



MYMATCH

Deliverable D3.2

List of End-user Needs and Requirements



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R	Document, report	X
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DATA	Data sets, microdata, etc	
ETHICS	Ethical analysis of the content of the surveys, informed consent, data management, with the approval of ethics committee before the begging of the activities.	
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Dissemination level		
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Project's summary

Climate change amplifies food safety risks by fostering the proliferation of pathogens and contaminants in the food supply chain and introducing unfamiliar or novel hazards.

Among the food safety threats, because of their ubiquity, MYMATCH will consider the effects of climate change on a selection of mycotoxins (related to fungi belonging to *Aspergillus*, *Fusarium*, and *Alternaria*) occurring in maize, wheat, tomato, and nuts.

Thanks to a strong and multi-actor partnership, MYMATCH will contribute to:

1. the prediction and mitigation of risk related to fungi and mycotoxin occurrence,
2. the assessment of mycotoxins exposure in humans (concerning different diets) and animals, and
3. the implementation of proper risk management measures.

This will be achieved with data collection taking place at different levels, from literature considering events that happened in the past, under controlled environments and open fields, enabling the generation of the missing datasets needed to fulfil the project aims.

This will support the development and implementation of fungi and mycotoxin predictive models founded on accurate climate change scenarios to anticipate the changes in mycotoxin occurrence in European food systems.

MYMATCH AI mycotoxin management Platform will be the final output, the support for all food system actors with tailored predictions, recommendations, and mitigation approaches. By using this platform, the agri-food researchers, farmers, industry stakeholders, and policymakers, involved in the project through the MYMATCH's Multi-Actor Framework, will be assisted in taking threat-mitigation initiatives and in decision-making, both in the short- and strategic long-term planning.

MYMATCH tools and methods will be generated in a way that is easily extendable to other contaminant issues and co-created and developed with a strong interaction with potential users like EFSA.

Document's objective and executive summary

The intensifying impacts of climate change have emerged as a formidable challenge to global food safety, posing serious risks to human health through the increased prevalence of biological and chemical contaminants in food systems. Among these, mycotoxins (MY), toxic secondary metabolites produced by certain fungi, present a particularly persistent and complex challenge. MYs can be produced at multiple stages of the food system—from cultivation and harvest to storage and processing—each of which is sensitive to climate variability. Recent studies have found MY occurrence above detectable levels in 60-80% of food samples. Climate change has been shown to influence both the geographical distribution of mycotoxigenic fungi and their toxin-

producing capacities, potentially leading to elevated contamination levels in some regions and the emergence of new hotspots in other. The consumption of food products contaminated with mycotoxins adversely affects human and livestock health, undermines the marketability of food commodities, and heightens food safety concerns. Estimates suggests that over five billion people are exposed daily to mycotoxins. Mycotoxins exert various adverse effects on human health, including carcinogenicity, mutagenicity, teratogenicity, cytotoxicity, neurotoxicity, nephrotoxicity, immunosuppression, and estrogenic effects. According to the Food and Agriculture Organization (FAO), an estimated 25% of food is contaminated by mycotoxins, with severe consequences for health as well as economic prosperity globally. Although the risks from mycotoxins are well known, climate change is expected to alter their occurrence, posing new challenges for food safety and security. These contaminants are not only a threat to public health-causing hepatotoxic, mutagenic, and carcinogenic effects-but also jeopardize food security and international trade, especially in developing countries where monitoring systems are less robust. Given the multifaceted nature of food safety under climate stress, effective stakeholder engagement-encompassing policymakers, farmers, scientists, food producers, and consumers is essential. Furthermore, innovations in artificial intelligence (AI) are redefining food safety protocols. Machine learning models and AI-driven diagnostics are enabling real-time detection of aflatoxins and other contaminants, overcoming the cost and time barriers of traditional methods. The development of mycotoxin detection methods must consider the diverse and evolving needs of end users, as stakeholder demands are constantly changing. However, a common pitfall in the development of such methods is the limited or late involvement of stakeholders in the research process. Therefore, identifying and incorporating stakeholder requirements early in the development process is essential to ensure that new detection technologies are both practical and widely adopted. As climate change alters pathogen ecology and increases chemical risks in the food chain, integrating AI with genomic tools and blockchain technologies could provide a resilient, transparent, and equitable food system. Thus, ensuring food safety in the era of climate change requires a coordinated approach grounded in scientific innovation, policy reform, and inclusive stakeholder participation to safeguard human health and promote sustainable food systems. The main objective of this work is to contribute to the effective implementation of the MyMATCH project by supporting the co-creation of a shared food system perspective and the identification of user requirements. Partners' needs are only one component of the overall requirements and will be aggregated with data collected from surveys and inputs provided by the SAB. The activities presented, such as collecting partner needs, conducting tailored stakeholder surveys, and developing a common glossary, are designed to ensure that each component meaningfully advances the project's overall objectives.

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List of abbreviations

AI – Artificial Intelligence

API – Application Programming Interface
CERPS – Commissione Etica per la Ricerca in Psicologia
EFSA – European Food Safety Authority
EL – Greece
ES – Spain
EU – European Union
FAO – Food and Agriculture Organization
FR – France
GDPR – General Data Protection Regulation
HTTPS – HyperText Transfer Protocol Secure
HU – Hungary
ID – Identification Number
IT – Information Technology
IT – Italy
JWT – (JSON Web Tokens)
MY – Mycotoxins
MIR – Mid-infrared
NIR – Near-infrared
NO – Norway
PT – Portugal
QA – Quality Assurance
REST – Representational State Transfer
RS – Serbia
SAB – Stakeholders Advisory Board
SPSS – Statistical Package for the Social Sciences
SOA – Service-Oriented Architecture
UK – United Kingdom
WP – Work Package

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1. Introduction

The intensifying impacts of climate change have emerged as a formidable challenge to global food safety, posing serious risks to human health through the increased prevalence of biological and chemical contaminants in food systems. It alters the occurrence, distribution, and intensity of biological and chemical hazards—such as pathogens, natural toxins, and environmental contaminants within the food supply chain. Rising temperatures, shifting precipitation patterns, and extreme weather events influence the occurrence and severity of foodborne diseases and mycotoxin contamination, particularly in crops like grains and nuts (Casu et al., 2024; Taiwo et al., 2025; Zai et al., 2025). Among these, mycotoxins (MY), toxic secondary metabolites produced by certain fungi, present a particularly persistent and complex challenge. MYs can be produced at multiple stages of the food system—from cultivation and harvest to storage and processing—each of which is sensitive to climate variability. Their heat stability and resistance to conventional food processing make them difficult to eliminate, posing ongoing risks to public health and economic stability. Mycotoxins, (such as aflatoxins produced by *Aspergillus* spp) are increasingly prevalent due to favorable conditions for fungal proliferation under warmer climates (Deshmukh et al., 2025; Şen & Kabak, 2025).

Recent studies have found MY occurrence above detectable levels in 60-80% of food samples (Eskola et al., 2020), with the economic burden reaching billions of dollars annually in the United States alone. Climate change has been shown to influence both the geographical distribution of mycotoxigenic fungi and their toxin-producing capacities, potentially leading to elevated contamination levels in some regions and the emergence of new hotspots in other (Battilani & Leggieri, 2015; Medina et al., 2017; Moretti et al., 2019). An estimated 30 to 50% of food commodities are lost during pre-harvest or post-harvest globally, which not only threatens global food security but also leads to the inefficient use of 1.47-1.96 Gha of arable land, 0.75-1.25 trillion cubic meters of water, and 1 to 1.5% of global energy (Fox & Fimeche, 2013). The consumption of food products contaminated with mycotoxins adversely affects human and livestock health, undermines the marketability of food commodities, and heightens food safety concerns (Soares Mateus et al., 2021). Estimates suggest that over five billion people are exposed daily to mycotoxins (Khodaei et al., 2021).

Mycotoxins exert various adverse effects on human health, including carcinogenicity, mutagenicity, teratogenicity, cytotoxicity, neurotoxicity, nephrotoxicity, immunosuppression, and estrogenic effects (Silva et al., 2019). The severity of these effects depends on the amount ingested, duration of exposure, and individual factors such as age, gender, body weight, diet, and health status (Abrunhosa et al., 2016). For instance, a poor and unbalanced diet increases the risk and intensity of mycotoxicosis, which may be further influenced by interactions between mycotoxins that can produce antagonistic, additive, or synergistic outcomes (Magnussen, 2013; Šegvić Klarić, 2012; Smith et al., 2016).

