still have a long way to go (Fishman, K. N., 2024).

Grant et al. (2019) support that the challenges of social acceptability are significant, going beyond technical problems. Adaptation to new technologies can require a reduction in efficiency at first. There is "excess inertia" in existing sociotechnical systems that makes shifting to new standards difficult (Grant et al., 2019). Differences exist in national surveillance and monitoring programs, and administrative processes can have varying requirements, leading to stress for users like farmers. Some rural communities have traditional agricultural practices that may not align with modern measures (Michi et al., 2023). There can be differing risk understanding among social groups regarding plant protection measures (Hartmann, et al., 2025). Resistance to change among populations and socio-economic contexts can prevent implementation (Grobert, et al., 2024).

Getting all supply chain actors involved and aligned is also challenging due to the global nature and high number of participants (Frezal & Garsous, 2020). Stakeholder engagement needs to manage points of friction within the existing system and appreciate different logistic and political imperatives (Grant et al., 2019). Insufficient cooperation at local and regional levels can be a threat (Trigkas, et al., 2024).

Numerous other threats (like deforestation, wildfires, other pests) compete for the attention and funding of key stakeholders (Trigkas, et al., 2024). Raising awareness among stakeholders about specific threats and proposed tech solutions is crucial but challenging. Insufficient public awareness is noted as a weakness. Communication needs to be improved to address differing risk perceptions (Hartmann, et al., 2025).

Finally, concerns related to data privacy, confidentiality, and cybersecurity exist for big data and AI (Frezal & Garsous, 2020). Transactions on platforms like blockchain may include confidential information that participants do not wish to become public. Ethical and privacy

concerns must be considered for data sharing in integrated surveillance systems (Grobert et al., 2024).

Enablers of Digital Adoption

The development of new digital technologies like blockchain, big data analytics, and AI offers significant potential (Frezal & Garsous, 2020). They can provide deeper and more rapid insights, as well as better predictive models (Grobert et al., 2024). These technologies can support policies related to traceability, authentication, monitoring, and control (Frezal & Garsous, 2020). Integrated IT systems enable rapid and standardised data exchange. Advances in sensors and microfluidics lead to innovative diagnostic methods (Buja, et al., 2021). Emerging innovative technologies like IoT, AI, and 5G are also transforming approaches to forest protection (Trigkas et al., 2024).

Digital tools can improve the efficiency and effectiveness of risk management processes, enable automated inspections, and enhance the monitoring of online trade (Frezal & Garsous, 2020). Wider adoption could significantly reduce the risks of illegal activities. Real-time monitoring is possible with systems like e-traps, allowing timely planning of interventions (Ascolese et al., 2022). Low-cost IoT sensor meshes enable remote measurement over large areas with adequate precision and reliability (Varandas et al., 2020). Wearable sensors and IoT allow for monitoring environmental and botanical aspects (Buja et al., 2021). Digital technologies can contribute to efficient, sustainable, and environmentally conscious practices (Fundurulic et al., 2023). AI can detect affected areas using remote sensing (Hartmann et al., 2025). Integrated surveillance systems can detect and respond to health threats across species and environments (Grobert et al., 2024). Interdisciplinary approaches like Climate-Smart Pest Management can overcome limitations and increase resilience (Buja et al., 2021).

Technologies enable secure data exchange and potentially cross-organisation automation (smart contracts), (Frezal & Garsous, 2020). Databases like TRACES can serve as central repositories for information. Standardised methodologies and data formats are crucial for integrating data and knowledge. Integrated surveillance systems need to facilitate data collection, sharing, and analysis (Grobert et al., 2024).

A well-established legislative environment at the EU and Member State levels can serve as a supportive instrument (Trigkas et al., 2024). EU policies advocate for sustainable management, providing a framework for digital tool application, and solid political and

legislative frameworks exist (Trigkas et al., 2024). The framework of EU regulations and international standards underlies efforts.

Furthermore, a good network of EU and national stakeholders exists and can be an effective platform for communication and information dissemination (Trigkas et al., 2024). Stakeholder engagement, especially early in the design process, improves the chances of adoption (Grant et al., 2019). Working through existing networks can connect technology innovation with wider communities.

Raising awareness about the correlation between plant health and other critical areas (food security, economy) is also recommended by Michi et al. (2023). Social networking can be leveraged for public awareness campaigns (Trigkas et al., 2024). Investments in awareness activities are also seen as useful strategies (Michi et al., 2023). Effective communication is of pivotal importance for successful implementation (De Groot, et al., 2020). Media exposure is associated with awareness and policy acceptability, and initiatives to educate children are examples of engaging different levels (Green et al., 2023). The COVID-19 pandemic has helped raise the profile and explain principles of plant health biosecurity (Green et al., 2023). In that sense, the concept of shared responsibility is highlighted.

Designing technologies with stakeholders and incorporating user perspectives (mental models) is crucial for adoption (Grant et al., 2019). Co-design approaches can support the development of tools that meet end-users' needs, and tailoring communication approaches based on audience analysis can be planned (Michi et al., 2023). Empowering individuals to act as field inspectors can make them part of the solution (Trigkas et al., 2024), while public support for early detection and rapid response systems exists (De Groot et al., 2020).

Technological innovation is actively supported by numerous EU-funded projects (Trigkas et al., 2024). This funding is crucial for advancing research and development of early detection and evaluation technologies.

Surveillance and the application of insecticides can be economically viable options (Hartmann, et al., 2025), and digital tools can potentially enhance the cost-effectiveness of these measures. Reduced need for chemical treatments through technologies like fungus-resistant varieties can increase access to environmental subsidies (Hartmann, et al., 2025). Digital solutions can enable substantial savings, for example, by reducing the amount of phytosanitary treatments (Buja, et al., 2021).

3.2 Results – Stakeholders' perspectives

Section 3.2 presents the findings derived from the perspectives of various stakeholders regarding the integration of digital technologies into plant health policy. As part of the STELLA project's Work Package 5, Task 5.1, 81 semi-structured interviews were conducted with policymakers, agricultural/forestry advisors, farmers/foresters, and citizens across European Union member states (Greece, Italy, Lithuania, France) and at the EU level. These interviews aimed to gather insights into the perception and practical implementation of digital innovations in plant health surveillance, exploring the associated needs, challenges, and benefits. The results capture stakeholders' views on current practices, the extent of digitalisation, data sharing mechanisms, challenges encountered, and how digital tools can support early warning and detection of regulated pests, contributing to policy integration and addressing broader environmental goals.

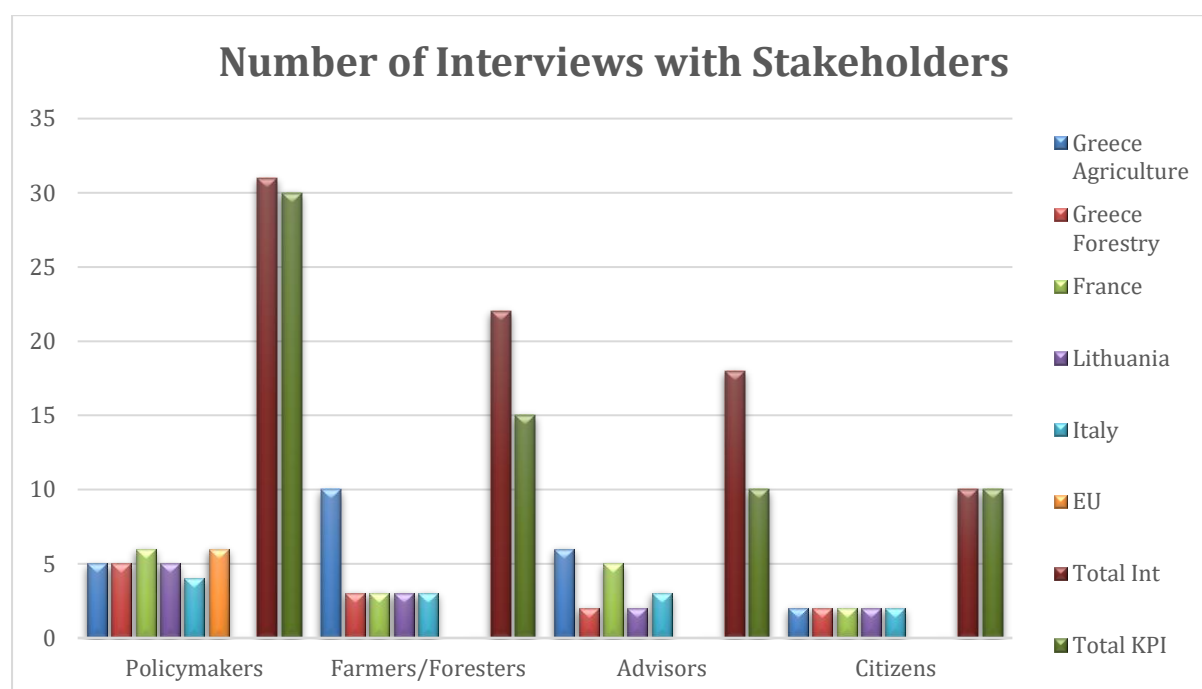


Figure 11: Number of Interviews with stakeholders at EU and national levels (France, Greece, Italy and Lithuania)

3.2.1 Policymakers' interviews

As part of the STELLA project (WP5, Task 5.1), semi-structured interviews with 31 policymakers from Greece, Italy, Lithuania, France, and at the EU level were conducted. The aim was to understand how digital innovations in plant health policy are perceived and implemented in practice, so we examined the needs and challenges associated with these innovations. We also explored how digital tools can be integrated into plant health policies to enhance early warning systems and detection of regulated pests, as well as to address climate change and biodiversity loss. These policymakers, representing the agriculture and forestry sectors, provided valuable insights into current plant health surveillance practices, the extent of digitalisation, data-sharing mechanisms, challenges encountered, and how these efforts are integrated into policy.

The policymakers interviewed for the STELLA project represented a diverse cross-section of roles across European, national, and regional levels. At the EU level, interviewees held positions in directorates and units responsible for digitalisation, agricultural policy, and plant health governance, with responsibilities ranging from strategic policy design and coordination to overseeing data governance frameworks and innovation programs. At the national level, policymakers from Greece, Italy, and Lithuania were primarily engaged in the implementation of plant health legislation, inspection and certification procedures, coordination of surveillance activities, and the development of digital tools to support agricultural monitoring. In Greece, several interviewees also worked within the National Plant Protection Organisation, directly applying EU legislation in the national context. At the regional level, particularly in France and parts of Italy, respondents were responsible for supporting the adaptation of national and EU policies to local agricultural contexts, often with a focus on surveillance systems, biosecurity, and support for sustainable practices.

Most participants had significant experience in policymaking, typically ranging from mid-career to over two decades, and demonstrated a strong familiarity with EU phytosanitary legislation, notably Regulation (EU) 2016/2031. Their roles reflected a balance between high-level strategy and on-the-ground implementation, with varied degrees of involvement in digitalisation initiatives depending on institutional mandate and national context.

Through the analysis, we identified the following four main themes that capture the core issues discussed by policymakers regarding plant health policies and digitalisation. These themes are consistent across the interviews from all regions, though with some variation in emphasis and implementation between countries:

- Theme 1: Policy Integration and Support in Digital Plant Health Surveillance
- Theme 2: Data Sharing and Collaboration
- Theme 3: Benefits and Challenges to Implementing Digital Plant Health Surveillance
- Theme 4: Future Needs and Opportunities

3.2.1.1 Policy Integration and Support in Digital Plant Health Surveillance

Policymakers emphasise that integrating digital plant health surveillance into policy frameworks is becoming increasingly important, as supported by existing EU and national initiatives. Several interviewees pointed to the Common Agricultural Policy (CAP) as a significant driver, providing financial support and requiring digitisation strategies from Member States. Other foundational policies and acts at the EU level mentioned include the Digital Europe Programme, Connecting Europe Facility³⁷, Data Act, Data Governance Act, Interoperable Europe Act, and AI Act³⁸, which establishes the legal and technical foundations necessary for digital adoption. Initiatives like the Green Deal and Horizon Europe projects further promote the use of digital technologies.

At the national level, examples of use of digital systems and initiatives cited include TRACES, EUROPHYT, France's BSV 2.0 and ECOPHYTO plan with technology subsidies, Italy's electronic export/import certificates and regional online reporting systems, Lithuania's [VATIS system](#) and IKOK, and Greece's ongoing digitisation of the Plant Health Register and use of digital certificates. Policymakers view these efforts as enabling early warning and detection of plant health issues, allowing for more targeted pesticide use and environmental protection through precision interventions, optimising resources, and fostering evidence-based policies. Funding mechanisms from the CAP and specific project calls are seen as policy tools to encourage adoption. Some note that legislative frameworks defining data use and ownership are a necessary policy support. However, there is a notable absence of comprehensive national strategies focused explicitly on digital surveillance in plant health.

³⁷ Regulation (EU) 2021/1153 of the European Parliament and of the Council of 7 July 2021 establishing the Connecting Europe Facility and repealing Regulations (EU) No 1316/2013 and (EU) No 283/2014, OJ L 249, 14.7.2021, p. 38–81, <http://data.europa.eu/eli/reg/2021/1153/oj>

³⁸ Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence and amending Regulations (EC) No 300/2008, (EU) No 167/2013, (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1139 and (EU) 2019/2144 and Directives 2014/90/EU, (EU) 2016/797 and (EU) 2020/1828 (Artificial Intelligence Act). OJ L, 2024/1689, 12.7.2024, <http://data.europa.eu/eli/reg/2024/1689/oj>

Challenges remain in the effective integration of digital plant health surveillance at both the national and EU levels. Policymakers often describe the broader digital transformation initiatives and specific tools being implemented rather than a cohesive strategy. In Greece, for example, sectoral policy divides complicate the situation, as responsibilities for plant health fall under different ministries. Italian interviewees observed that regional plant health policies are in line with EU frameworks and emphasised the importance of improved data sharing and better coordination among stakeholders. Similarly, in France, the policymakers noted that both national and regional plant health policies align well with EU regulations, but they stressed the need for more effective implementation, reliable data, and practical tools. Lithuanian policymakers highlighted a lack of communication between experts from different fields, along with a lack of tools to motivate and encourage farmers to improve.

Several interviewees highlight that plant health is not a priority at either the national or regional level in some countries, which hinders the effective implementation of policies and the adoption of digital technologies. A Greek policymaker stressed that the Ministry of Rural Development and Food must take the lead in promoting digital technology integration and data sharing through legislative action. There is also a clear need for comprehensive legislative and policy frameworks. While EU-wide regulations, such as the Plant Health Law, the Data Act and AI Act, provide foundational elements, effectively adapting them to keep pace with technological changes remains a challenge. Policies should establish secure and transparent data governance frameworks, provide incentives for data sharing, clarify the status of data, and ensure transparency and permission to share data. A legislative act is specifically mentioned as needed for technologies like drones.

Overall, the interviewed policymakers indicated that establishing clear legislative and policy frameworks, providing incentives for data sharing, enhancing available resources, and addressing fragmentation through common databases and data management networks are necessary steps.

3.2.1.2 Data Sharing and Collaboration

Most of the policymakers replied that data sharing and collaboration are crucial for developing effective and evidence-based policies in plant health, pesticide reduction, and environmental protection. Shared data can significantly increase the predictability and correctness of results, especially for AI applications, by providing more quality data to train algorithms. This leads to

better risk analysis because it helps to identify where harmful organisms are spreading and makes surveillance and interventions more reliable and precise. Data sharing facilitates rapid response, allowing for faster preservation of unaffected areas. It also helps decision-makers optimise resources by better targeting where efforts are needed, and researchers understand complex interactions and obtain a complete picture of the situation. Furthermore, timely data sharing can contribute to pesticide reduction by enabling early diagnosis and targeted action, thus minimising the need for broad applications.

However, the interviewees mentioned several challenges that hinder effective data sharing and collaboration among stakeholders in plant health management. They consider as a primary obstacle the lack of trust and fear among farmers and other stakeholders regarding data misuse, particularly concerning sensitive information about regulated pests that could impact their businesses or lead to regulatory control. The data fragmentation across various organisations and sectors (e.g., agriculture, environment, regional authorities, research) was also discussed. There is a need for standardisation and clear guidelines on how data is collected and validated to ensure quality and make aggregation meaningful. Policymakers also highlighted the lack of sufficient financial and human resources, technical skills, and capacity within national and regional administrations to manage and utilise complex digital systems and data effectively. The heterogeneity in technical capacity across regions and member states also presents a challenge. The data ownership and the cost of accessing necessary data, even for official services, remain important issues according to the interviewees.

To promote wider adoption and integration of data sharing, policymakers suggested several policy recommendations and mechanisms. Developing common, user-friendly data platforms, information systems, or databases is seen as crucial for centralising data and facilitating smooth and rapid exchange among authorities and stakeholders. It is vital to establish clear legal frameworks and policies that define data use and ownership, ensure transparency, and provide robust safeguards against misuse to build trust. Providing incentives for participation, such as financial support or demonstrating the added value for farmers (e.g., better insurance, targeted interventions), is necessary, especially for data-sharing initiatives. Capacity building and training programs are essential, targeting not only farmers but also administrators and inspectors, to equip them with the necessary skills to utilise digital tools and understand data management. Involving stakeholders from the design stage of digital tools and fostering collaboration through technical tables or working groups is also recommended to ensure tools

meet real needs and facilitate data exchange. Some also suggested that publicly funded research projects should have an obligation to make their resulting data available.

3.2.1.3 Benefits and Challenges to Implementing Digital Plant Health Surveillance

The policymakers identified several benefits regarding the adoption of digital tools in plant health management. They highlighted, as a primary benefit, their potential to improve **early detection and warning systems**. An EU policymaker emphasised that digital technologies are crucial enablers for prevention and early warning, allowing tools like sensors, drones, and AI to detect issues faster and enable swifter responses from farmers and authorities. Remote sensing, in particular, was noted by another EU interviewee, for its ability to identify symptoms before they become visible, according to another EU policymaker, enabling authorities to focus resources on targeted areas and improving reaction time. A Greek interviewee highlighted that aerial imagery and remote sensing provide the ability to monitor forests and crops and can significantly improve the timeliness of detection. These technologies assist in early diagnosis of potential harmful organisms and prompt implementation of control measures.

The integration of digital tools directly leads to better **precision and optimisation of resources**. An EU interviewee explained that integrating digital technologies helps decision-makers in optimising the resources they use. This increased precision also strongly supports sustainability goals, such as those outlined in the Farm to Fork and Biodiversity strategies. Many interviewees stressed that digitalisation enables precision in pesticide use and can significantly reduce application rates when widely adopted.

Furthermore, digital tools offer practical efficiencies, such as reducing the manual workload and mental burden on operators, enabling the efficient collection of large datasets in a short period, and fostering improved information sharing among stakeholders, as a French interviewee noted. Collecting a greater amount of information from various sources is seen as an advantage by Greek policymakers, and an EU participant added that integrating these technologies makes efforts much more sustainable than before. Data sharing through digital platforms, is also considered as fundamental for developing more **effective and evidence-based policies** and enhancing the predictability of pest outbreaks.

Despite the benefits of digital technologies, policymakers identify several significant technical and data-related challenges to implementing digital technologies in plant health surveillance. A primary obstacle is the **fragmentation of data** across various organisations and sectors. Often, data sources remain isolated, making it difficult to aggregate information meaningfully. Ensuring data quality and reliability is critical and requires standardised and clear guidelines,

a common protocol, and thorough validation processes to avoid aggregating diverse information or potentially "unreliable" data.

The **lack of interoperability** between databases and the convergence problem of numerical solutions between different digital tools further complicates the integration of diverse digital tools. Some technologies are still evolving, especially in dealing with the variability of living organisms and the complexity of plant pathogens, which can make accurate diagnosis difficult. The reliance on large volumes of base data for AI can pose barriers as well, because this data may not always be readily accessible due to cost and fragmentation.

Human and social factors represent another major category of challenges. A significant barrier is the widespread lack of trust among farmers and citizens regarding how their data will be used. There is suspicion and a fear of misuse, especially when it comes to sensitive information about regulated pests, which can lead to a tendency to hide problems. Policymakers stress the need for tools that are user-friendly and clearly demonstrate added value to incentivise data sharing.

Capacity-building and training programs are deemed essential but are often underdeveloped. Farmers, administrators, and inspectors need training alike to address the shortage of skilled human resources. Citizen science also holds great potential, but challenges remain in validating contributions and managing the influx of reports to ensure the reliability of information.

3.2.1.4 Future needs and opportunities

Across the interviews, policymakers offered valuable insights and recommendations for the future integration of digital technologies in plant health management, highlighting both needs and opportunities. A consistent theme for future policy direction was the necessity of enhancing **interoperability between databases** across different levels and organisations to maximise the value of digital tools. Several participants stressed the critical need for **increased financial and human resources**, particularly specialised personnel, within national and regional authorities to manage the complexity of digitalisation. This includes the need for **capacity building within administrations** themselves, not just for farmers. Recommendations also centered on designing policies from the end-user's perspective, ensuring tools are **simple, affordable, and accessible** to various farmer types, especially small-scale ones, to avoid creating a digital divide. Making the objectives and benefits of adopting digital technologies clearly understood was seen as crucial for gaining support,

especially given the associated costs. One interviewee strongly advocated for technologies to be **reliable, mature, and operational**, as dependable as human observation, stating that "The first condition is that the technologies be reliable, mature, and operational". Another key policy suggestion was to clarify the legal **status of data** through a ministerial position to build trust and facilitate data sharing, and to prioritize plant health at the national level. The importance of creating **collaboration networks** and integrating digital proficiency into broader economic development strategies was also highlighted.

The potential of **citizen science** was also discussed as a valuable contributor to plant health surveillance and monitoring. Many saw "huge" potential, especially for early warning, noting that citizens can complement professional monitoring efforts and might detect unusual issues faster. Some pointed to existing initiatives and the potential to involve citizens via mobile applications. However, significant concerns were raised regarding the **reliability of data** provided by the general public and the risk of overwhelming official services with irrelevant or false reports, citing examples like numerous reports for common issues that might clog reporting channels. Interviewees stressed that citizen reports should always be confirmed by official services. To mitigate these challenges, the need for **continuous public awareness campaigns and education** was emphasised, aiming to guide citizens and ensure data reliability. It was also suggested that citizen science efforts could be more targeted and focused on specific, easily identifiable pathogens.

The discussions also illuminated key opportunities presented by digitalisation and provided direct advice for researchers working in the field. Opportunities consistently mentioned included the potential for **enhanced early detection and warning systems**, improved surveillance through targeted monitoring, and optimisation of resources. Precision farming and targeted interventions were seen as ways to reduce pesticide use and environmental impact. Digital tools can also help reduce manual workload, collect data efficiently, and facilitate information sharing among farmers. Advice to researchers frequently emphasised prioritising the **end-user's perspective**, developing tools that are **easy to use, provide clear benefits**, and build trust. A critical focus for research should be on **concrete applications** and ensuring effective **knowledge transfer** from research institutions to professionals and end-users. Researchers were encouraged to collaborate across specialties, maintain scientific rigor and use reliable data, while also being humble about the complexities of living systems and not overestimating technology's current capabilities. Addressing real needs, particularly in areas not commercially viable, and staying updated on legislative frameworks were also highlighted as crucial for research impact.

3.2.2 Advisors

The 18 advisors interviewed for the STELLA project represent a diverse and experienced group of professionals working across Greece, Italy, Lithuania, and France in both agricultural and forestry advisory services. They provide advisory services regarding plant health monitoring, pest and disease management, adoption of digital tools, organising training activities, and facilitating knowledge exchange between stakeholders.

They hold roles in cooperatives, public agencies, research institutions, and technical advisory bodies, providing a mix of field-based support, strategic coordination, and policy-related guidance. Their roles include wine consultants with expertise in organic and conventional viticulture, territory monitoring, and the recognition of diseases and pests, sometimes consulting national or international networks for little-known issues. Agronomists participating in the interviews also work at regional level, serve as managers of agricultural crop protection products stores, function as company representatives, specialise in agricultural consulting with a focus on crop protection and integrated crop management, or work as agricultural store employees specialising in crop protection and nutrition, particularly for orchards. Additionally, the profiles feature digital agronomy consultants and experts specialising in the use of decision support systems, integrating digital tools into agricultural practices, and experts in digital farming tool development and sustainable crop management, specifically grapevine.

The years of experience reported by these advisors vary significantly, reflecting a wide spectrum of professional backgrounds. The reported durations in advisory roles range from 2 to 30 years. The majority of the interviewed advisors expressed willingness to be contacted for follow-up questions after their interviews, though one stated their willingness was dependent on the timing, and two indicated they were not willing to be contacted further.

Collectively, this group of advisors offers a broad understanding of the challenges and opportunities facing plant health management in different contexts, and their insights provide valuable input into the objectives of the STELLA project. The thematic analysis of the advisor interviews revealed a set of recurring patterns and insights that cut across national and sectoral contexts. Despite differences in local conditions and institutional settings, common challenges, needs, and opportunities emerged in relation to plant health management and the integration of digital technologies. The themes identified reflect the lived experiences and professional judgments of advisors working in agriculture and forestry, and are closely aligned with the objectives of STELLA WP5 Task 5.1. Each one captures different aspects of advisory

work, such as the role of digital tools, the importance of training and knowledge exchange and the influence of policy frameworks. There are also differences between sectors and countries, offering valuable insights into how advisory services can evolve to support innovation and resilience in plant health governance.