According to the Food and Agriculture Organization (FAO), an estimated 25% of food is contaminated by mycotoxins, with severe consequences for health as well as economic prosperity globally (Soares Mateus et al., 2021). Although the risks from

mycotoxins are well known, climate change is expected to alter their occurrence, posing new challenges for food safety and security (Adunphatcharaphon et al., 2022). These contaminants are not only a threat to public health-causing hepatotoxic, mutagenic, and carcinogenic effects-but also jeopardize food security and international trade, especially in developing countries where monitoring systems are less robust (Subedi et al., 2025). Integrated surveillance strategies, such as those adopted in Singapore using human biomonitoring and total diet studies, are becoming critical to assess population-level exposures to chemical hazards (Li et al., 2025).

Given the multifaceted nature of food safety under climate stress, effective stakeholder engagement-encompassing policymakers, farmers, scientists, food producers, and consumers is essential. Furthermore, innovations in artificial intelligence (AI) are redefining food safety protocols. Machine learning models and AI-driven diagnostics are enabling real-time detection of aflatoxins and other contaminants, overcoming the cost and time barriers of traditional methods (Deshmukh et al., 2025; Tan et al., 2025).

With the growing use of user-friendly testing tools-from pregnancy tests to rapid mycotoxin kits, it is essential to identify the end-user profile and integrate their needs early in the development process to ensure effective and accessible technologies. The development of mycotoxin detection methods must consider the diverse and evolving needs of end users, as stakeholder demands are constantly changing (Adunphatcharaphon et al., 2022; Tittlemier et al., 2022). Technologies such as near-infrared (NIR) and mid-infrared (MIR) spectroscopy (De Girolamo et al., 2019; Shen et al., 2022), as well as NIR-based hyperspectral imaging (Femenias et al., 2022), are gaining popularity due to their simplicity and environmentally friendly approaches (Freitag et al., 2022). However, a common pitfall in the development of such methods is the limited or late involvement of stakeholders in the research process. This is problematic, as different user groups - such as national reference laboratories, which focus on confirmatory methods (Eskola et al., 2020), and the food industry, which often relies on rapid screening tools like ELISA (Gruber-Dorninger et al., 2019)-have distinct needs and expectations. Therefore, identifying and incorporating stakeholder requirements early in the development process is essential to ensure that new detection technologies are both practical and widely adopted.

Simultaneously, the application of AI in risk assessment is gaining traction, enabling predictive analytics that support proactive responses to emerging food safety threats (Liu et al., 2025). As climate change alters pathogen ecology and increases chemical risks in the food chain, integrating AI with genomic tools and blockchain technologies could provide a resilient, transparent, and equitable food systems (Liberty, 2025).

Thus, ensuring food safety in the era of climate change requires a coordinated approach grounded in scientific innovation, policy reform, and inclusive stakeholder participation to safeguard human health and promote sustainable food systems. This work aims to contribute to the effective implementation of the MyMATCH project by supporting the co-creation of a shared food system perspective and the identification

of user requirements. Partners' needs are only one component of the overall requirements and will be aggregated with data collected from surveys and inputs provided by the Stakeholders Advisory Board (SAB). The activities presented, such as collecting partner needs, conducting tailored stakeholder surveys, and developing a common glossary, are designed to ensure that each component meaningfully advances the project's overall objectives.

2. Description of Activities

2.1 Partners' Needs and Technical Requirements

2.1.1 Overview

Effective project implementation requires a comprehensive understanding of all end-users needs, both from an operational and technical standpoint. This chapter synthesizes the key requirements gathered from partner meetings, reflecting a cross-section of end users, as the partners either represent or possess deep knowledge of end-user needs. It explicitly addresses requirements related to weather data management, digital agronomic record-keeping, standardized data formats and sharing procedures, and the necessary Information Technology (IT) infrastructure, including a secure, compliant data repository for the project platform.

2.1.2 Partners' Operational Needs

The following operational needs have been identified:

WP4 Requirements: Clear guidelines on methods, data formats, and standards, aligned with joint schemes established within WP4 and WP7.

WP5 Requirements: Detailed clarification of planned activities, data types, and sharing procedures. A significant consensus emerged on adopting standardized data schemes, particularly for field mycotoxin data management, similar to those already employed by WP4. Additionally, a tailored dashboard for field data management was requested to facilitate efficient data visualization and management on the project platform.

WP6 and WP7 Requirements: Clear and standardized procedures for data sharing and management to ensure consistency across different work packages.

Weather Data Management: Partners expressed the necessity for adaptable weather data formats to match diverse operational contexts and specific requirements, ensuring maximum usability across all partners.

Agronomic Digital Record-Keeping: Strong emphasis on the need to develop a reliable, user-friendly digital notebook for agronomic data, allowing standardized, secure, and efficient record-keeping and real-time monitoring of agronomic activities.

2.1.3 Technical Needs for Platform Creation

The platform creation, driven by an advanced IT infrastructure, involves comprehensive technical specifications and requirements. Below, we outline the essential technical components identified for the MYMATCH AI management platform.

Distributed Architecture Philosophy

The platform architecture is designed based on a distributed model, comprising dedicated data storage servers, service management servers, and servers for hosting AI models. A virtualized environment is established, underpinned by a distributed backup system, addressing crucial aspects such as:

Data Redundancy: Ensuring data duplication to prevent loss due to hardware failures.

High Availability: Maintaining continuous operational performance and access.

Security and Disaster Recovery: Implementing robust security measures and a comprehensive recovery strategy to manage potential threats and disruptions.

Key technologies include PostgreSQL/PostGIS for data model management, and VMware as the virtualization backbone supporting the hosting architecture.

Data Repository

A centralized repository compliant with stringent data security standards and protection regulations will serve the project's multiple needs, including:

Secure Data Storage: Ensuring data integrity and confidentiality.

Data Sharing Capabilities: Facilitating efficient, secure, and role-based access to data across partners and work packages.

Data Input for Model Simulation: Providing a robust environment for uploading, processing, and managing input data required for advanced predictive model simulations.

2.1.4 Data Flow Management

The project employs a Service-Oriented Architecture (SOA) to enhance modularity, scalability, and interoperability. Data Input/Output (I/O) operations are managed via HTTPS REST APIs to guarantee seamless data transfer and integration. APIs are carefully designed to cater to specific data requirements, enabling efficient and precise communication between different platform modules. Standardized data formats such as GeoJSON and JSON ensure maximum flexibility and compatibility.

Technologies employed in data flow management include:

J2EE, to manage API services and ensure robust data flow.

Python, C/C++, Matlab, PL/pgSQL, R: For advanced data manipulation and specialized computational procedures.

Access Control and Scalability

Access control is managed through a double-token authentication system (OAuth 2.0), ensuring secure and scalable user authentication. The platform will employ role-based access control, allowing specific user roles to have tailored access to various platform functionalities and datasets. This ensures granular control over sensitive information and system features.

Technological solutions to manage access control include:

J2EE, Implementation of web services and role-based access management.

JWT (JSON Web Tokens), For secure user profiling and session management.

PostgreSQL, For comprehensive management of user permissions and data security protocols.

2.1.5 Partners' Needs and Technical Requirements Conclusion

The identification and clear documentation of end-users' operational and technical needs ensure the robust foundation and tailored implementation of the MYMATCH platform. By addressing these precise requirements, the project aims to deliver an efficient, secure, and user-friendly digital environment, significantly enhancing partners' capabilities to manage agronomic data, weather data, mycotoxins and fungi standardized data formats, effectively. All partner needs regarding data formats, metadata, and database creation will be integrated within WP7, which will develop a structured common database. Similarly, information collected regarding platform creation needs will directly inform Task 3.3 in developing MYMATCH AI MY Management Platform's architecture and technical specifications.

2.2 Survey Development (Farmers, Policymakers, Food Industry, Consumers)

The concept of the stakeholder requirements survey was to include all actors of the food chain for which mycotoxin testing might be relevant. The survey questionnaire protocol was composed based on inputs by a multi-disciplinary team, including experts from the field of mycotoxin detection, technology development, stakeholder engagement, and end-user studies. Besides the selected group of AI developers, actual stakeholders in the field of mycotoxin testing were also involved in the process. The surveys aimed to holistically assess stakeholder awareness, attitudes, and adaptive capacities in response to climate-induced food safety risks, particularly mycotoxin contamination. Tailored online questionnaires were developed for four key groups: farmers, policymakers, food industry professionals, and consumers. These instruments were designed to collect both quantitative and qualitative insights while maintaining structural consistency across stakeholder categories to facilitate cross-sectional analysis.

2.2.1 Farmers and Food Industry Survey

The farmer and food industry surveys shared a five-part structure:

Climate Change Perceptions and Challenges-Items - This section explored how respondents perceive the influence of climate variability on agricultural production and food safety, including exposure to extreme weather and associated impacts on crops, pests, and supply chain operations.

Mycotoxins Contaminants Views & Food System Awareness - Respondents were asked about their knowledge of mycotoxins, perceived contamination risks, and awareness of how such risks intersect with broader food system vulnerabilities.

Digital Knowledge - This section assessed familiarity with and use of digital tools for food safety, such as data logging systems, predictive platforms, and AI-driven monitoring technologies.

Willingness to Engage in Multi-Actor Platforms - Here, the focus was on respondents' openness to participate in collaborative initiatives involving researchers, public agencies, and other stakeholders, to address food safety challenges collectively.

Demographic Information - Basic demographic data were collected to contextualize responses and allow for subgroup analysis.

2.2.2 Consumer Survey

The consumer survey was structured into four sections:

Climate Change Perceptions and Challenges - Questions examined awareness of climate change and its potential to disrupt food systems and compromise food safety.

Food Safety Concerns and Mycotoxins Contaminants - Respondents indicated their level of concern regarding contaminants such as mycotoxins, and the trust they place in regulatory bodies and food labeling.

Experience with Digital Technologies for Food Safety Information - This section explored how consumers access food safety information online or via digital tools, and their preferences for receiving alerts or traceability data.

Demographic Information - Socio-demographic data were gathered to examine patterns across income, education, and geographic location.

2.2.3 Policymakers Interviews

Given the complexity and strategic nature of the policymakers, we will adopt a qualitative, interview-based method aimed at collecting deeper and more context-specific insights from selected policymakers. The interviews will be conducted one-on-one (range 10 - 15 participants) and guided by five thematic areas:

Climate Change and Food Safety - Exploring perceptions of climate-related risks to national/regional food safety and the adequacy of current responses.

Mycotoxins and Risk Management - Understanding awareness of mycotoxin contamination, current mitigation strategies, and regulatory or institutional gaps.

Digital and AI Integration - Assessing familiarity with digital tools, including AI-based systems, and their integration (or lack thereof) into food policy frameworks.

Multi-Actor Collaboration - Discussing openness to cross-sector collaboration and participatory governance in the design of future food safety strategies.

Institutional Context - Capturing the respondent’s professional role, policy level, and organizational type to contextualize responses.

The interview guide will follow a semi-structured format to allow for depth and flexibility, while ensuring consistency across interviews. This qualitative approach is expected to generate more targeted and actionable insights than a survey could provide, particularly in relation to policymaker priorities, decision-making processes, and how MYMATCH outcomes can align with real-world needs.

3. Methodology

3.1 Study Design and Sampling

A quantitative study design was adopted, using a purposive, non-probabilistic sampling strategy combined with a snowball recruitment approach. This method is appropriate for exploratory research aimed at understanding stakeholder perceptions. Initial stakeholder groups were identified through partners’ networks, professional associations, institutional contacts, and targeted outreach to farmers, food industry actors, policymakers, and consumers.

An initial stakeholder mapping exercise identified 264 relevant individuals across four key groups: Farmers (58), Consumers (36), Food Industry (87), and Policymakers (84) as highlighted in Table 1 below. These mapped stakeholders form the preliminary sampling frame for survey distribution. Notably, many of these individuals represent broader collectives such as producer associations, industry unions, and policy networks, offering extended access to a wider range of stakeholder views.

S.No	Country	Farmers	Consumers	Industry	Policymakers	Total
1	ES	3	4	4	2	13
2	HU	3	2	5	2	12
3	FR	3	3	5	4	15
4	NO	2	1	6	4	13
5	UK	4	3	7	3	17
6	PT	5	1	5	4	15
7	RS	9	1	5	4	19
8	HU	0	0	0	0	12

9	EL	3	1	5	3	12
10	IT	4	13	13	15	45
11	IT	0	0	0	0	0
12	IT	22	7	32	43	104
Total		58	36	87	84	264

Table 1: Stakeholders' Distribution by Country and Group

While final response numbers will depend on participation rates, the actual sample is expected to exceed the initial mapping due to broader dissemination via the MYMATCH consortium's networks, the European Union (EU) Food Safety platform, professional associations, and other engagement channels. Quota sampling and continuous monitoring will be applied to support balanced representation across the four stakeholder groups. This approach is intended to ensure meaningful and diverse input to guide the validation and refinement of the MYMATCH platform. The study aims to collect a minimum of 200 completed questionnaires.

3.2 Data Collection Tools

Given the quantitative nature of the study, structured surveys have been developed for each stakeholder group: farmers, food industry representatives, policymakers, and consumers. These surveys are designed to capture measurable data on knowledge, practices, and perceptions related to the project's objectives.

To streamline data collection and ensure consistency across countries, all surveys will be digitized and administered using Qualtrics, a secure and widely used online survey platform. Qualtrics will enable efficient distribution, centralized data management, and real-time monitoring of responses. The platform also supports multilingual versions, allowing each partner country to deploy the survey in their respective languages while maintaining uniformity in structure and logic.

3.3 Statistical Analysis

Given the quantitative nature of the data, statistical analysis will be conducted to identify patterns, trends, and relationships across stakeholder groups and countries. Descriptive statistics will be used to summarize key variables, while inferential techniques will be applied to explore associations and test hypotheses as appropriate.

In addition, we plan to carry out qualitative interviews with selected key policymakers to gain deeper strategic insights, and we are considering the use of a professional panel service to support the recruitment of consumer participants for the data collection.

The choice of statistical tests will depend on the nature of the data collected and the specific research questions addressed. Analyses will be performed using standard statistical software (e.g., SPSS, Stata etc.,) to ensure accuracy and reliability of results.

Cross-country comparisons and subgroup analyses may also be conducted to highlight context-specific insights.

3.4 Ethical Considerations

Ethical compliance is a central component of this research. All activities involving human participants will adhere to ethical principles, including participation to surveys, informed consent, confidentiality, voluntary participation, and data protection in accordance with applicable regulations.

The necessary documentation for ethical approval has been prepared and is ready for submission to the Ethics Commission for Research in Psychology (Commissione Etica per la Ricerca in Psicologia – CERPS). The approval process is necessary as a condition for the beginning of the activities with the stakeholders, and will ensure that the study design, instruments, and procedures align with ethical standards for research involving human subjects.

4. Expected Results & Discussion

4.1 Personas (Clustering) of Stakeholders

Personas are abstract description of potential target users that are invented. They are based on real data about user behaviors, goals, and motivations, and help teams understand and empathize with the needs of their target audience. The focus of the tables below is to provide one illustrative example per stakeholder type relevant to the project.

4.1.1 Farmers

Example of personas (clustering) of farmers.

MYMATCH PERSONA	
PERSONA ID	PERSONA ROLE IN MYMATCH
ANYS_01	Farmer
IDENTITY	QUOTES
<i>(name, age, occupation, domain, years of experience)</i>	<i>(important things he/she said)</i>
Male farmer, aged 45 Based in Northern Italy Manages approximately 150 hectares of wheat and maize Educational background: High school diploma	<i>“With just a high-school background, I need tools that explain risks simply. I can’t spend hours learning complex software—I need clear, practical advice on my phone so I can protect my harvest.”</i>

GOALS <i>(what he/she wants to achieve)</i>	FRUSTRATIONS / PAIN POINTS <i>(what frustrates him/her currently at work)</i>
<ul style="list-style-type: none"> • Primary Goal: Minimize mycotoxin contamination in crops to ensure marketability and food safety compliance • Secondary Goals: • Optimize pre-harvest management based on climate predictions • Reduce economic losses from rejected harvests • Maintain sustainable farming practices while adapting to climate change • Access real-time risk assessments for on-farm decisions 	<ul style="list-style-type: none"> • Testing Costs and Delays: Laboratory mycotoxin tests are too expensive and slow • Weather Uncertainty: Unreliable forecasts make harvest timing difficult • Regulatory Complexity: Changing food-safety rules across markets • Economic Pressure: Rising prevention costs without guaranteed yield protection • Tool Accessibility: Lack of simple, on-farm prediction tools.
TECHNOLOGY / TOOLS USED	OTHER IMPORTANT INFO
<ul style="list-style-type: none"> • Current Tools: Basic weather apps, manual soil-sampling equipment • Digital Comfort Level: Moderate—uses smartphone for calls and messaging, limited app experience • Preferred Interface: Clear visual dashboards with straightforward alerts • Device Preference: Mobile-optimized solutions that function offline in the field 	<ul style="list-style-type: none"> • Often relies on neighbor-to-neighbor advice networks • Prefers local language support and pictorial guides • Budget constraints limit frequent technology upgrades • Highly values peer-tested, field-proven solutions
SHORT DESCRIPTION	

A medium-scale Italian grain farmer adapting to unpredictable weather and rising mycotoxin risks with limited formal education.