3.2.2.1 Awareness of Policies and Current Use of Digital Tools

Advisors' awareness of the EU plant health legislative framework (Regulation (EU) 2016/2031) was generally moderate to high, though not universal. Responses varied among the participants. Several advisors indicated they were familiar with the regulation, while others described their knowledge as being at a medium level or average, noting that they access information when needed. One advisor mentioned familiarity with certain elements through Certiphyto, which pertains to the certification for plant protection products in France, and had knowledge of the framework and specifications for authorized treatments related to *Flavescence dorée*, a highly destructive phytoplasma disease affecting grapevines. However, some advisors expressed a lack of familiarity with the EU's plant health legislative framework. One advisor pointed out that while they were aware of the general framework, it is the French framework that matters most to them.

Regarding awareness and current use of digital tools and technologies for managing plant health, the responses also showed diversity. Some advisors were aware of or actively using various digital tools. These included imaging detection of virus or phytoplasma symptoms, resource platforms, and reporting tools, as well as digital tools for reporting observations and weed recognition. More advanced tools mentioned included remote sensing technologies such as satellites and drones for monitoring crop condition and identifying disease/pest, automatic weather stations for risk analysis, Artificial Intelligence (AI) solutions for data analysis, and Decision Support Systems (DSS) based on models that provide information on if and when the environmental conditions are favourable for a specific disease to develop. Specific tools like Phyto Data, [ePhytia detection tools](#)³⁹, and the [CHOUETTE tool](#) (Precision viticulture services for optimal management of wine farms) were also mentioned. One advisor detailed their use of remote sensing technologies, IoT, GIS applications, plant disease prediction models, and DSS, having worked as an advisor in digital agronomy since 2012.

³⁹ The INRAE portal [e-phytia](#) hosts several plant health applications allowing in particular: i) to identify the diseases and pests of various cultivated plants, to know their biology, and finally to choose relevant protection methods; ii) to put into practice biological and / or alternative protection methods in full knowledge of the facts; and iii) to carry out epidemiological surveillance, or even to contribute to participatory sciences.

Conversely, a significant number of advisors stated they were not aware of any digital tools or technologies currently used for managing plant health.

3.2.2.2 Perceived Benefits of Digital Pest Management Technologies

Across all interviews, advisors frequently highlighted the potential benefits of integrating digital technologies such as AI, remote sensing, IoT, citizen science, and decision support systems into plant health management. A key advantage identified was the capacity for **broad, rapid monitoring of a farm**, which allows for observations to be confirmed and large-scale observation sites to be organised more precisely and completely. Technologies such as remote sensing were seen as making it possible to monitor crop conditions and identify disease and pests efficiently. The real-time data collection and mapping of issues leads directly to improved decision-making and enhanced control of plant diseases and pathogens.

Advisors noted these tools can **improve risk mapping** and monitoring, allowing them to be responsive and adapt advice in real time, implement appropriate control strategies, and prioritise protective measures according to the risk level. The enhanced precision and planning can potentially lead to the anticipation and mitigation of risks, early diagnosis, reduced pesticide use, lower crop protection expenses, and optimisation of farm work planning, ultimately saving resources and time. The immediate and fast responses offered by digital technologies can also minimise human error.

Looking beyond immediate operational benefits, advisors also discussed the strategic importance and broader impacts of these technologies. Digital tools are widely **seen as the future**, forming an essential base of resources, data, and exchanges needed to anticipate and react to health problems before they become serious, particularly in the context of globalisation and disease transfers. Decision Support Systems (DSS) are valued specifically for their ability to translate data into information on key management actions. An advisor from the National Paying Agency noted that citizen science can enhance public awareness of plant health and promote responsible farming practices, while DSS effectively integrate various data sources. The overall consensus was that technological advancement will make a significant contribution to plant health management by enabling early detection and reducing losses. They noted that access to accurate, up-to-date data is essential for effective decision-making, helping farmers anticipate and mitigate risks for better crop protection and sustainability.

They also consider digital technologies as crucial tools for **addressing environmental challenges and promoting sustainability** in plant health management. They noted that digital tools can lead to a reduction in the use of chemical pesticides by enabling more accurate application and early detection. This also translates to better use of resources like fertilisers. The integration of digital technologies is seen as necessary to tackle major issues such as climate change affecting pest spread and contributing to the broader goals of the EU Green Deal and Farm to Fork Strategy, aiming to mitigate biodiversity loss. While one advisor mentioned considering the carbon footprint of digital technologies, the overall perspective is that these advancements are essential for creating more resilient and sustainable agricultural systems.

Advisors also highlighted the crucial importance of **data sharing and collaboration** for effective plant health management. Many viewed it as essential for good disease management and believed it would significantly support the efforts of agronomists and technicians and contribute to better and faster disease management. The sharing of knowledge was considered necessary for serving the sector rather than being used for individual purposes. Collaboration was seen as fundamental because multiple actors operate within the same territory, and sharing information helps coordinate control strategies. The increased data utilisation stemming from collaboration can lead to fewer errors, better use of resources (like fertilisers and pesticides), and reduced costs.

Cooperation among farmers, scientific institutions, and the authorities was expected to significantly improve plant health management. Specifically, access to reliable data is considered very important as it allows for prevention and enables professionals to be responsive and adapt advice in real time. It helps avoid over- or underreaction to risks and prevents bias in risk analysis. A Lithuanian Science Manager added that data sharing allows farmers and foresters to respond promptly to threats and make faster decisions on necessary actions. Collaboration facilitates the development of more accurate predictive models, enhances disease monitoring, and improves response strategies. An Italian digital agronomy consultant noted that shared information helps anticipate and mitigate risks, ensuring better crop protection and sustainability. Ultimately, open data fostered by collaboration can drive innovation, allowing scientists, companies, and startups to rapidly develop new solutions.

3.2.2.3 Barriers and Challenges to Adoption of Digital Tools

Advisors highlighted several practical and technical barriers hindering the widespread adoption of digital tools in plant health management. A significant concern raised was the high **cost** associated with digital technologies, including the initial investment in equipment, which can be prohibitive for farmers, especially individual operations in regions like Alsace with fewer collective structures. The need for financial incentives or public funding was frequently mentioned as a way to address this.

Beyond cost, **technical challenges** include ensuring the reliability of detection methods and the technical ease and adaptability of tools to different types of equipment. Some advisors noted difficulties with specific technologies, such as a technical deadlock experienced with drone and onboard camera tests for Flavescence dorée monitoring, and the challenge of distinguishing diseases due to confusion with other symptoms.

Managing the large volume of data generated by digital tools was also seen as difficult, requiring **coordination** in data acquisition and storage, **standardisation** across European countries, and a **clear legal framework** for data use and privacy. Advisors expressed uncertainty regarding the fate of data after it is collected, highlighting concerns about data governance and the ease of access and exchange. Some advisors also pointed out the potential risk of lawsuits against digital platforms if users experience a decline in production. Furthermore, one advisor raised a critical issue about the carbon footprint associated with digital technology, questioning whether the environmental benefits truly outweigh the energy and resources these tools consume. Although this concern is not universally held, it reflects a general scepticism that new technologies should not create additional challenges, such as high costs, increased complexity, or environmental trade-offs, while addressing existing issues.

Complementing the technical challenges are significant human and social barriers to adoption. A major hurdle is the **insufficient training** and educational level of farmers and advisors. Digital tools require dedicated training, which can be difficult to adapt to the seasonality of farm work and farmers' limited time. There is a perceived lack of skills and expertise in digital approaches, with one advisor noting, "We suck today, we're not up to speed in Alsace" regarding AI for mass data processing and vineyard advice. The human aspect remains very important, and there is a concern that digital tools may not fully replace human expertise and could potentially lead to a loss of skills through over-automation or even undervalue the agronomist's role.

Moreover, concerns about **confidentiality**, the management of anonymised data, and a lack of trust hinder data sharing and collaboration. An advisor from Alsace shared a negative past

experience where data reportedly fell into the "wrong hands," leading to inappropriate advice with disastrous consequences for biodiversity. Specific digital tools, such as drone surveillance, were also perceived as having a potential defamatory implication. Concerns were raised about the data protection of private companies by an Italian agronomist. Ensuring data protection and clearly defining access rights and limits of use were emphasised as necessary steps. An Italian expert noted that it is very difficult to make farmers share their information, while an advisor from Alsace felt that for winemakers, data sharing is "more complicated with GDPR". Finally, challenges exist at the policy level, including the need for technologies to be validated by regulations, communication problems between EU, national, and user levels, difficulties interpreting regulations, and the perception that European regulations often seem far removed from the realities on the ground.

3.2.2.4 Advisors' Recommendations for Policy and Governance

Advisors offered several key recommendations for policymakers looking to support the adoption and integration of digital technologies in plant health management. A prominent suggestion was the **need for financial support and incentives** to help farmers and foresters acquire expensive equipment. While one advisor felt that relevant solutions would be adopted naturally without incentives, others explicitly called for public funding and grants for technology acquisition. Some even suggested that adoption might need to be made mandatory, coupled with necessary funding. Beyond direct financial aid, recommendations included investing in the human resources needed to structure and support digital developments and improving rural internet infrastructure to bridge the digital divide. Developing comprehensive support instruments covering a broad range of eligible expenditures was also proposed.

Further policy suggestions centred on the **design and implementation of the policies** themselves. Advisors emphasised the importance of harmonisation of digital tools and regulations across European countries, while also advocating for the simplification of applications to make them user-friendly and using accessible, pragmatic language for advisors and end-users. There was a strong call for policymakers to come to the field to understand the reality on the ground and create appropriate solutions, and to rely on and listen to the expertise of technicians and researchers. Regarding data, developing a **clear policy on the use of digital data** for the benefit of farmers was recommended, alongside ensuring data governance and defining access rights.

Policymakers should also work to strengthen links between technological and agricultural professions, support innovation by **involving farmers** in the process of developing new technologies, and clarify the objectives of digital tools to encourage their adoption. Ultimately, digital tools are considered essential for anticipating and reacting to plant health problems, requiring policy support to facilitate their easy, intuitive, and harmonised use. It was also noted that strict compliance with the European plant protection framework can sometimes make problem-solving difficult, suggesting a need for practicality in policy application. Addressing climate change challenges also requires strengthening the integration of agronomic solutions into policy.

3.2.3 Farmers / Foresters

In the framework of the STELLA project – which aims to develop a digital Pest Surveillance System (PSS) for early warning of regulated pests – farmers across Greece, Italy, Lithuania, and France were interviewed to capture their views on European Union (EU) plant health policies and the potential integration of digital technologies into pest and disease management. Across the four countries participating in the STELLA project, a total of twenty-one individuals, including eighteen farmers and three foresters, were interviewed in the framework of Work Package 5, Task 5.1. Their profiles reflect a wide range of agricultural and forestry practices, experience levels, and educational backgrounds. The farmers interviewed are primarily involved in specialised forms of agriculture, with a notable emphasis on viticulture, horticulture, and crop production. At the same time, foresters are engaged in the management of woodland and forest ecosystems. While most farmers operate small to medium-sized holdings, with land sizes ranging from approximately two to eleven hectares, the farm sizes of the respondents reach 650 hectares.

In terms of experience, the majority of respondents have been active in farming or forestry for several decades, with some working in the field since the 1990s. A large portion of the participants fall within the age range of fifty to sixty-four years old, although younger individuals are also represented. Educational backgrounds vary, with some farmers relying solely on practical experience, while others have completed formal agricultural training, including university-level education or specialised technical courses in areas such as viticulture.

In Greece, interviewees included olive farmers and foresters. These individuals typically manage small plots of land and possess either practical farming knowledge or a blend of practical experience and relevant academic training. In Italy, the farmers tend to work in wine

production and horticulture, often with substantial experience and, in some cases, full agricultural education. In Lithuania, the farmers are primarily involved in horticulture and arable farming, with many reporting longstanding engagement in agriculture, supported mostly by basic formal training. In France, the interviewees are winegrowers operating family-owned vineyards. These individuals generally have both practical and general training in viticulture or oenology and decades of operational management experience.

The thematic analysis of the farmers/foresters' interviews revealed several cross-cutting themes across all four countries. These themes represent the major strands in how farmers and foresters perceive EU plant health policies and the integration of digital technologies for pest and disease management. The interviewees expressed serious concerns about plant health risks and the adequacy of current policies, a general lack of widespread use of advanced digital tools in their current practices coupled with varying degrees of awareness of such tools, a recognition of clear benefits that digital technologies could offer for managing pests, but also significant barriers and reservations about adopting these technologies. Furthermore, there was a unanimous emphasis on the importance of reliable information sharing and collaboration to combat plant pests, and farmers outlined specific supports or changes needed, such as training and policy incentives, to better integrate digital solutions into plant health management. Each theme is detailed below with supporting evidence from the interviews.

3.2.3.1 Concerns about Plant Health Policies and Pest Risks

Farmers and foresters expressed several significant concerns regarding plant health and pest management policies. A primary area of concern across various interviewees related to the increasing pressure from diseases and pests, coupled with limitations in the available tools and methods to combat them effectively, with one farmer noting, "No matter what we do, diseases and insects remain resilient". This challenge is compounded by a perceived insufficient supply of pest control products and a lack of effective policy recommendations. A young Greek farmer, who also had academic training in agriculture, voiced worries that policy constraints could leave farmers "without enough effective pesticides to protect my crops". In Lithuania and Italy, farmers also mentioned the effectiveness of products and maintaining yields as top concerns.

Furthermore, climate change was frequently mentioned as a worsening factor, bringing new pests and diseases or altering pest lifecycles. The Greek farmers, in particular, highlighted

that climate change contributes to the spread of new pathogens, which can outpace the current policy framework. A farmer noted that in such cases, the approval processes for biological control products are time-consuming, suggesting that authorising new, environmentally friendly solutions leaves a policy gap. There was a shared feeling that state institutions should take more initiative and increase investigative activity to address these challenges.

A significant part of the discussion focused on the adequacy and impact of current policies, particularly concerning the availability and use of plant protection products. The elimination of many active substances was repeatedly mentioned. While generally supportive of goals to reduce pesticide use and move towards sustainable models, some practitioners felt that despite supporting integrated farming, there are currently "not enough technical means to achieve 100% organic agriculture", as an Italian farmer noted.

The expense of chemical products was also a concern. Many felt that EU regulations often fail to consider local particularities and the operational difficulties farmers face in the field, emphasising that policies should align with the "real needs of agricultural production" to genuinely encourage sustainable practices. Suggestions for improvement include making plant protection products more accessible, providing quick risk information, and offering practical solutions for daily use.

Specific local issues were also raised, such as the *Verticillium* wilt and the spread of diseases through planting materials. In France, where agriculture has undergone increasing regulatory pressure to reduce pesticide use, farmers expressed strong support for the *goals* of these policies, such as protecting the environment and human health, but also highlighted the practical difficulties in meeting those goals. One French winegrower stressed his personal objective of having a "healthy vine [with] quality grapes" while doing "as little [treatment] as possible" to minimise environmental and health impacts. Another French farmer, managing a larger vineyard with employees, enumerated his main policy-related worries as "*the health of humans [workers and himself], the effectiveness of products, respect for the environment, and maintaining production and yield*".

Another aspect of concern was the lack of enforcement or implementation of preventive measures. A forester in Greece expressed concern about seeing that disease prevention measures are not being followed in practice, despite the existence of policies on paper. He referred to instances like insufficient inspection of nurseries (leading to the spread of infected plant material) and the "*uncontrolled pruning of plane trees*" with contaminated machinery, which has facilitated the spread of a lethal fungus [*Ceratocystis platani*] in Greece.

Farmers across all countries also pointed to low awareness and education among producers regarding plant health regulations and best practices as a policy shortcoming. Several participants felt that many of their peers are not well informed about either the threats or the rules. Other farmers noted that policies should align with the real needs of agricultural production to encourage farmer participation, and others emphasised the need for practical training, expert support, and user-friendly tools to facilitate adoption of new technologies, implicitly suggesting that lack of such support hinders implementation. There were also concerns about a lack of initiative and cooperation from the relevant public authorities.

In summary, farmers face a tension between policy goals and the practical needs of pest management. They largely agree with the objectives of EU plant health policies, such as promoting integrated pest management (IPM), reducing the use of hazardous pesticides, and preventing the spread of pests. Many demonstrate a personal commitment to these principles. However, they are concerned about issues such as resistance and emerging pests outpacing policy responses, bureaucratic delays in approving new solutions, insufficient on-the-ground enforcement of phytosanitary measures, and inadequate outreach to farmers. These concerns form a backdrop against which they evaluate any new initiative, including digital tools. Their responses suggest that any digital technology integration must go hand in hand with policies that are responsive, supportive, and aware of field realities. As one farmer summed up his stance, what's needed is a "well-balanced approach...integrating technological innovations with the practical knowledge of experts", implying policy should coordinate top-down innovation with bottom-up practical knowledge.

3.2.3.2 Perceived Benefits of Digital Technologies and Data Sharing for Pest Management

Across the interviews, farmers and foresters expressed a generally positive outlook on the potential benefits of digital technologies for managing plant health and pests. Even those with little personal experience using such tools were aware, at least conceptually, of their promised advantages.

The **benefits were seen as undeniable**, with a Lithuanian farmer stating that they are important and widely applied to help efficient and productive farming. Digital systems are expected to provide a practical and widely applicable system that will solve emerging problems with pests. Farmers anticipate that these technologies will support them in facing modern agricultural challenges, as an Italian farmer stated, and have proven effective in increasing

both the quantity and quality of farm production when used rationally and with agronomic knowledge. They are also seen as contributing to improving aspects like traceability and work organisation, and could potentially help the agricultural sector by reducing pesticide use and reducing long-term production costs while improving quality and quantity. One Greek farmer highlighted that investing significant resources in creating an organisation to coordinate local or regional entities for technology introduction and adoption is crucial for successful implementation.

More specifically, participants recognised the value of digital tools for **improving early detection, monitoring, and decision-making** regarding plant health risks. Benefits mentioned by French farmers include quick access to information, for example, when in doubt about a symptom, and the speed of diagnosis. A Greek farmer noted that that high-tech systems could significantly enhance the early diagnosis and management of plant pathogens, ultimately reducing crop losses. This expresses the hope that real-time monitoring (through sensors, automated traps, or image analysis via AI) will alert them to issues before they become severe. Similarly, a Greek forester pointed out the advantage of timely disease detection and more accurate monitoring of forest areas, indicating that digital surveillance could identify problems across large, remote areas that may be overlooked by humans. French winegrowers also appreciated the emphasis on speed and accuracy, viewing digital systems as a fast, accurate, and reliable source of information for plant health. Speed matters greatly in pest management, and this perception that technology could give an “early warning system” was widespread.

Another closely related benefit is **improved decision-making** through better data. Greek farmers noted that digital platforms integrating field data (like weather, soil moisture, pest alerts) can enable more informed decision-making and optimise plant protection measures. They believed this could help apply pesticides or other measures only when and where truly needed, which ties directly to both economic and environmental benefits. Digital technologies are seen as offering decision-making assistance and the advantage of AI, if “done well, good rigour... behind technical science”. Other perceived benefits include increased accuracy of advice, better anticipation of risks, and the ability to model protection programs more precisely.

Participants believe these tools can help them make good decisions, use the right products, guarantee harvest levels, and make decisions that optimise the company's economy by avoiding spending money on unnecessary products. Access to reliable information and data on plant health risks is considered very important because it enables effective problem-

solving, preventing diseases, timely protection of crops, and effective management of pest monitoring and regulation. Farmers also highlighted **economic and labour efficiency** as a benefit, saving time and resources. A French farmer listed “*less time-consuming*” as a positive aspect of certain digital tools, for example, automating monitoring tasks or quickly analysing data, which could free up the farmer’s time.

Data sharing and collaboration were frequently highlighted as crucial for enhancing plant health management. The perspective was largely positive among Greek and French farmers. Sharing data is believed to increase the amount of information which will allow AI to be more efficient and conduct accurate analysis. It also allows for the exchange of knowledge, experiences and skills, serving as a form of continuing education and enabling farmers to question their own practices by seeing what is happening with others. Participants were generally willing to share their data to contribute to a broader pest surveillance system, although some specified conditions, such as **sharing only with reliable organisations**, or ensuring **anonymity** and use solely for scientific and management-related objectives. The importance of bridging practical experience with scientific expertise through collaboration was also emphasised. One Greek farmer noted that data sharing makes sense only with nearby areas that have similar conditions to ensure applicability.

3.2.3.3 Barriers and Reservations: Cost, Complexity and Trust in Digital Technologies

While farmers recognised many potential benefits of digital tools, they also voiced significant barriers and reservations that make them hesitant to adopt these technologies in practice. Indeed, every participant who discussed positives was quick to balance them with warnings, effectively saying, “Yes, that sounds great, but...” and then listing various concerns regarding the adoption and implementation of digital technologies and data sharing for pest management. Despite growing interest in digital agriculture, most farmers currently **make little use of advanced digital technologies** for pest and disease management, relying instead on traditional methods and basic tools such as weather stations or simple online data.

While a small minority, often younger and more educated, or managing larger farms, demonstrates awareness of innovations like GIS, AI, drones, and decision support systems, the actual implementation of these tools is rare, with usage mostly limited to farm administration or isolated experiments rather than core agronomic practices. Even a young Greek farmer who demonstrated considerable awareness of digital agriculture innovations

admitted, “At the moment, I do not use these technologies in my field”, apart from checking a local weather station for planning his spray timings. Many farmers openly admit to lacking both knowledge and confidence in digital solutions, and even those familiar with the concepts often fail to apply them in practice, citing a gap between theoretical understanding and real-world use. The findings underscore a **significant disconnect between the potential of digital agriculture and its current adoption**, highlighting that for most farmers, integrating digital technologies into pest management represents a novel challenge rather than an incremental improvement. Overcoming this gap will require substantial efforts in awareness-raising, training, and demonstrating practical benefits.

A frequently cited obstacle is the **cost** of these technologies. Farmers from France and Greece stated that the technology is not very affordable, with cost being their primary concern. One Greek farmer bluntly noted that due to their cost, *“a medium-sized farmer often cannot afford to invest in such technologies alone” and that “these technologies might be better acquired by cooperatives, allowing all members to benefit from their use.* The sentiment about investment is shared by multiple interviewees, with one stating that large investments could be a disadvantage and another including the cost of implementation and maintenance among the factors to consider. While some believe digital tools could reduce long-term costs, the initial financial outlay remains a major hurdle for many farmers. The suggestion was even made that policymakers should consider subsidising them to make them affordable. Beyond the direct price, the time required for installation, training, and data management was also mentioned as a “cost”.

The **complexity and practical challenges** of using digital tools were also noted as significant barriers by several farmers. The lack of familiarity with digital technologies indicates a **knowledge gap** that hinders adoption, so the need for training and support was frequently emphasised. A farmer from France felt that there was not enough perspective to know exactly what he needed regarding training. He ideally preferred a tool that did not require a day of training or the involvement of a service company to manage the data. There were concerns about the potential for digital tools to be time-consuming and to add to the workload, with one farmer expressing worry about becoming too reliant on technology. The sensitivity and fragility of components in relation to the reality on the ground highlighted the need for technologies to be adapted to specific grape varieties and soil types. The farmers noted that they need simple instructions, underscoring the necessity for tools that are user-friendly and robust enough for practical farm environments. The emphasis on practical, hands-on training suggests farmers don’t just want a pamphlet or a one-off workshop. They would need ongoing support, perhaps demonstration projects or local training centres where they can see the tools in action on real

farms. Without such capacity-building, many admitted they would likely not use a tool correctly or to its full potential, rendering it ineffective.

Concerns around **trust and data sharing** were also discussed. While many were willing to share data, some expressed doubts about data reliability, with a Greek farmer noting that "appearances can be deceiving" and that diagnosis often requires laboratory testing, not just visual symptoms. One forester from Greece specified a willingness to share data only if anonymity is guaranteed and the data is used solely for scientific and management-related objectives. The risk of increasing social isolation was also mentioned by a French farmer as a drawback of relying on digital tools over collective human interaction.

The barriers, identified by farmers and foresters, to adopting digital pest management tools, such as high costs and uncertain returns, insufficient knowledge and skills, complexity and effort, doubts about reliability, cultural and social factors, and time constraints, are significant, but they are not unmanageable. They form a checklist of issues that need to be addressed for the successful integration of digital technologies into plant health policies. The presence of these barriers explains why current adoption is low, but it also guides what conditions farmers stipulate for considering adoption, which leads into the next theme of what support or changes they say they would need.

3.2.3.4 Support and Policy Measures Needed for Digital Integration

Building on the recognition of barriers and the value of collaboration, farmers and foresters offered a range of suggestions for support and policy changes that would help them adopt digital technologies for plant health management. **Financial measures** were frequently mentioned as crucial. Financial support could be provided through various programmes, perhaps by adding "additional scores when participating in programs" for those who use these technologies, suggested a farmer from Lithuania. Another Italian farmer proposed improving the "incentive system (by increasing it) in proportion to the actual use of these technologies and the resulting benefits". Beyond direct subsidies, increasing financial support for the development and deployment of digital technologies and simplifying the procedures for acquiring and using tools were also highlighted as essential steps by a forester from Greece. Recognising a significant knowledge gap, participants emphasised the critical need for **appropriate training** and continuous **technical support** to build confidence in using digital tools. Farmers and foresters requested clear and detailed information on innovative technologies and specific courses. The training should include hands-on instruction with clear and understandable explanations, on-site field demonstrations, and expert guidance. Simple

instructions, potentially in local languages and accompanied by videos, were also requested. Access to resources like an "Online library for expert guidance" was also mentioned as a form of needed support.