Table 2 : Personas (Clustering) of Stakeholders (Farmers)

4.1.2 Food Industries

Example of personas (clustering) of food industries.

MYMATCH PERSONA	
PERSONA ID	PERSONA ROLE IN MYMATCH
ANYS_02	Food Industry Quality Manager
IDENTITY <i>(name, age, occupation, domain, years of experience)</i>	QUOTES <i>(important things he/she said)</i>
Female professional, aged 38 Based in Germany Works as a Quality Assurance Manager in a large food processing company Holds a PhD in Food Science Has 12 years of experience in food safety, with expertise in contaminant monitoring	<i>"Climate change has made mycotoxin risk assessment much more complex. We need predictive tools that integrate forecasts, supplier locations, and historical data so we can be proactive rather than reactive."</i>
GOALS <i>(what he/she wants to achieve)</i>	FRUSTRATIONS / PAIN POINTS <i>(what frustrates him/her currently at work)</i>
<ul style="list-style-type: none"> • Ensure raw materials meet safety standards while maintaining efficiency • Implement predictive risk strategies to reduce testing delays • Develop supplier risk assessment protocols incorporating climate factors • Integrate climate risk into existing quality systems 	<ul style="list-style-type: none"> • Complexity of global supply chains with varying climate impacts • Analytical bottlenecks delaying production • Regulatory variations across markets • Pressure to balance comprehensive testing with cost controls

	<ul style="list-style-type: none"> Inconsistent supplier data quality
TECHNOLOGY / TOOLS USED	OTHER IMPORTANT INFO
<ul style="list-style-type: none"> Current Tools: statistical and database software Digital Comfort Level: High—proficient with advanced analytical platforms Preferred Interface: Customizable dashboards with trend analysis and real-time alerts Device Preference: Desktop with mobile notifications for critical issues 	<ul style="list-style-type: none"> Manages cross-functional teams including procurement and R&D Requires audit trails and full traceability for regulatory compliance Collaborates regularly with external labs and certification bodies Prioritizes solutions that integrate seamlessly with existing enterprise systems
SHORT DESCRIPTION	
A seasoned Quality Assurance (QA) professional in a multinational food processing firm, leveraging data integration for proactive mycotoxin risk management.	

Table 3: Personas (Clustering) of Stakeholders (Food Industries)

4.1.3 Policymakers

Example of personas (clustering) of policymakers.

MYMATCH PERSONA	
PERSONA ID	PERSONA ROLE IN MYMATCH
ANYS_04	Food Safety Policymaker
IDENTITY	QUOTES
<i>(name, age, occupation, domain, years of experience)</i>	<i>(important things he/she said)</i>
Female professional, aged 52 Based in Belgium Holds a senior scientific position at a European food safety authority	<i>“We need robust scientific evidence to update mycotoxin regulations for climate change. The challenge is being precautionary without overburdening</i>

<p>Academic background: PhD in Environmental Health and MSc in Public Policy</p> <p>Has 15 years of experience in food safety regulation, including 8 years focused on climate impacts</p>	<p><i>producers already adapting to new conditions.”</i></p>
<p>GOALS</p> <p><i>(what he/she wants to achieve)</i></p>	<p>FRUSTRATIONS / PAIN POINTS</p> <p><i>(what frustrates him/her currently at work)</i></p>
<ul style="list-style-type: none"> • Develop evidence-based policies balancing precaution with practicality • Integrate climate risk assessments into EU mycotoxin regulations • Harmonize standards across member states • Foster innovation in monitoring technologies • Engage stakeholders in participatory policy development 	<ul style="list-style-type: none"> • Incomplete standardized data on climate’s effect on mycotoxin occurrence • Slow regulatory adaptation to new risks • Divergent stakeholder interests across industry and civil society • Making decisions under scientific uncertainty • Ensuring uniform policy implementation in 27 member states
<p>TECHNOLOGY / TOOLS USED</p>	<p>OTHER IMPORTANT INFO</p>
<ul style="list-style-type: none"> • Current Tools: statistical and database software • Digital Comfort Level: High—proficient with advanced analytical platforms • Preferred Interface: Customizable dashboards with trend analysis and real-time alerts • Device Preference: Desktop with mobile notifications for critical issues 	<ul style="list-style-type: none"> • Active in international standard-setting bodies • Liaises with national agencies for data collection and pilot implementations • Requires transparent methodologies to defend policies politically and legally • Seeks platforms that facilitate cross-border data sharing under GDPR
<p>SHORT DESCRIPTION</p>	

An European Food Safety Authority (EFSA) official crafting policy frameworks to safeguard public health amid evolving climate-driven food safety challenges.

Table 4: Personas (Clustering) of Stakeholders (policymakers)

4.1.4 Consumer

Example of personas (clustering) of consumers.

MYMATCH PERSONA	
PERSONA ID	PERSONA ROLE IN MYMATCH
ANYS_04	Health-Conscious Consumer
IDENTITY	QUOTES
<i>(name, age, occupation, domain, years of experience)</i>	<i>(important things he/she said)</i>
Female participant, aged 34 Based in Sweden Works as a Marketing Manager Has a Bachelor's degree in Communications Also a mother of two	"As a mother, I want easy-to-understand info on mycotoxins. I'd pay more for safe food, but only with clear, trustworthy guidance."
GOALS	FRUSTRATIONS / PAIN POINTS
<i>(what he/she wants to achieve)</i>	<i>(what frustrates him/her currently at work)</i>
<ul style="list-style-type: none"> • Ensure safe, healthy food for her family • Access transparent information on food safety and climate impacts • Make informed purchasing decisions • Support producers adopting sustainable practices • Understand mycotoxin risks and avoidance strategies 	<ul style="list-style-type: none"> • Overload of conflicting food safety information • Limited supply chain transparency • Premium prices without clear safety justification • Anxiety over long-term food security under climate change • Difficulty interpreting technical safety data
TECHNOLOGY / TOOLS USED	OTHER IMPORTANT INFO
<ul style="list-style-type: none"> • Current Tools: Food-info apps; social media communities 	<ul style="list-style-type: none"> • Active in local food-safety and sustainability forums

<ul style="list-style-type: none"> • Digital Comfort Level: High—frequent use of mobile apps and online research • Preferred Interface: Mobile-friendly apps with QR scanning and clear visuals • Device Preference: Smartphone with push notifications 	<ul style="list-style-type: none"> • Favors apps that gamify healthy habits and track product origins • Responds positively to community-driven reviews and certifications • Values quick alerts on emerging food safety incidents
<p>SHORT DESCRIPTION</p>	
<p>A digitally engaged parent prioritizing food safety and sustainability, seeking clear risk communication on mycotoxins.</p>	

Table 5: Personas (Clustering) of Stakeholders (Consumers)

5. Conclusion

The project has reached a critical preparatory milestone, with key deliverables such as survey instruments, digitalization plans, and ethical documentation nearing completion. The groundwork laid so far ensures a strong foundation for the data collection phase, which will begin upon ethical clearance. As we move into implementation, continued coordination across WP3 partners and close monitoring of progress will be essential to ensure the timely achievement of project goals. The next reporting update will reflect the launch of field activities and preliminary insights from early responses.

Next Steps

The next immediate priority is to initiate data collection, beginning with the rollout of the consumer survey in Italy by early September. This will ensure that initial responses are available for analysis and inclusion in the upcoming report. Parallel efforts will focus on finalizing the translated versions of the surveys for all partner countries, ensuring linguistic accuracy and cultural relevance, in coordination with the designated team leads.

The survey instruments will be fully deployed on the Qualtrics platform, allowing for standardized distribution and centralized data monitoring. Final testing and quality checks will be conducted prior to launch.

In addition, the complete ethical documentation has been submitted to the Ethics Commission for Research in Psychology (CERPS), marking an important step toward full compliance with institutional and legal requirements.

Internal coordination will continue to define responsibilities, set timelines for survey circulation across countries, and prepare for the active monitoring of early responses.

This structured approach will support the timely implementation of the data collection phase and help address any technical or operational challenge that may arise.

Survey Data Collection Plan

As described above, all the surveys have been prepared and refined after receiving final feedback from the project coordinator Prof. Battilani. Initially, the survey will be launched in Italy, as a pilot case at the end of August/start of September and will subsequently advance to other partner countries. The surveys will be circulated to the stakeholders identified (see stakeholder mapping). Surveys will also be disseminated using the EU Food Safety platform, a specific panel service (especially for consumers), via the MYMATCH social media platforms (LinkedIn etc.), as well as dedicated communication campaigns using panel surveys, particularly consumer survey.

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Appendix 1 (Questionnaires)

Farmers Survey

Climate Change Risks in Farming

Dear participant, Thank you for your interest in participating in this survey. The study is part of the European project MYMATCH – MYcotoxin MAnagement platform To face Climate change impact on food safety and Human Health, funded under Horizon Europe. The goal of the project is to understand the needs and perspectives of food system stakeholders—such as farmers, food industry representatives, policymakers, and consumers—on managing mycotoxins in the context of a changing climate. The survey is coordinated by the EngageMinds HUB – Consumer, Food and Health Engagement Research Centre at Università Cattolica del Sacro Cuore (Italy), in collaboration with the Consiglio Nazionale delle Ricerche (CNR, Italy) and EXUS AI Labs. The following questionnaire was developed to gather your input on topics such as climate-related food risks, mycotoxin management, and digital tools for food safety. Your participation will contribute directly to the co-design of the MYMATCH platform, ensuring it reflects real stakeholder needs and supports effective, user-friendly solutions to emerging food safety challenges.

We kindly ask you to answer all the questions. There are no right or wrong answers—what matters is that your responses reflect your personal experience and opinions.

The questionnaire will take approximately 15-20 minutes to complete. Participation is entirely voluntary, and you may withdraw at any time without providing a reason or facing any negative consequences. If you have any questions or need further clarification, you are welcome to contact the project coordinator, Prof. Guendalina Graffigna (guendalina.graffigna@unicatt.it). Your responses will be collected anonymously and processed in accordance with the Italian Legislative Decree 30 June 2003, No. 196, and the EU General Data Protection Regulation (GDPR - EU Regulation 2016/679).

Do you agree to participate?

- Yes
- No

Part 1. Climate Change

This section explores how climate change may be affecting your farming practices. We're interested in hearing your experiences and observations: how climate change has shaped your daily work, what new challenges you face, and what support or tools you think are needed to better manage these risks.

1. Are you aware of climate change-related events that could impact the food system in general?
 - Yes
 - No
 - I don't know
2. (If yes to Q1) On a scale from 0 to 10 (0 = not concerned at all, 10 = Extremely concerned), how concerned are you about the impacts of climate change-related events on the food system in general?
3. Are you aware of climate change-related events that could impact your farming activities?
 - Yes
 - No
4. (If yes to Q3) On a scale from 0 to 10 (0 = not concerned at all, 10 = Extremely concerned), how concerned are you about the impacts of climate change-related events on your farming activities?
5. Have you personally experienced climate change-related events affecting your farming activities?
 - Yes
 - No
6. (If yes to Q5) Which of the following climate change-related events have affected your farming activities? (please select only three options)
 - Changes in planting or harvesting dates
 - Unusual shifts in rainfall timing or intensity
 - More frequent or prolonged droughts
 - Increased incidence of extreme heat or heatwaves
 - Higher risk of crop diseases or pests
 - Reduced crop yields or quality
 - Difficulty in predicting weather patterns
 - Soil degradation or erosion
 - Flooding of fields
 - Others (please specify)

7. Based on your experience, do you think that these climate change-related effects will intensify or become more frequent in the coming years?
- Yes
 - No
 - I don't know

Part 2. Mycotoxins Contaminants Views & Food System Awareness

This part focuses on whether you've faced issues about mycotoxin contamination, how they impact your work, and what support you might need to handle them better.

8. Are you aware of mycotoxin contamination?

- Yes
- No

Mycotoxin contamination happens when certain molds grow on crops or food and produce toxic substances. These toxins can harm both people and animals if ingested and reduce the safety and quality of food products. Changes in weather, like warmer temperatures and increased humidity, can make it easier for these molds to grow, increasing the risk of mycotoxin contamination.

9. On a scale from 0 to 10 (0 = Not at all, 10 = Extremely concerned), how concerned are you about mycotoxin contamination in the food supply chain in general?

10. Are you aware of mycotoxin contamination that could impact your farming activities?

- Yes
- No

11. (if yes to Q10) On a scale from 0 to 10 (0 = not concerned at all, 10 = Extremely concerned), how concerned are you about the impacts of mycotoxin contamination on your farming activities?

12. Have you personally experienced mycotoxin contamination affecting your farming activities?

- Yes
- No

13. Do you monitor mycotoxin contamination?

- Yes
- No

14. (If yes to Q14) how do you monitor mycotoxin contamination?
- By auto control measures
 - By external laboratories
 - I rely to external databases and information
15. Which agro-environmental parameters are most responsible for increased mycotoxin occurrence in your area? (please select only three options)
- Increased temperature
 - Greater humidity
 - Irregular rainfall or drought
 - Water scarcity
 - Higher CO₂ levels
 - Increased pest activity
 - I don't know
 - Others (please specify)
16. Do you plan to implement measures for managing changes in mycotoxin contamination?
- Yes, in the short term
 - Yes, in the medium/long term
 - No, we do not have resources/capacity
17. (If Yes to Q. 16) What strategies do you take for managing changes in mycotoxin contamination? (please select only three options)
- Routine post-harvest testing for mycotoxins
 - In field testing for biotic/abiotic stress
 - Supplier audits
 - Use of ozone or other decontamination technologies
 - Improved on-farm storage and drying practices
 - Crop rotation
 - Different varieties
 - Training and awareness programs
 - Other (please specify)

18. What are the key challenges you face in managing mycotoxin contamination? (please select only three options)
- High cost of detection or mitigation technologies
 - Lack of regulatory clarity
 - Limited access to reliable testing
 - Unpredictable climate variability
 - Lack of training or awareness
 - Limited access to adequate on-farm or shared storage infrastructure
 - Limited consumer demand or awareness about mycotoxin-safe products
 - Others (please specify)
19. When facing challenges related to mycotoxin contamination, which of the following do you rely on for advice or support? (please select only three options)
- National/local agricultural authorities or extension services
 - Agricultural cooperatives or producer organizations
 - Academic or public research institutions
 - Input suppliers or Agri-tech companies
 - Digital tools and apps (e.g., weather, risk alerts, crop advice)
 - Other farmers or informal networks
 - New crop varieties or resistant hybrids
 - I don't usually seek external advice
 - Others (please specify)

Part 3. Digital Knowledge

In this section, we ask about your experience with digital technologies - whether you're using them already or just starting out.

20. Are you able to locate your farm using Google Maps or similar digital mapping tools (e.g., smartphone, apps, online apps)?
- Yes, I can do it easily
 - I can do it, but I may need help
 - No, I don't know how to do that
21. Are you familiar with digital platforms related to food safety and risk management?

- Yes
- No

22. What kind of digital tools do you currently use to help with your farming work? (please select only three options)

- Mobile apps (e.g., for weather, irrigation, crop monitoring)
- Websites or online platforms for farming advice or alerts
- Tools for tracking farm records or inputs (e.g., spreadsheets, digital logs)
- Satellite maps or geolocation tools
- Artificial Intelligence (AI)
- I don't use any digital tools
- Others (please specify)

23. (If you answered anything other than "I don't use any digital tools" to Q 22) On a scale from 0 to 10 (0 = Not reliable at all, 10 = Extremely reliable), how reliable do you consider these digital tools and technologies to be in practice?

24. (if "I don't use any digital tools" to Q 22) What are the main barriers not to use digital tools? (please select only three options)

- Too complexity or difficult to use
- Cost of the tool or service is too high
- I don't see clear benefits to learn or use it
- I don't have enough time to learn or use it
- Difficult to find the right information or tool
- Limited or unreliable internet/mobile network
- Lack of access to digital devices (e.g., smartphones, computer)
- Tools are not available in my language
- I don't have the necessary digital skills or knowledge
- Digital tools are unreliable or don't meet my needs
- Poor data quality or data entry issues
- Lack of interoperability with other systems
- Data security or privacy concerns
- Low trust in the platform or data provider

- o Resistance to change among staff or users
- o No support for updates or troubleshooting
- o Other (please specify)

25. What improvements or enhancements would you like to see in these tools? (Select all that apply)

- o Real-time alerts and notifications
- o Better integration across supply chain stages
- o Simpler, more user-friendly interface
- o Mobile accessibility or app development
- o More frequent updates and technical support
- o Multilingual functionality
- o Stronger data privacy and cybersecurity features
- o Better visualization and dashboard tools
- o Automated data collection (e.g., IoT or sensors)
- o Access to predictive analytics or AI insights
- o Others (please specify)

Part 4. Willingness to Engage in Multi-actor Platform

In this section, we are interested in learning more about your potential interest in engaging with collaborative digital platforms that connect farmers, researchers, policymakers, and other key actors.

Climate change is inducing unprecedented shifts in weather patterns and thereby increasing food safety risks by promoting the diversification of fungi and the occurrence of mycotoxins in key crops such as maize, wheat, tomatoes, and nuts.