Collaboration and structural support were also seen as vital for successful digital integration. Several interviewees highlighted the potential for cooperatives to play a key role in facilitating access and support. Farmers suggested that policymakers should invest significant resources in creating an organisation that will coordinate local or regional entities for the introduction and adoption of these technologies. Training and education should be carried out at a local level, organised by municipalities or regional authorities. Participants emphasised the importance of integrating practical experience with scientific expertise and promoting collaboration among scientists, farmers, and stakeholders.

Farmers in France also indicated that leveraging **existing agricultural bodies** (like technical institutes, cooperative boards, etc.) is important. Instead of imposing top-down rules or technologies, working through organisations that farmers already interact with would be more effective. Farmers and foresters expect policymakers to be inclusive and consultative, avoiding one-size-fits-all mandates. The local focus and the use of existing networks underscore the need for innovation integration to be tailored and participatory.

In concrete terms, some of the key policy and support measures that farmers and foresters are advocating for include localised training initiatives, subsidies or grants for technology adoption, pilot programs, and demonstration farms. They also call for the encouragement of cooperative ownership or third-party services, streamlining regulations around digital technologies, and integrating digital strategies into broader policy goals. Continuous dialogue with farmers and foresters is also essential. They propose a policy roadmap from their perspective, a range of supportive measures that would enable the promised benefits of digital tools to be realised in practice, in their pest management routines.

3.2.4 Citizens

Ten qualitative interviews were conducted with citizens from Greece, Italy, Lithuania, and France, who are part of each country's STELLA multi-actor community at the local, regional, or national level, under the STELLA project's Task 5.1. Each interview was conducted to explore citizens' perceptions of EU plant health policies and how digital technologies can be integrated to manage plant pest and disease outbreaks. The citizens interviewed represent a varied group, particularly in their connection to agriculture or forestry and their prior experience with citizen science.

Several interviewees have a direct connection to the agricultural or forestry sector, including individuals who work through technical institutes, whose family members are involved in farming or agricultural research, own agricultural land, or are farmers themselves, some with family members working on the farm or holding relevant qualifications. Most of the individuals interviewed indicated that they had never participated in a citizen science project before. Only one interviewee reported prior participation, which was specifically noted as being related to biodiversity rather than agriculture, forestry, or plant health.

The interviewees displayed a wide range of self-assessed knowledge regarding plant pests and diseases. While some participants characterised their understanding as minimal or basic, others described it as moderate, often linked to educational backgrounds or practical experience. Those actively involved in agriculture reported higher levels of knowledge thanks to their professional roles, such as agronomists. Interestingly, one participant from outside the agricultural sector claimed to have an advanced understanding. A farmer highlighted the importance of knowledge gained through collaborations with agronomists and agricultural associations.

Comfort levels with digital technologies for crop and pest management were notably higher in France and Italy, where tools like decision support systems, drones, and remote sensing were commonly referenced. In contrast, participants from Greece and Lithuania expressed minimal familiarity with these technologies. Overall, most interviewees showed a willingness to engage further, indicating a commitment to contributing to the project's goals.

The thematic analysis yielded a set of key themes that sum up the perspectives shared by citizens across Greece, Italy, Lithuania, and France regarding plant health policies and how digital technologies can be integrated to manage plant pests and disease outbreaks. In total, we identified four overarching themes that are common across the countries. The themes are i) Digital Technologies in Plant Health, ii) Citizen Science Participation, iii) Data Sharing and Privacy and iv) Policy and Support.

3.2.4.1 Digital Technologies in Plant Health

During the interviews, participants shared a range of perspectives on the potential and practicalities of integrating digital technologies into plant health management. They discussed various tools they were familiar with or saw potential in, such as Decision Support Systems

(DSSs), robotics, remote sensing, connected traps, precision farming using drones for tasks like spraying, disease and soil mapping, and mobile applications or online platforms for reporting pest sightings and sharing observations.

Many saw these innovations as holding **significant promise**. Benefits highlighted the ability to facilitate solutions and farm work, increase farm productivity, reduce yield loss, enable earlier detection, potentially lead to a reduction in resources and expenses, and allow for better farm management overall. Some felt that these tools could **improve pest and disease management** at a broader European level, facilitating faster communication and data sharing, which could be particularly useful for managing quarantine pests. While recognising the potential, it was also noted that these digital tools should be viewed as additions to the existing "toolbox" of crop protection methods, which includes biocontrol, prophylaxis, and adapted agronomic practices, rather than a complete replacement for techniques like chemical methods.

However, the interviews also revealed several perceived **challenges and drawbacks** associated with the adoption of these digital strategies. A prominent concern was the high **cost** of the technology, with one participant explicitly stating that the price of the technology would be the deciding factor for the farmer. This financial barrier was seen as potentially threatening small farms, which might not be able to afford the equipment, while larger farms could better equip themselves. Participants also mentioned the practical difficulties, such as the need to master the tools and the requirement for experts to train the complex systems. There was a sentiment that increased digitisation could potentially lead to a loss of the "touch" or practical ability of agricultural technicians. Furthermore, the potential for errors in digital tools when dealing with complex or unfamiliar diseases was a concern. The need for trustworthy information was also repeatedly emphasised.

3.2.4.2 Citizen Science Participation

The theme of Citizen Science Participation primarily revolved around the potential use of mobile applications or online platforms for reporting pest sightings and sharing plant health observations. Participants generally expressed **positive views** on these tools. They were seen as a very good idea that could enable relationships between stakeholders. The benefits highlighted included facilitating **faster communication** and more effective data sharing, which could be particularly useful, especially for quarantine pests, as this would allow faster

interventions and containment measures in general. Another participant appreciated them positively, stating that this would increase the farm's productivity and reduce yield loss. Some felt that such platforms could serve as another potential method for timely intervention and problem-solving or even act as a "kind of BSV-Social Network" for sharing observations. It was suggested that the role of reporting might shift, where "the farmer... will pass on his observations to the technicians".

However, for citizens to feel confident in participating in such initiatives, certain conditions were deemed necessary. The need for sufficient information and **training** was a recurring point. This included suggestions for informative sessions, instructional videos designed to guide citizens on how to effectively use various applications, as well as providing information through meetings, training courses, and exhibitions. Basic requirements, such as a basic understanding of agriculture, familiarity with legal guidelines, and competence in digital technologies, were also mentioned. Furthermore, **trust** in the reliability and accessibility of the data shared was crucial, as were expectations regarding data confidentiality and privacy.

3.2.4.3 Data Sharing and Privacy

During the interviews, participants frequently discussed the importance of accessing **trustworthy information and data** regarding plant health risks. They wanted assurance that their data, particularly any associated personal information, would be protected and used only for **scientific or research purposes**, not for marketing. Some felt that while pest assessment data should be accessible, it should not be modifiable. For individuals involved in agriculture, this was seen as extremely important because it has a significant influence on farmers' yields and remuneration, and directly determines the farm's results. One participant emphasised its significance from an economic perspective.

Beyond its direct economic impact, reliable data was also considered important for adopting an agroecological approach, providing **advanced warning** of pests and diseases, and for preserving local wildlife. The need for trustworthiness was reiterated in the context of digital tools, such as Decision Support Systems, where farmers' reluctance to rely entirely on an application highlights the necessity for reliable data to build trust. Another participant stated that digitalisation in plant health can only be used with trustworthy data and information.

3.2.4.4 Policy and Support

The interviewees expressed varying degrees of familiarity with existing plant health policies and legislative frameworks. Participants offered several suggestions for how policymakers could better support the adoption and integration of digital technologies in plant health management. A key theme was the **need for financial support**. Practical support is also considered important, including supporting research to improve performance, streamlining administrative burdens by automating processes, and ensuring effective communication to keep everyone informed.

Some felt that policymakers should take more initiative in introducing these technologies, and a call was made for more urgent decisions and changes regarding regional policy amendments. Suggestions also included providing **access to qualified consultants** for proper guidance, promoting awareness and digital literacy through workshops in schools, and fostering more **cooperation** between farmers, scientific institutions and EU structures. Overall, there was a sense that policymakers have a significant role to play in overcoming barriers, such as cost and lack of understanding, to make digital tools more accessible and effective for improving plant health management, with one participant specifically asking for "more information and initiatives such as the STELLA project".

4 Discussion – Synthesis of results

4.1 Policy Integration and Alignment with EU and Global Frameworks

The findings reveal that EU plant health policies are broadly aligned with international standards and sustainability goals, yet gaps remain in implementation. At the highest level, the EU's legislative framework – notably **Regulation (EU) 2016/2031** on protective measures against pests – complies with the **International Plant Protection Convention (IPPC)** and reflects global biosecurity norms. The analysis, which included the associated country New Zealand, shows that both the EU and NZ emphasise commitment to international instruments like the IPPC, the **UN Sustainable Development Goals (SDGs)**, and the **One Health approach**. Aligning national measures with these frameworks is seen as essential, given that pests and diseases cross borders and climate change intensifies phytosanitary risks. This top-level alignment indicates a strong strategic commitment to early detection, prevention and response strategies in plant health governance.

Crucially, the policy mapping and interviews under Task 5.1 indicate that digital technologies are beginning to be mainstreamed into these frameworks. Policymakers highlighted that existing policies now actively support digital integration. For example, the **Common Agricultural Policy (CAP)** is cited as a driver for innovation, providing financial support and requiring Member States to include digitisation strategies in their plans. At the EU level, new horizontal initiatives and policies – such as the **Digital Europe Programme, Connecting Europe Facility, Data Act, Data Governance Act** and **Interoperable Europe Act** are establishing the legal and technical foundations necessary for digital adoption. These create an enabling environment by addressing data standards, funding digital infrastructure, and promoting interoperability. Likewise, broader strategies like the **European Green Deal** (and its **Farm to Fork** and **Biodiversity** projects) are explicitly promoting the use of digital tools in agriculture and plant health.

At the **national level**, the study found many examples of **policy support for digital solutions**. New Zealand's Biosecurity 2025 Direction Statement emphasises harnessing science and technology for smarter detection and management, including establishing national data standards and networks for sharing organism information. Interviewees from various EU countries noted systems like the EU's TRACES and EUROPHYT for phytosanitary information sharing, France's "Bulletin de Santé du Végétal (BSV) 2.0" and the ECOPHYTO plan, which subsidise precision technologies, Italy's move to electronic phytosanitary

certificates and regional e-reporting systems, Lithuania's VATIS pest information system (and IKOK platform), and Greece's digitisation of its plant health registry. These initiatives show that national authorities, in line with EU policy, are starting to integrate digital tools for surveillance, response and knowledge dissemination. Such integration supports more uniform and efficient implementation of plant health measures across the EU. Notably, the STELLA Task 5.1 analysis also identified policy gaps and needs, for instance, the requirement to update or harmonise certain regulations, in line with the targets of the EU Farm to Fork and Biodiversity strategies. This indicates awareness that policies must continually evolve to meet green and digital transition goals.

Despite solid alignment on paper, EU stakeholders reported a persistent **implementation gap between policy design and practice**. Some felt that current regulations “are not put into practice,” suggesting that having progressive policies is not enough if they do not translate into action on the ground. For example, a forester interviewee identified that disease prevention laws exist but are ignored during field operations, highlighting cases of infected plant material transmission due to poor inspection and the use of contaminated equipment. This indicates that resourcing and enforcement at the operational level lag behind policy objectives. Similarly, participants acknowledged that the EU regulations at times, fail to account for the ground realities. European regulation may seem distant and hardly equate with on-the-ground implementation challenges. This kind of observation implies the need for more vertical integration in the governance structure so that EU and national policies are adaptable and supported at the regional/local levels.

Another critical insight is the importance of **aligning policies with practical needs** and the realities of farmers and foresters. Producers and advisors largely agree with the high-level goals of EU plant health policy; for instance, they support objectives like promoting Integrated Pest Management (IPM), reducing hazardous pesticide use, and preventing the spread of invasive pests. In France, farmers demonstrated strong support for these environmental and health protections, highlighting at the same time the practical difficulties in meeting such goals. One winegrower, for instance, is personally committed to minimising treatments and has cut his pesticide use by half compared to the regional average. Yet, he stressed how challenging it is to do so while maintaining crop health. Others raised concerns that policies need to be more aware of “the real needs of agricultural production”, offering quick information on emerging risks and readily applicable solutions on the farm. In essence, while the direction of current policies aligns with sustainability and digital transition goals, the synthesis of results underscores a gap between policy ambition and agricultural reality. Closing this gap will

require not only writing supportive policies but also investing in their implementation through extension services, local capacity, and feedback mechanisms, so that ambitious frameworks (EU Plant Health Law, Farm to Fork targets, IPPC commitments) achieve their intended impact on plant health outcomes.