MYMATCH is developing an AI-driven predictive DSS-platform to assess and manage mycotoxin risks in European food systems affected by climate change. It will predict fungal contamination in crops, assess human and animal exposure, and implement risk management strategies. Data from past events and controlled studies will support accurate climate-based predictive models. The platform will aid farmers, food industries, and policymakers with tailored risk predictions, mitigation approaches, and decision-making tools.

Your participation in this survey is essential to ensure the platform meets the needs of all stakeholders. Your feedback will help shape a more effective and practical tool for safeguarding our food systems in the European Union.

26. On a scale from 0 to 10 (0 = Not at all, 10 = Extremely Interested), how interested would you be in using a platform like MYMATCH to help you manage mycotoxin contamination risks on your farm?
27. On a scale from 0 to 10 (0 = Not at all, 10 = Extremely Confident), how confident are you that you could use MYMATCH effectively to make on farm decisions (e.g. respond to alerts, run risk prediction scenarios)?
28. Would you be willing to join a pilot of the MYMATCH platform (e.g. test it on your farm for 3-6 months)?
- Yes
 - No
29. If yes to Q 28) How would you participate in a pilot of the MYMATCH platform?
- I want to be informed
 - I want to contribute to surveys and/or debates
 - I am willing to share my data
 - Other (please specify)
30. Which MYMATCH platform features would you find most valuable? (please select only three options)
- Realtime contamination alerts
 - Risk-prediction scenarios for mycotoxins
 - Step-by-step mitigation guidance
 - Training videos and tutorials
 - Peer-to-peer forum for farmer Q&A
 - Simple dashboard of farmspecific risk metrics
 - Exportable reports for regulators or buyers
 - Support for daily operational decisions
 - Strategic long-term planning & advice
 - Practical, cost-effective intervention recommendations
 - A tool that helps you comply with food safety regulations or standards
 - Insights based on climate trends or specific dietary patterns
 - Integration with existing systems (e.g. farm, processing, policy dashboards)
 - Increased awareness of food safety risks due to climate conditions

- o Economic benefits (e.g., reduced losses, improved product quality)
- o Support for communication and collaboration between stakeholders
- o Reduced occurrence of fungi or mycotoxin contamination
- o Other (please specify)

Part 5. Demographics

To help us better understand the perspectives of different groups, we would appreciate some basic information about you. This information will only be used for analytical purposes in this study. All responses are confidential, and data will be anonymized and reported in aggregated form.

31. What is your age?

- o Age in numbers

32. What is the highest level of education you have completed? (Please choose only one answer)

- o Primary school (usually completed around age 11–12)
- o Lower secondary school (e.g., middle school or junior high)
- o Upper secondary school (e.g., high school diploma, A-levels, Baccalauréat, Matura)
- o Post-secondary vocational training (e.g., technical or professional courses after high school)
- o Bachelor's degree (or equivalent university degree)
- o Master's degree (or equivalent postgraduate degree)
- o Doctorate (PhD)
- o Other (please specify)

33. What is your gender?

- o Male
- o Female
- o I prefer not to mention

34. Which of the following best describes your farm's ownership and management structure?

- o Owned – Individually or family managed
- o Owned – Managed in partnership



- o Owned – Managed by a for-profit company
- o Owned – Managed by a non-profit organization
- o Rented – Individually or family managed
- o Rented – Managed in partnership
- o Rented – Managed by a for-profit company
- o Rented – Managed by a non-profit organization
- o Other (please specify)

35. For how many years has your farm been in operation (including any period before you started managing it)?

- o Number of years

36. Which one of the following best describes you?

- o Full-time farmer
- o Part-time farmer
- o Semi-retired farmer
- o Other (please specify)

37. How big is your farm (Area Covered-Farm size)?

- o Small farm (smallholder < 50 ha)
- o Medium farm (5-50 ha)
- o Large farm (50-100 ha)
- o Very large farm (> 100 ha)

38. What is the main production type of your farm?

- o Crops
- o Livestock
- o Both Crops & Livestock
- o Mixed
- o Other (please specify)

39. Which is your region of operation?

- o List of regions in EU/in relevant country (dropdown menu) *see appendix

40. How would you describe your area of land (choose the one where most of the relevant cropping system is)

- Flat area
- Hilly area
- Mountainous
- Others (please specify)

Thank you for your time and participation!

Your responses are greatly appreciated and will contribute significantly to our research. If you have any questions or would like to receive updates about this study, please feel free to contact us.

Food Industry Survey

Climate Change Risks in Food Industries

Dear participant,

thank you for your interest in participating in this survey. The study is part of the European project MYMATCH – MYcotoxin MAnagement platform To face Climate change impact on food safety and Human Health, funded under Horizon Europe. The goal of the project is to understand the needs and perspectives of food system stakeholders—such as farmers, food industry representatives, policymakers, and consumers—on managing mycotoxins in the context of a changing climate.

The survey is coordinated by the EngageMinds HUB – Consumer, Food and Health Engagement Research Centre at Università Cattolica del Sacro Cuore (Italy), in collaboration with the Consiglio Nazionale delle Ricerche (CNR, Italy) and EXUS AI Labs.

The following questionnaire was developed to gather your input on topics such as climate-related food risks, mycotoxin management, and digital tools for food safety. Your participation will contribute directly to the co-design of the MYMATCH platform, ensuring it reflects real stakeholder needs and supports effective, user-friendly solutions to emerging food safety challenges.

We kindly ask you to answer all the questions. There are no right or wrong answers—what matters is that your responses reflect your personal experience and opinions. The questionnaire will take approximately 15-20 minutes to complete. Participation is entirely voluntary, and you may withdraw at any time without providing a reason or facing any negative consequences. If you have any questions or need further clarification, you are welcome to contact the project coordinator, Prof. Guendalina Graffigna (guendalina.graffigna@unicatt.it). Your responses will be collected anonymously and processed in accordance with the Italian Legislative Decree 30 June 2003, No. 196, and the EU General Data Protection Regulation (GDPR – EU Regulation 2016/679).

Do you agree to participate?

- Yes
- No

Part 1. Climate Change

This section explores how climate change may be affecting your farming practices. We're interested in hearing your experiences and observations: how climate change

has shaped your daily work, what new challenges you face, and what support or tools you think are needed to better manage these risks.

1. Are you aware of climate-related events that could affect the food industry in general?
 - Yes
 - No
 - I don't know
2. (If Yes to Q1) On a scale from 0 to 10 (0 = not concerned at all, 10 = Extremely concerned), how concerned are you about the impacts of climate change-related events on the food system in general?
3. Are you aware of climate change-related events that could impact your food industry operation or activities?
 - Yes
 - No
 - I don't know
4. (If Yes to Q3) On a scale from 0 to 10 (0 = not concerned at all, 10 = Extremely concerned), how concerned are you about the impacts of climate change-related events on your food industry operation or activities?
5. Have you personally experienced climate change-related events affecting your food industry operation or activities?
 - Yes
 - No
6. (If Yes to Q5) Which of the following climate change-related events have affected your food industry operations or supply chain? (please select only three options)
 - Reduced yields or quality of raw ingredients
 - Drought or water shortages for production
 - Increased pest or disease outbreaks (crops, livestock, stored products)
 - More frequent or intense floods and storms
 - More frequent extreme heatwaves
 - Higher energy or refrigeration requirements
 - Supply shortages
 - Price volatility

- Transportation or delivery delays
 - Route disruptions due to extreme weather
 - Damages to goods during storage or transport
 - Worker absenteeism due to heat stress or illness
 - Increased operational costs due to climate impacts
 - Other (please specify)
7. Based on your experience, do you think that these climate change-related effects will intensify or become more frequent in the coming years?
- Yes
 - No
 - I don't know

Part 2. Mycotoxins Contaminants Views & Food System Awareness

This part focuses on whether you've faced issues consequently to climate change, how they impact your work, and what support you might need to handle them better.

In addition, we want to understand your awareness and views on broader food system challenges-such as regulatory barriers, market-related delays, or other obstacles - and how these affect your day-to-day work as a food industry operator.

8. Are you aware of mycotoxin contamination?

- Yes
- No

Mycotoxin contamination happens when certain molds grow on crops or food and produce toxic substances. These toxins can harm both people and animals if ingested and reduce the safety and quality of food products. Changes in weather, like warmer temperatures and increased humidity, can make it easier for these molds to grow, increasing the risk of mycotoxin contamination.

9. On a scale from 0 to 10 (0 = Not at all, 10 = Extremely concerned), how concerned are you about mycotoxin contamination in the food supply chain in general?