4.2 Data Sharing and Collaboration: Trust and Governance of Information

A major theme emerging from both the policy analysis and stakeholder interviews is the pivotal role of **data sharing and collaboration** in plant health governance. Effective digital surveillance of pests depends on timely, accurate information exchange among a wide range of actors, from farmers and foresters in the field to national plant protection organisations and EU authorities. The study found that the EU has begun to put structures in place to facilitate this exchange. For example, a *Scientific Network on Plant Pest Surveillance* was established in 2023 to provide training on pest survey methodologies and harmonise data practices across Member States. In parallel, the EU's data governance initiatives and policies and HORIZON EUROPE projects, such as STELLA Pest Surveillance System, are intended to enable secure, interoperable data flows among stakeholders. These efforts recognise that collaboration and knowledge-sharing are essential for early warning systems to function effectively on an EU scale.

Despite these developments, **trust and data governance** are still sensitive issues. Stakeholders expressed varied comfort levels with sharing data, largely worrying about how the information would be used and protected. Many interviewees stressed that digitalisation in plant health can only succeed with “trustworthy data and information” and clear rules on data use. Several farmers and advisors said they would, in principle, be *willing* to share personal or farm data for research and surveillance purposes, *provided* it is used responsibly and solely for its intended scientific or plant health purpose. Farmers and foresters require the contributed data to be handled in a transparent and confidential way without falling into the “wrong hands” or being repurposed inappropriately. For instance, one advisor shared a negative experience where data ended up misused, leading to misguided advice with “disastrous consequences for biodiversity”. Such incidents erode trust and illustrate why clear data governance protocols (regarding anonymity, access rights, and consent) are critical components of any digital plant health network.

Privacy regulations like the EU's General Data Protection Regulation (GDPR) were frequently mentioned in this context. On the one hand, GDPR provides important safeguards for personal data, aligning with the ethical use of information. On the other hand, interviewees noted that it can make data sharing burdensome – for example, vineyard advisors in one region felt that sharing pest data is “complicated even with GDPR,” as farmers are cautious and the rules for consent and data ownership are complex. In some cases, data held by private companies (e.g. from sensor providers or crop input firms) adds another layer of concern. Stakeholders want assurance that such data will not be misappropriated for commercial advantage or leaked. These findings imply that **governance arrangements must strike a balance**, facilitating the flow of pest information needed for the public good while respecting privacy and building user confidence. Instruments like the EU Data Governance Act and the upcoming European Common Data Space for Agriculture are steps in this direction, as they aim to create frameworks for sharing data securely and for agreed purposes. Still, the human factor of trust must be actively managed through engagement and clear communication about how data will be used in plant health initiatives.

The results also underscore that collaboration in plant health is not only about data but also about **multi-level and cross-sector relationships**. Participants pointed out that better communication is needed both horizontally (between sectors) and vertically (across governance levels). For instance, several highlighted disconnects between EU-level policymakers and local implementers. One of the findings was that EU policies are “far removed from the realities on the ground,” reflecting the perception that local knowledge and constraints are not necessarily accounted for in policy-making. In addition, local actors may not be as knowledgeable about or involved in developing the policies they are supposed to implement. To improve collaboration, interviewees suggested more platforms for dialogue where farmers, advisors, scientists, and policymakers can share experiences and co-develop solutions. In fact, the STELLA project's approach of organising policy workshops and stakeholder engagement via its digital platform is cited as a good practice to follow. This kind of workshop could facilitate the identification of common challenges and best practices across regions and support the development of policy recommendations that are grounded in stakeholder input and responsive to on-the-ground needs.

In summary, establishing a culture of collaboration and trust is as important as deploying the technologies themselves. Robust networks for information sharing – underpinned by clear data governance and active stakeholder inclusion – are fundamental to a responsive plant health system. The study's insights suggest that when stakeholders feel confident that their

contributions are valued and safeguarded, they are more likely to participate in digital surveillance initiatives (for example, using a citizen science app to report pest sightings or sharing farm pest data with authorities). Thus, investing in the “soft” infrastructure of trust and collaboration will directly influence the success of the “hard” digital infrastructure in plant health governance.

4.3 Benefits and Challenges of Digital Technology Adoption

The results of this study shed light on both the benefits that digital technologies promise for plant health management and the challenges that hinder their adoption. On the benefits side, there is broad agreement that digital tools can significantly strengthen plant health surveillance and response. Both the literature and interviewees highlighted how innovations like remote sensing (drones, satellites), automated pest traps, predictive modelling, and mobile reporting apps can improve the **speed and accuracy of pest detection**. Early warning systems and data-driven risk models enable authorities and farmers or foresters to identify emerging pest issues sooner and with greater precision than traditional methods. This allows for targeted interventions – for example, focusing quarantine or treatment efforts on “hotspot” areas identified via risk mapping, which can support timely eradication, minimise unnecessary pesticide use and crop losses. Such capabilities directly support the objectives of the EU Plant Health Law and international standards (IPPC) by shifting the paradigm from reactive to proactive pest management. They also contribute to environmental and health goals. Interviewees noted that if digital tools help apply treatments “as little as possible” while safeguarding crops, they align with the pesticide reduction ambitions of the Farm to Fork Strategy and the promotion of IPM and sustainable farming practices. In essence, the integration of digital technologies creates an opportunity for smarter, more sustainable plant health governance, where decisions are informed by real-time data and where interventions can be both timely and minimised in impact.

Stakeholders across different groups recognised several **concrete benefits of digital integration**. Policymakers saw value in better data for decision-making and enhanced cooperation (e.g. shared surveillance databases). Farmers and advisors appreciated the prospect of quicker information about pest risks and “practical solutions that we can easily apply in our daily work” – for instance, decision support systems that could recommend actions when a pest threat is detected. In the Use Case pilots, stakeholders anticipated that the STELLA platform’s features (like user-friendly interfaces and mobile accessibility) would improve their crop protection practices and environmental outcomes. There was also optimism

that digital monitoring could help document compliance and best practices, possibly easing access to eco-scheme payments or insurance by evidencing reduced risk. These perceived benefits and the need to make plant health systems more efficient, preventive, and aligned with sustainability targets show why the EU and national governments are investing in agri-digital innovations.

Of course, there are also significant **challenges and barriers** identified. A recurrent theme was concern about the **reliability and user-friendliness** of new technologies. Many end-users are cautious and need to be convinced that a digital tool will work as expected under real farming conditions. Some farmers voiced scepticism about “smart” monitoring systems, fearing false alarms or missed detections, especially given the high stakes of pest outbreaks. Additionally, if a tool is too complex, it can become more of a burden than a benefit. Digital tools are not always easy to use for an older generation of farmers and require dedicated training to use effectively.

The study found that **limited digital skills and confidence**, particularly among small-scale or older producers, make technology adoption a slow process. This challenge is getting worse, with concerns that over-automation might sideline human expertise. Advisors in the study stressed that while data analytics and AI are powerful, they should *complement rather than replace* agronomic knowledge and local experience. There is a tangible fear of loss of personal judgement in pest management, if farmers become too dependent on automated advice, there’s a risk of deskilling or blindly following a tool without understanding the context. These **cultural and educational factors** represent a significant hurdle that technology developers and policymakers must address through user-centric design and training.

Economic and infrastructural challenges also emerged clearly. **Cost** is a major barrier; advanced traps, sensors, or analytic services can be expensive, and many farmers operate on thin margins. Multiple stakeholders noted that without subsidies or a clear return on investment, uptake will remain limited. In some cases, even where financial support exists, the long-term maintenance and updating of digital systems raise questions of economic sustainability.

Furthermore, **adequate infrastructure** (such as internet connectivity in rural areas, data management systems, and technical support) must be in place, otherwise digital tools cannot function as intended. While not always explicitly mentioned by interviewees, it is implicit that a modern IT backbone is needed for things like uploading field observations or running cloud-based pest models. Any weaknesses there can hinder technology usefulness.

Another challenge category is **policy and regulatory fit**. The study highlighted that governance frameworks have some catching up to do with technological innovation. For instance, the use of **drones** for pest surveillance or the integration of **citizen-sourced data** in official pest alerts may face regulatory hurdles (from aviation rules to data privacy, respectively). Some participants pointed out that new tools often need official validation – e.g. a model's predictions might not yet be accepted as evidence in a quarantine decision – which can slow their adoption by agencies.

Moreover, inconsistent interpretation of regulations between different countries or regions can create uncertainty for those deploying technology. If one country's rules accommodate a digital monitoring method but others do not, it complicates scaling these innovations across the EU single market. The **implication for governance** is that policy innovation must run in parallel with technical innovation to remove unnecessary barriers and provide clear guidelines on new practices.

The weighing of benefits and drawbacks serves to establish that the integration of digital tools in plant health is a **double-edged sword**. It offers effective means to achieve policy targets and increase resilience but also introduces pragmatic, social, and regulatory complexities that must be addressed. The findings show that the benefits will be optimised by facing the challenges head-on. This includes generating user trust in technology through demonstration and education, making tools cost-effective and user-focused, and reshaping policy environments to promote new digital approaches. It is only through this that the potential of digital technologies can be harnessed in strengthening the plant health governance of the EU and its associated countries.

4.4 Barriers and Enablers to Policy Implementation and Digital Adoption

Bringing together the above insights, the study identifies the external conditions that facilitate or hinder the adoption of digital technologies and the implementation of policies that support them. Several key barriers that hinder policy implementation and digital technology adoption are discussed below:

A **lack of awareness** of plant health regulations and **limited digital literacy** among end-users are significant constraints. Many farmers, foresters and even some advisors are not well informed about existing pest rules or the availability of new tools, which undermines uptake. As one Greek farmer observed, “the lack of farmer awareness... makes sustainable crop

management more challenging,” since even the best policies will fail if the farming community doesn’t understand or buy into them. Likewise, the absence of sufficient training and capacity building means digital tools often seem discouraging or unusable to those on the ground.

The perceived **complexity of digital solutions** and **mistrust** in their outputs form another barrier. Participants noted that many technologies are not yet user-friendly, and there is a sharp learning curve for tools like AI-based decision systems or remote sensors. This complexity can breed scepticism and make farmers doubt data-driven recommendations if they do not understand how they are generated. In addition, trust has been undermined by past negative experiences, which makes others hesitant to share information or rely on such systems. Building simplicity into tool design and establishing a track record of reliable performance is thus critical to overcoming this barrier.

Strict privacy regulations and **fear of data misuse** present a double-edged challenge. While frameworks like GDPR protect individuals, they also create uncertainty over how data can be shared for plant health purposes. Farmers and advisors expressed concern about who accesses their farm data and for what ends. In some cases, this leads to reluctance to participate in digital reporting at all. An Italian agronomist emphasised the need to clearly define access rights and limits of use for any shared data. Similarly, others noted it is “very difficult to make farmers share this information,” given worries about confidentiality and consequences. Unless stakeholders are confident that their contributions will be anonymised, secured, and used ethically, data sharing will remain limited.

Another barrier repeatedly highlighted in both the literature and interviews is the economic one. The **cost of technology** – whether it be purchasing IoT devices, subscribing to data services, or maintaining equipment – is prohibitive for many users without support. Farmers who usually operate on narrow profit margins may prioritise immediate needs over investing in novel tools, especially if the return on investment is unclear. Additionally, smaller or less developed regions may lack the financial resources to deploy digital infrastructure at scale. Thus, even when policies encourage digital adoption, inadequate funding at the farm or local government level can stall implementation.

Regarding **policy and regulatory gaps**, there are areas where current policies do not fully accommodate or incentivise digital approaches. For instance, some innovative practices are in a grey zone of regulation – using a drone to survey crops for pests might run into airspace rules or sharing pest data across borders might conflict with existing reporting protocols. Interviewees noted that technologies often need to be validated by regulations before they can be widely used, yet regulatory updates lag behind tech developments. Furthermore, when

the rules are applied inconsistently, even mandated surveillance or biosecurity checks might not be happening in reality, discouraging stakeholders, who feel that their efforts might be in vain if others are not held to the same standard. Without policy reforms that provide openness, remove outdated measures, and ensure compliance, digital innovations may struggle to find their place in the plant health system.

However, the study also identified critical facilitators which can enhance progress and simplify the application of digital technologies in plant health policy. A clear enabling factor is when **policy frameworks actively support** and align with digital innovation. The study found that the CAP's requirements for member states to have digital strategies, along with EU-level initiatives (e.g. the Data Act, Interoperable Europe Act), are creating positive momentum. These policies highlight digital transformation as a priority, and they often come with funding or legislative tools that encourage adoption. At national levels, schemes like France's Ecophyto or Italy's digital certification system show how aligning national policy instruments with digital goals (through subsidies, mandates, etc.) can drive implementation. When policymakers integrate digital objectives into law and strategy, it empowers stakeholders to act, knowing that their efforts are backed by governance and may be financially or institutionally supported.