10. Are you aware of mycotoxin contamination that could impact your food industry operation or activities?

- Yes
- No

11. (If Yes to Q10) On a scale from 0 to 10 (0 = not concerned at all, 10 = Extremely concerned), how concerned are you about the impacts of mycotoxin contamination on your food industry operation or activities?
12. Have you personally experienced mycotoxin contamination affecting your food industry operation or activities?
 - o Yes
 - o No
13. Do you monitor mycotoxin contamination?
 - o Yes
 - o No
14. If Yes to Q13, how do you monitor mycotoxin contamination?
 - o By auto control measures
 - o By external laboratories
 - o I rely to external databases and information
15. Which agro-environmental parameters are most responsible for increased pathogen/mycotoxin occurrence caused by climate change? (please select only three options)
 - o Increased temperature
 - o Greater humidity
 - o Irregular rainfall or drought
 - o Water scarcity
 - o Higher CO₂ levels
 - o Increased pest activity
 - o I don't know
 - o Others (please specify)
16. Do you plan to implement measures for managing changes in mycotoxin contamination?
 - o Yes, in the short term
 - o Yes, in the medium/long term
 - o No, we do not have resources/capacity

17. If your answer is Yes to Q. 16, what strategies do you take for managing changes in mycotoxin contamination? (please select only three options)
- Routine lab testing for mycotoxins
 - Implementing monitoring tools/procedures along the supply chain
 - Use of decision support systems
 - Supplier audits
 - Use of ozone or other decontamination technologies
 - Improved storage and drying practices
 - Suggesting different crop management
 - Promoting different and more tolerant varieties
 - Considering alternative regions for raw material sourcing
 - Training and awareness programs
 - None of the above
 - Other (please specify)
18. What are the key challenges you face in managing mycotoxin contamination? (please select only three options)
- High cost of detection or mitigation technologies
 - Lack of regulatory clarity
 - Limited access to reliable testing
 - Unpredictable climate variability
 - Lack of training or awareness
 - Inadequate storage infrastructure
 - Consumer trust issues
 - I don't know
 - Others (please specify)
19. When facing challenges related to mycotoxin contamination, which of the following do you rely on for advice or support? (please select only three options)
- National government guidelines (Ministries, Regional Authorities)
 - International bodies (e.g., EU, EFSA)
 - Academic research

- o Industry best practices
- o Umbrella associations/federations guidelines
- o Private food safety consultants/advisors
- o Digital tools & platforms
- o I don't know
- o Others (please specify)

Part 3. Digital Knowledge

In this section, we ask about your experience with digital technologies - whether you're using them already or just starting out.

20. Are you familiar with any digital platform related to food safety and risk management?

- o Yes
- o No
- o I don't know

21. What kind of digital platforms do you currently use to help with your operation? (Please select only three options)

- o Mobile apps (e.g., for updates, monitoring)
- o Websites or online platforms for alerts or forecast
- o Artificial Intelligence (AI)
- o I don't use any digital tools
- o Others (please specify)

22. If you answered "I don't use any digital tool" what are the main barriers not to use a new digital platform? (please select only three options)

- o Too complex or difficult to use
- o Cost of the tool or service is too high
- o I don't have enough time to learn or use it
- o I don't see clear benefits to learn or use it
- o Difficult to find the right information or tool
- o Restricted access to digital technologies

- High cost of access to ICT
- Insufficient digital content in my language
- Lack of ICT equipment
- Lack of power, telephone, network
- Unreliable digital technologies
- Lack necessary skills/knowledge
- I face no barriers
- Other (please specify)

23. What improvements or enhancements would you like to see in these tools? (Select all that apply)

- Real-time alerts and notifications
- Better integration across supply chain stages
- Simpler, more user-friendly interface
- Mobile accessibility or app development
- More frequent updates and technical support
- Multilingual functionality
- Stronger data privacy and cybersecurity features
- Better visualization and dashboard tools
- Automated data collection (e.g., IoT or sensors)
- Access to predictive analytics or AI insights
- Others (please specify)

24. Are you aware of Artificial Intelligence (AI) usage in food industry?

- Yes
- No
- I don't know

25. On a scale from 0 to 10 (0 = Very uncomfortable– 10 = Very Comfortable), how comfortable would you be using an AI based digital platform?

Part 4. Willingness to Engage in Multi-actor Platform

In this section, we are interested in learning more about your potential interest in engaging with collaborative platforms that connect farmers, researchers,

policymakers, and other key actors. Climate change is inducing unprecedented shifts in weather patterns and thereby increasing food safety risks by promoting the diversification of fungi and the occurrence of mycotoxins in key crops such as maize, wheat, tomatoes, and nuts.

MYMATCH is developing an AI-driven predictive DSS-platform to assess and manage mycotoxin risks in European food systems affected by climate change. It will predict fungal contamination in crops, assess human and animal exposure, and implement risk management strategies. Data from past events and controlled studies will support accurate climate-based predictive models. The platform will aid farmers, food industries, and policymakers with tailored risk predictions, mitigation approaches, and decision-making tools.

Your participation in this survey is essential to ensure the platform meets the needs of all stakeholders. Your feedback will help shape a more effective and practical tool for safeguarding our food systems in the European Union.

26. On a scale from 0 to 10 (0 = Not at all, 10 = Extremely Interested), how interested would you be in using a platform like MYMATCH to help you manage contamination risks in food industry?

27. On a scale from 0 to 10 (0 = Not at all, 10 = Extremely Confident), how confident are you that you could use MYMATCH effectively to make informed decisions (e.g. respond to alerts, run risk prediction scenarios)?

28. Would you be willing to join a pilot of the MYMATCH platform (e.g. test it on your operation for 3-6 months)?

- Yes
- Maybe, I'd need more information
- No
- I don't know

29. If Yes to Q27, how would you participate in a pilot of the MYMATCH Platform?

- I want to be informed
- I want to contribute to surveys and/or debates
- I am willing to share my data
- Other (please specify)

30. Which MYMATCH platform features would you find most valuable? (please select only three options)

- Realtime contamination alerts
- Risk-prediction scenarios for mycotoxins and other hazards

- o Step-by-step mitigation guidance
- o Training videos and tutorials
- o Peer-to-peer forum for industry Q&A
- o Simple dashboard of operation-specific risk metrics
- o Exportable reports for regulators, auditors, or buyers
- o Support for daily operational decisions (e.g., storage, processing)
- o Strategic longterm planning & advisory insights
- o Practical, cost-effective intervention recommendations
- o Other (please specify)

Part 5. Demographics

To help us better understand the perspectives of different groups, we would appreciate some basic information about you. This information will only be used for analytical purposes in this study. All responses are confidential, and data will be anonymised and reported in aggregated form.

31. What is your age?

- o Age in numbers

32. What is the highest level of education you have completed? (Please choose only one answer)

- o Primary school (usually completed around age 11–12)
- o Lower secondary school (e.g., middle school or junior high)
- o Upper secondary school (e.g., high school diploma, A-levels, Baccalauréat, Matura)
- o Post-secondary vocational training (e.g., technical or professional courses after high school)
- o Bachelor's degree (or equivalent university degree)
- o Master's degree (or equivalent postgraduate degree)
- o Doctorate (PhD)
- o Other (please specify)

33. What is your gender?

- o Male
- o Female



- I prefer not to mention

34. Which of the following best describes your company's ownership and management structure?

- Privately owned and managed
- Cooperative (producer- or member-owned)
- Publicly listed company
- State-owned or publicly funded
- Non-profit or NGO
- University or research institution
- Other (please specify)

35. For how many years has your company been in operation (including any period before you started managing it)?

- Number of years

36. Which one of the following best describes your role in the food industry?

- Full-time employee
- Part-time employee
- Manager or executive in food production/processing
- Owner of a food production/processing
- Partner of a food production/processing
- Semi-retired
- Other (please specify)

37. How large is your food production/processing facility?

- Micro enterprise (fewer than 10 employees)
- Small enterprise (10–49 employees)
- Medium enterprise (50–249 employees)
- Large enterprise (250 or more employees)
- Startup
- Others (please specify)

38. What is your company's main production or processing focus?

- o Processed crops (e.g., cereals, grains, legumes)
- o Animal products (e.g., dairy, meat, poultry, seafood)
- o Both plant-based and animal-based products
- o Ready-to-eat or packaged foods
- o Beverage production
- o Food additives, flavorings, or supplements
- o Other (please specify)

39. Which is your region of operation?

- o List of regions in EU/in relevant country (dropdown menu)

Thank you for your time and participation!

Your responses are greatly appreciated and will contribute significantly to our research. If you have any questions or would like to receive updates about this study, please feel free to contact us.

Consumers Survey

Climate Change Risks and Food Safety

Dear participant, Thank you for your interest in participating in this survey.