Given the barrier of cost, **providing financial aid and incentives** is a powerful enabler for adoption. Stakeholders in the study called for more programs that offer grants, tax breaks, or co-funding for purchasing or upgrading equipment. Examples suggested include subsidies for smart traps or sensors or incentive payments for farmers who participate in digital reporting networks. Such measures can lower the entry cost and risk, especially for smallholders. The availability of EU funds (through the CSPs) and national budgets earmarked for digital agriculture is thus an enabling condition that directly addresses one of the chief practical constraints.

Almost every stakeholder group emphasised that **better training and advisory support** would facilitate digital transitions. The need for practical training sessions, demonstration sites, and the inclusion of digital skills in agricultural extension came out strongly. For example, advisors themselves noted that they needed up-skilling in areas like data analysis and the use of AI tools to confidently support farmers. Enabling adoption will, therefore, require investing in human capital by organising workshops, developing easy-to-understand guides, and having tech support readily available in rural areas. The presence of knowledgeable intermediaries – such as extension agents or trained consultants – was seen as vital. These intermediaries can bridge the gap by translating digital insights into actionable guidance for farmers. The study

shows that when users feel competent and have help at hand, their willingness to try new technologies increases significantly.

Building **strong networks and communities** of practice acts as a catalyst for technology uptake. The discussion highlighted that cooperation between farmers, scientific institutions, industry, and authorities could break down scepticism and spread best practices. Peer learning is a powerful force. Initiatives like the STELLA policy workshops and the STELLA Pest Surveillance Platform aim to create these knowledge-sharing environments. By bringing different actors together, they aim to encourage the exchange of experiences and the co-creation of solutions. Another aspect of collaboration is multi-stakeholder governance by involving end-users in the design and roll-out of digital tools and making sure the tools meet real needs and gain trust. Overall, an enabling environment is one where stakeholders are not operating in silos but are connected in formal or informal networks that support mutual learning and collective problem-solving.

Finally, seeing **real-world success stories** enables further adoption. Stakeholders in the study requested more pilot projects and on-the-ground demonstrations (like those provided by STELLA's use case pilots) to showcase the value of digital approaches. When a digital system effectively contains an outbreak or a model accurately predicts a pest surge, it creates a compelling case that can convince even doubters. These tangible outcomes help convert abstract benefits into credible evidence. They also allow for refining tools with user feedback, which in turn improves the technology and its reputation. Thus, continuing to pilot and evaluate digital solutions in diverse conditions – and communicating the results – is an enabling practice. It builds the “social license” for digital tech in agriculture: farmers and officials will be more inclined to adopt innovations that have been proven in practice and endorsed by fellow practitioners. More information, dissemination and initiatives like the STELLA project itself can gradually shift perceptions from seeing digital tools as risky or novel to seeing them as standard and indispensable instruments in plant health management.

In combination, these enablers address the barriers listed earlier. For instance, strong policy support and financial incentives tackle economic constraints; training and networks address the human factor and trust issues; and successful demonstrations help refine regulatory acceptance and user confidence. The interplay of these factors will determine how effectively the EU and associated countries can implement the studied recommendations and progress toward a digitally enhanced plant health system.

Table 2: Barriers and Enablers to the adoption of digital technologies in plant health management and policies.

Barriers	Enablers
High Cost of technology, infrastructure, development, implementation, and maintenance.	Policy Support and Financial Incentives , such as grants, subsidies, tax breaks, or co-funding programs
Technical Limitations and Complexity of new digital tools, including issues with reliability, data transmission, accuracy of detection, interoperability between platforms etc.	Technological Development and the emergence of innovative tools like AI, remote sensing, IoT. Initiatives like Horizon Europe support continuous research and development.
Lack of Awareness, Knowledge, and Digital Skills among farmers, foresters, advisors, and even within administrations.	Training, Education, and Capacity Building for farmers, advisors, administrators, and inspectors is crucial to address the digital skills gap.
Data Fragmentation and Interoperability Issues across various organisations, sectors, and existing IT systems.	Development of Common Data Platforms and Interoperability Efforts for centralising data and facilitating seamless and rapid exchange.
Lack of Trust and Concerns about Data Privacy, Confidentiality, and Misuse among stakeholders.	Building Trust through Transparent Data Governance and Security measures with clear legal frameworks, defined access rights, data protection, anonymization etc.
Absence or Lag in Legal and Regulatory Frameworks to formally recognise, validate, or govern the use of new digital tools and data, creating uncertainty and hindering.	Supportive Policy Frameworks at EU and national levels, including regulations that recognise and validate new digital methods and data (policy innovation).
Social and Cultural Resistance to change, traditional agricultural practices, scepticism about technology and concerns about potential social isolation.	Building Strong Networks and Collaboration among stakeholders fosters knowledge sharing, peer learning, and co-creation of solutions.
Implementation and Enforcement Gaps , where policies exist but are not effectively put into practice.	Demonstrating Practical Utility through pilot projects, real-world applications, and on-the-ground demonstrations.
Competing Priorities and Lack of Prioritisation for plant health or digital initiatives compared to other agricultural or environmental challenges.	Strong Strategic Commitment at the EU and national levels to leverage digital technologies and prioritise plant health. Acknowledging the contribution of plant health to food security, biodiversity, and climate.

4.5 Implications for Plant Health Governance

In the framework of the STELLA project and its objectives, the above findings have several implications for the **governance of plant health** in the EU and associated countries. Fundamentally, the results suggest that governance systems need to become more **adaptive, inclusive, and proactive** to leverage digital opportunities for plant health protection.

One clear implication is that plant health governance **must update its regulatory and legislative frameworks** to integrate digital tools as standard practice. Traditional plant health

regulations, designed in an era of paper forms and manual surveys, may not yet accommodate data from drones, citizen apps, or AI-based models. To remedy this, policymakers should consider introducing guidelines or amendments that recognise and validate these new sources of information for surveillance and response. For example, suppose remote sensing or automated diagnostics can reliably detect a quarantine pest. In that case, governance frameworks should allow such data to trigger official actions (e.g. alerts or movement restrictions) alongside conventional inspections. This kind of adaptation was hinted at by stakeholders who noted the need for technologies to be “validated by regulations”. In practice, the legislation could establish technical standards for data quality, set protocols for verifying and using citizen-reported data, and clarify liability and privacy issues. Such provisions in a regulatory system can harness real-time data streams, improving compliance with international obligations like early pest reporting under the IPPC and strengthening overall biosecurity.

Another implication is the need to embrace a **more inclusive governance model**. Digital technologies enable a wider array of actors to participate in plant health measures – farmers, foresters, researchers, and even the general public (through citizen science) become key contributors of surveillance data and local knowledge. Governance structures should formalise and encourage this inclusivity. For instance, EU bodies can establish formal schemes or partnerships involving farmer networks and citizen observers as part of the pest surveillance system. This would involve trust-building and capacity-building, as discussed in Section 4.4.

The interviews revealed that farmers and foresters typically have excellent ideas and are willing to get involved when provided with the necessary equipment and assurance to do so. By institutionalising such collaboration (through agreements, community monitoring initiatives, or stakeholder committees), governance can be made more participatory and representative of ground-level realities.

The results also imply that digital plant health solutions will blur the traditional boundaries between sectors and agencies, requiring **better coordination in governance**. For example, climate data and pest data are increasingly interlinked (pests spreading due to climate change), so environmental and agricultural authorities need to share information and strategies. Similarly, digital platforms for plant health might be connected with those for food safety, trade (customs), or biodiversity monitoring. Governance mechanisms at both EU and national levels should facilitate this cross-sector integration, perhaps through inter-departmental working groups or unified data platforms. The EU’s push for interoperability and data-sharing frameworks is a step in this direction. Digital tools can be used to their full

potential across different policy domains. As an example, a robust pest surveillance system can support the Farm to Fork Strategy's pesticide reduction target by informing safer pest control decisions, goals that cut across agriculture and environment ministries. Thus, governance should be orchestrated in a way that digital innovations coherently serve multiple objectives.

From a strategic viewpoint, the discussion points to governance focusing on **capacity-building** as a core element of implementing digital plant health measures. This includes human capacity (training of staff, hiring of data analysts in plant health services, educating farmers) and technical capacity (IT infrastructure, laboratories for validating new tech). Many stakeholders noted the current shortfall in skills and resources. If governance bodies treat digital transition as a long-term change management process, they can allocate resources to gradually build up these capacities. This might mean investing in pilot projects and learning exercises (as STELLA is doing), establishing permanent units or observatories for digital agriculture within ministries, and ensuring rural development funds target digital skill development. The outcome is a more **resilient plant health system** that can cope with increasing pest pressures under climate change and globalisation. The use of digital tools will detect pests and diseases earlier and respond faster, mitigating economic and ecological damage. This improved preparedness and responsiveness are exactly what the EU's plant health policy aims to achieve in the face of rising threats. In short, governance should incorporate digital readiness as part of its core resilience strategy for agriculture and forestry.

By integrating digital tech, plant health authorities directly support the **implementation of the EU Plant Health Law** and its mandate for modern, risk-based surveillance. They also contribute to global objectives, when better pest control aids food security and sustainable agriculture targets (SDG 2, SDG 12), protects biodiversity (SDG 15), and helps mitigate climate-related pest outbreaks (SDG 13). Additionally, effective digital integration will help deliver the European Green Deal's objectives, by providing the data and tools to enact those changes. This perspective can justify allocating appropriate funding and political attention to the plant health sector. The STELLA project's emphasis on policy recommendations and toolkits accessible via its platform is one example of how aligning project-level work with EU policy objectives can support governance.

Finally, an underlying implication is that governance approaches must give attention to the **social dimension** by building trust among stakeholders and ensuring the legitimacy of digital interventions. The study showed that without stakeholder trust, even the best technological system will fail to gain traction. Thus, plant health authorities and policymakers should embed

transparency and stakeholder engagement in their governance of digital tools. This can take the form of clear data policies (who owns the data, how privacy is safeguarded), ethical guidelines for use of AI and surveillance, and open communication about both successes and failures of digital experiments. For instance, establishing community advisory panels for a new pest app can empower users. Governance must therefore cultivate that trust through accountability and inclusion, which in turn will legitimise the digital transition in the eyes of farmers, foresters, industry, and the public.

In conclusion, the implications for governance emerge as key areas that need to be addressed. These mirror the thematic insights of the study, translating them into actionable considerations for decision-makers. As the STELLA project moves from analysis (Task 5.1) to developing recommendations (Task 5.2), these governance implications will form a crucial foundation to ensure that the proposed digital innovations can be effectively integrated into the European plant health regime and beyond.

5 Conclusions

Plant health is a cornerstone of agricultural productivity, food security, and environmental protection. It lays the foundation of our food system and contributes to healthy ecosystems. However, plant pests and diseases pose significant threats, with outbreaks potentially causing substantial economic losses and negative environmental and public health impacts. Addressing these growing challenges, exacerbated by factors like climate change and global trade, necessitates innovative solutions, including harnessing the power of digital technologies.

This report, compiled under Work Package 5, Task 5.1 of the [STELLA project](#), aims to provide a comprehensive analysis of the current policy frameworks in the European Union and New Zealand regarding the integration of digital technologies into plant health policies and to gather the perspectives of various stakeholders on this evolving landscape. The report examined existing legislation, strategies, and the lived experiences of policymakers, advisors, farmers, foresters, and citizens, aiming to identify the state of play, examine how existing policy frameworks facilitate or hinder the integration of digital surveillance tools in plant health management, acknowledge perceived benefits and challenges, and highlight areas for future action to foster a more resilient and digitally enabled plant health system. This work will contribute to informing the strategic direction for future plant health policies, particularly within the context of the Common Agricultural Policy (CAP) and the European Green Deal (EGD), and supporting the effective adoption of innovative digital tools for pest surveillance and management.

The analysis reveals a **strong strategic commitment** at the EU level to leverage digital technologies for plant health and broader sustainability goals. Policies such as Regulation (EU) 2016/2031 (the **EU Plant Health Law**) and Regulation (EU) 2017/625 (the Official Controls Regulation) provide the legal foundation for protective measures against pests, aligning with international standards like the International Plant Protection Convention (IPPC). The integration of platforms like TRACES with the IPPC's ePhyto Hub and the development of regional pest surveillance networks provide evidence of institutional momentum toward more digitised and coordinated phytosanitary systems. The **Common Agricultural Policy (CAP)** is another key EU instrument promoting digital transformation in the agri-food sector, including for plant health. Digitalisation is a priority for the CAP, facilitating the achievement of the **EU Green Deal's** sustainability goals, including improved plant health and reduced chemical reliance.

Complementary EU initiatives and policies, including the **Digital Europe Programme**, the Data Act, the Data Governance Act, and the Interoperable Europe Act, are actively building the necessary infrastructure and regulatory environment to support digital transformation across sectors, including agriculture and plant health. These frameworks promote data standards, fund digital capabilities, and encourage interoperability, creating an enabling context for integrating digital tools into plant health governance.

Furthermore, the objectives of the EGD, including the Farm to Fork and Biodiversity strategies with their targets for pesticide reduction and pest control, implicitly **rely on digital innovation** for smarter pest management and enhanced surveillance. Digital technologies such as sensors, remote sensing, and AI are seen as providing the capabilities for faster detection, better monitoring, and targeted interventions necessary to meet these ambitious environmental goals.

National policies and initiatives, such as the use of systems like EUROPHYT and TRACES for information sharing, France's ECOPHYTO plan, Italy's electronic certification efforts, Lithuania's VATIS system, and Greece's digitisation of its plant health registry, demonstrate efforts at the Member State level to embed **digital tools in line with EU mandates**. Even though there are supportive policies and initiatives in place, stakeholder feedback and the analysis of implementation efforts point to persistent **gaps between strategic ambition and practical reality**.

Everyone agrees that sharing data and collaborating are essential for effective pest surveillance, monitoring and creating policies based on solid evidence, but there are significant hurdles to overcome. The main concern is **trust**, especially when it comes to who owns the data, how privacy is protected, and the risk of misuse. Furthermore, the current landscape of data regulations, such as GDPR, is quite complex. On top of that, the differences in **technical capacity** and the **lack of interoperability** between systems complicate the data exchange among authorities and stakeholders even further.

Stakeholders expressed a clear desire for common data platforms, clear legal frameworks defining data use, and incentives for participation to overcome reluctance to share valuable information. **Digital tools** such as remote sensing, IoT sensors, AI, and mobile applications offer significant **potential benefits for plant health management**, such as enhanced early warning systems, pest detection, improved accuracy, precision interventions, reduced pesticide use, and increased efficiency. The stakeholders value these benefits, hoping for more rapid access to information and solutions.

The application of such instruments is, however, **constrained by practical, social, and regulatory obstacles**. Concerns about the reliability and user-friendliness of new technologies, limited digital skills among many end-users, the high cost of implementation and maintenance, and inadequate rural connectivity infrastructure represent major hurdles. Furthermore, the uptake of digital technologies is not effective because there is a lack of awareness of existing policies and available tools among the stakeholders, along with communication gaps between different governance levels and sectors. The widespread deployment of these technologies requires validation and potential harmonisation of rules across regions.

On the other hand, the study identified **key enablers** that can lead to the digital transformation of the plant health sector. The policy support, both financial and institutional, is considered crucial. Countries should invest in education, training, and capacity building of the farmers, advisors, and administrators, as this will bridge the digital skills gap and build user confidence. The stakeholders need to build stronger networks among themselves and better collaborate through multi-actor participatory approaches and initiatives like citizen science, which can enhance knowledge sharing and encourage technology uptake. Critically, demonstrating the utility and practical worth of digital solutions through pilot projects and applications in real-world examples is vital for convincing sceptics and building trust.

As an innovation initiative under Horizon Europe, STELLA contributes to both technological development and the regulatory alignment necessary to scale digital innovations in the plant health sector across Europe and New Zealand. The findings of this policy analysis demonstrate that innovation in pest surveillance must be accompanied by innovation in governance. A digital Pest Surveillance System cannot succeed through technology alone. It requires governance models that are adaptive, inclusive, and strategically aligned across levels. Firstly, **regulatory frameworks need to evolve** to formally recognise and validate data and methods derived from new digital tools, setting clear standards for data quality and use while ensuring legal clarity and harmonisation across regions. This would provide the necessary legitimacy for digital surveillance and response to be fully embedded in official plant health measures.

Secondly, a **more inclusive, multi-actor approach could** formalise the involvement of farmers, advisors, researchers, and citizens in pest monitoring and policy co-design. Trust establishment through transparent data governance, open communication of data usage and privacy, and proactive engagement is necessary to enable stakeholder mobilisation. Such

engagement not only enriches data sources but also improves the legitimacy and responsiveness of plant health policies.

Third, **sustained investment in capacity building**, such as digital literacy training, technical support, and dedicated resources for national plant protection agencies, is essential to ensuring that all tiers of stakeholders have the infrastructure and capacity needed to implement and utilise digital tools effectively. Simultaneously, policymakers themselves would benefit from cross-sectoral coordination platforms that help align digital pest management objectives with broader environmental and agricultural goals.

Finally, any subsequent policy should be directed towards demonstrating the plain practical benefits of digital technologies in **real-world settings** and towards rendering instruments usable, affordable, and aligned with the actual needs and realities of forestry and agricultural practices, through further research. The Use Case Pilots embedded in STELLA offer a valuable opportunity to test and compare models, even by involving digitally advanced non-EU partners such as New Zealand, assess institutional readiness, and co-develop solutions with users. These pilot results should be evaluated not only for technical performance but for their policy relevance, including the institutional adjustments required to scale promising innovations.

Table 3: Initial policy recommendations for integrating digital technologies into plant health management and policies.

Recommendation Area	Specific Recommendation
Regulatory Frameworks	Update regulatory and legislative frameworks to integrate digital tools as standard practice, formally recognising and validating data and methods derived from new digital tools.
Data Governance & Standards	Set clear standards for data quality and use while ensuring legal clarity and harmonisation across regions.
Data Governance & Trust	Establish trust through transparent data governance, open communication of data usage and privacy, and proactive engagement.
Inclusivity & Collaboration	Embrace a more inclusive, multi-actor approach to formalise the involvement of farmers, advisors, researchers, and citizens in pest monitoring and policy co-design.
Capacity Building	Sustain investment in capacity building, such as digital literacy training, technical support, and dedicated resources for NPPOs
Demonstration & Alignment	Direct subsequent policy towards demonstrating the practical benefits of digital technologies in real-world settings.
Usability & Affordability	Ensure instruments are usable, affordable, and aligned with the actual needs and realities of forestry and agricultural practices.
Strategic Commitment	Secure the path forward through strategic clarity, institutional coordination, and the inclusion of stakeholders at the heart of EU's plant health systems.

It is feasible for policymakers to create an environment where digital technologies are not just a strategic goal or a technical add-on, but a practical, trusted, and effective component of a resilient and sustainable plant health system, ultimately contributing to the objectives of the CAP and the European Green Deal. While STELLA has only begun its journey, the groundwork laid through this policy analysis reveals both the urgency and the possibility of transforming plant health governance in Europe. The path forward must be secured in strategic clarity, institutional coordination, and the inclusion of those most affected by policy decisions, farmers, foresters, advisors, and citizens at the heart of Europe's agri-food systems.

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7 APPENDIX

7.1 Interview Guide for Policymakers

II. Background information	
i.	Can you explain your role and responsibilities regarding agricultural/forestry/plant health/digital policy at the national or regional level?
ii.	How long have you been involved in policymaking? (Number of years)
iii.	Are you willing to be contacted for follow-up questions after the interview?
Yes ☐	No ☐
III. Plant Health & Digitalisation	
1.	Are you familiar with the EU's plant health legislative framework (Regulation (EU) 2016/2031)?
Yes ☐	No ☐
2.	How do national and/or regional plant health policies align with the EU's plant health legislative framework?
3.	Can you highlight key policies or initiatives that have significantly advanced digitalisation in agriculture in the EU or in your country?
4.	What are the main opportunities and challenges in integrating digital technologies, such as those being developed in the STELLA project (AI, remote sensing, IoT, and citizen science), into plant health policies in your country?
5.	What is your opinion on the importance of capacity building and training programs in facilitating the adoption of digital technologies for plant health?

6. What are your thoughts on the role of citizen science in enhancing plant health surveillance and monitoring in your country or region?
IV. Data Sharing
7. The STELLA project aims to develop a Pest Surveillance System (PSS) that relies on data sharing. How can data sharing contribute to more effective and evidence-based policies in areas like plant health, pesticide reduction, and environmental protection?
8. How can national or regional policies be structured to enhance data sharing and collaboration among the various stakeholders involved in plant health management?
V. Suggestions - Final Remarks
9. What specific policy recommendations would you suggest to promote the wider adoption and integration of digital technologies in plant health management throughout your country?
10. What advice would you give to researchers focused on digitalisation in agriculture, forestry, or the plant health sector?

7.2 Interview Guide for Advisors

II. Background Information
i. What is your current position and area of expertise when it comes to advising farmers and foresters?
ii. How many years of experience do you have working as an advisor for farmers/foresters?

iii. Are you willing to be contacted for follow-up questions after the interview?
Yes ☐ No ☐
III. Plant Health and Digitalisation
1. Are you familiar with the EU's plant health legislative framework (Regulation (EU) 2016/2031)?
Yes ☐ No ☐
2. Are you aware of any digital tools or technologies that are currently used for managing plant health? If yes, which ones?
3. What are the main challenges in promoting the adoption of digital technologies for pest and disease management through EU, national, and regional policies?
4. What are your thoughts on the benefits and potential drawbacks of digital technologies, such as AI, remote sensing, IoT, citizen science, and decision support systems, in improving pest and disease management?
5. What are the most effective methods to educate farmers and foresters about the benefits and practical uses of digital tools for managing pests and diseases?
6. What training or resources would help you guide farmers and foresters in using digital technologies for pest and disease management effectively?
IV. Data Sharing

7. How important is it for you to have access to reliable information and data on plant health risks and why?
8. What are your thoughts on the importance of data sharing and collaboration in enhancing plant health management?
V. Suggestions - Final Remarks
9. What suggestions do you have for policymakers to better support the adoption and integration of digital technologies in plant health management?
10. Is there anything else you would like to share about your experiences with plant health management, pest surveillance, early pest detection and related European/national/regional policies and legislation?

7.3 Interviews with Farmers/Foresters

II. Background Information
i. What type of farming do you practice?
☐ Cereals ☐ Other field crops ☐ Horticulture, without greenhouses ☐ Horticulture, in greenhouses ☐ Wine ☐ Olive oil ☐ Other permanent crops ☐ Apiculture ☐ Forestry ☐ Other If other, please specify:.....

ii. How big is your farm/forest (<i>in hectares</i>)?
iii. How long have you been involved in farming/forestry? (Number of years)
iv. How old are you?
☐ Below 30 ☐ From 30 to 39 ☐ From 40 to 49 ☐ From 50 to 64 ☐ 65 or over
v. What is the level of your agricultural/forestry training?
☐ Practical experience only ☐ Basic agricultural/forestry training (secondary school/ certificates or short courses that cover foundational knowledge) ☐ Full agricultural/forestry training (at least 2 years of continued training at university or another institute of higher education specialised in agriculture or associated) ☐ Other If other, please specify:
vi. Are you willing to be contacted for follow-up questions after the interview?
Yes ☐ No ☐
III. Plant Health and Digitalisation
1. What are your main concerns regarding plant health and pest management policies?
2. Are you familiar with any digital tools or technologies currently used for plant health management? If so, which ones?
3. Are you currently using any digital technologies in your farming/forestry practices? If so, which ones, and how have they impacted your operations?

4. What are your perspectives about the benefits and drawbacks of the potential of digital technologies, such as AI, remote sensing, IoT, citizen science and decision support systems, to improve pest and disease management?
5. What factors would influence your decision to adopt or reject a new digital pest and disease management technology?
6. What kind of support or training would you need to feel more confident using digital tools for plant health management?
IV. Data Sharing
7. How important is it for you to have access to reliable information and data on plant health risks and why?
8. Would you share your data to contribute to a broader pest surveillance system?
V. Suggestions - Final Remarks
9. What are your suggestions for policymakers on how to better support the adoption and integration of digital technologies for plant health management?
10. Is there anything else you would like to add about your experiences with plant health management, pest surveillance, early pest detection, integrated pest management and related European/national/regional policies and legislation?

7.4 Interviews with Citizens

II. Background Information
i. Do you or anyone in your household work in agriculture or forestry?

ii. How would you describe your level of knowledge about plant pests and diseases?
iii. Have you ever participated in a citizen science project before?
Yes ☐ No ☐
If yes, was it related to agriculture/forestry or plant health? Provide a short description.
iv. Are you willing to be contacted for follow-up questions after the interview?
Yes ☐ No ☐
III. Plant Health and Digitalisation
1. Are you aware of the threats that plant pests and diseases pose to agriculture, forestry, the environment, the economy, and food security?
2. Are you familiar with the EU's plant health legislative framework?
Yes ☐ No ☐
3. Are you familiar with any digital tools or technologies being used for plant health management? If so, which ones?
4. What are your views on the benefits and drawbacks of digital technologies like AI, remote sensing, IoT, citizen science, and decision support systems in improving pest and disease management?
5. What do you think about using mobile apps or online platforms to report potential pest sightings and share observations on plant health in your local area?

6. What information or training would help you feel confident participating in citizen science initiatives for plant health?
IV. Data Sharing
7. How important is it for you to access trustworthy information and data regarding plant health risks, and why?
8. What are your expectations for data privacy and the use of information in citizen science projects?
V. Suggestions - Final Remarks
9. How can policymakers better support the adoption and integration of digital technologies in plant health management?
10. Is there anything else you would like to add about your experiences with plant health management, pest surveillance, early pest detection and related European/national/regional policies and legislation?