The study is part of the European project MYMATCH – MYcotoxin MAnagement platform To face Climate change impact on food safety and Human Health, funded under Horizon Europe.

The goal of the project is to understand the needs and perspectives of food system stakeholders—such as farmers, food industry representatives, policymakers, and consumers—on managing mycotoxins in the context of a changing climate.

The survey is coordinated by the EngageMinds HUB – Consumer, Food and Health Engagement Research Centre at Università Cattolica del Sacro Cuore (Italy), in collaboration with the Consiglio Nazionale delle Ricerche (CNR, Italy) and EXUS AI Labs.

The following questionnaire was developed to gather your input on topics such as climate-related food risks, mycotoxin management, and digital tools for food safety.

Your participation will contribute directly to the co-design of the MYMATCH platform, ensuring it reflects real stakeholder needs and supports effective, user-friendly solutions to emerging food safety challenges.

We kindly ask you to answer all the questions. There are no right or wrong answers—what matters is that your responses reflect your personal experience and opinions.

The questionnaire will take approximately 15-20 minutes to complete.

Participation is entirely voluntary, and you may withdraw at any time without providing a reason or facing any negative consequences.

If you have any questions or need further clarification, you are welcome to contact the project coordinator, Prof. Guendalina Graffigna (guendalina.graffigna@unicatt.it).

Your responses will be collected anonymously and processed in accordance with the Italian Legislative Decree 30 June 2003, No. 196, and the EU General Data Protection Regulation (GDPR – EU Regulation 2016/679).

Do you agree to participate?

- Yes

- No

Part 1. Climate Change

This section explores your views on climate change effects on food system and on your food choices.

1. Are you aware of climate-related events that could affect the food system?
 - o Yes
 - o No
 - o I don't know
2. (If Yes to Q1) On a scale from 0 to 10 (0 = not concerned at all, 10 = Extremely concerned), how concerned are you about the impacts of climate change-related events on the food system and your food choices?
3. Based on your experience, do you think that climate change-related events have increased in the last five years?
 - o Yes
 - o No
 - o I don't know
4. Based on your experience, do you think that climate change-related events will intensify or become more frequent in the coming five years?
 - o Yes
 - o No
 - o I don't know
5. (If Yes to Q4) On a scale from 0 to 10 (0 = Not concerned at all, 10 = Extremely concerned), how concerned are you about the effects of these climate change-related events on your food choices?
6. Which aspects related to food do you think will be most impacted by climate change-related events? (please select only three options)
 - Food availability
 - Food prices
 - Food quality/safety
 - Nutritional value of food
 - Food production methods (e.g., farming, fishing)

- Food variety
- Other (please specify)

Part 2. Food Safety Concerns and Mycotoxins Contaminants

Food safety means making sure the food you eat is clean, healthy, and free from harmful substances. This includes the rules and actions that protect food from contamination and keep it safe to eat. In this section, we want to know your thoughts and concerns about food safety and about mycotoxins/natural toxins produced that can be found in food.

7. On a scale from 0 to 10 (0 = completely inadequate, 10 = Completely adequate), how do you rate your knowledge of food safety?
8. Below, you will be presented with statements related to food safety. For each of them, please indicate your level of agreement on a scale from 0 to 10, where 0 = strongly disagree and 10 = strongly agree.
 - I believe food safety issues could negatively affect my health.
 - I am concerned that food safety problems may become more common soon.
 - Current food safety regulations are effective in protecting consumers.
9. Regarding the safety of the foods you eat, how concerned are you about the following aspects? Please respond using a scale from 0 (not concerned at all) to 10 (very concerned)
 - Chemical residues (pesticides, antibiotics, hormones)
 - Food additives and preservatives
 - Microbiological contamination (bacteria, molds, fungi)
 - Food processing methods (e.g., irradiation, fermentation)
 - Genetically modified foods
10. On a scale from 1 to 7 (1 = Not at all important, 7 = Extremely important), how important each of the following characteristics is to you when choosing food.

It is important to me that the food I eat on a typical day is...

- Healthy
- is a way of monitoring my mood (e.g.. a good feeling or coping with stress')
- is convenient (in buying and preparing)

- provides me with pleasurable sensations (e.g. texture. Appearance, smell and taste)
- is natural
- is affordable
- helps me control my weight
- is familiar
- is environmentally friendly
- is animal friendly
- is fairly traded

11. Are you aware of mycotoxin contamination in foods?

- Yes
- No

Mycotoxin contamination happens when certain molds grow on crops or food and produce toxic substances. These toxins can harm both people and animals if ingested and reduce the safety and quality of food products. Changes in weather, like warmer temperatures and increased humidity, can make it easier for these molds to grow, increasing the risk of mycotoxin contamination.

12. Below, you will be presented with a series of statements regarding mycotoxin contamination in food. Please read the statements and indicate your level of agreement for each, on a scale from 0 to 10 (0 = Strongly disagree, 10 = Strongly agree)

- I believe that mycotoxin contamination is a serious health risk in the food I consume.
- I am concerned about the possibility of consuming food contaminated with mycotoxins.
- I think that mycotoxins in food are a significant threat to public health.
- I believe that current food safety regulations do enough to prevent mycotoxin contamination.

13. I believe that current food safety regulations do enough to prevent mycotoxin contamination.

How much do you trust the following sources for information about food safety on a scale from 1 to 10? (0 = Do not trust at all, 10 = Trust completely)

- Family, friends, and community

- Government agencies
- Food producers and retailers
- Traditional media (TV, newspapers)
- Social media and online platforms

Part 3. Experience with Digital Technologies for Food Safety Information

In this section, we ask about your experience with digital technologies used to obtain information regarding food safety.

14. Do you currently use any digital tools (apps/websites) to check food safety information?
- Yes
 - No
15. (if yes to Q.14) On a scale from 0 to 10 (0 = Not at all, 10 = Very comfortable), how comfortable are you with digital tools (apps/websites) to access food safety information?
16. (if no to Q.14) What makes it difficult for you to use websites or apps related to food safety information? (Please select all that apply)
- I don't have time to try new tools
 - I'm not very familiar with using digital tools
 - They are too complicated or hard to use
 - They cost too much or require payment
 - I don't see how they would help me
 - I worry about how my data is used or shared
 - I don't trust the source or the platform
 - The platform is not in my language
 - I don't have good internet or a suitable device
 - I prefer getting information in other ways (TV, friends, etc.)
 - I'm not interested in food safety information
 - Other (please specify)

Part 4. Demographic Information



To help us better understand the perspectives of different groups, we would appreciate some basic information about you. This information will only be used for analytical purposes in this study. All responses are confidential, and data will be anonymised and reported in aggregated form.

17. What is your age?

- Age in numbers

18. What is the highest level of education you have completed? (Please choose only one answer)

- Primary school (usually completed around age 11–12)
- Lower secondary school (e.g., middle school or junior high)
- Upper secondary school (e.g., high school diploma, A-levels, Baccalauréat, Matura)
- Post-secondary vocational training (e.g., technical or professional courses after high school)
- Bachelor's degree (or equivalent university degree)
- Master's degree (or equivalent postgraduate degree)
- Doctorate (PhD)
- Other (please specify)

19. What is your gender?

- Male
- Female
- I prefer not to mention

20. Which of the following best describes your current employment status?

- Employed-full time
- Employed-part-time
- Self-employed
- Student
- Unemployed
- Retired
- Homemaker
- Other (please specify)

21. Do you follow any specific dietary preferences or restrictions? (Select all that apply)

- No specific preferences
- Vegetarian
- Vegan
- Organic food only
- Prefer local or seasonal foods
- Gluten-free
- Other (please specify)

22. Are you the primary person responsible for buying food in your household?

- Yes
- No

23. Are you the primary person responsible for preparing food in your household?

- Yes
- No

24. Where do you currently live?

- Regione di residenza
- Abruzzo
- Basilicata
- Calabria
- Campania
- Emilia-Romagna
- Friuli-Venezia Giulia
- Lazio
- Liguria
- Lombardia
- Marche
- Molise
- Piemonte

- Puglia
- Sardegna
- Sicilia
- Toscana
- Trentino-Alto Adige
- Umbria
- Valle d'Aosta
- Veneto

25. What type of area do you live in?

- Urban (city or large town)
- Suburban (smaller town or outskirts)
- Rural (countryside or village)

Thank you for your time and participation!

Your responses are greatly appreciated and will contribute significantly to our research. If you have any questions or would like to receive updates about this study, please feel free to contact us.

Appendix 2 (Glossary of Climate Terms)

Abrupt Climate Change

The nonlinearity of the climate system may lead to abrupt climate change, sometimes called rapid climate change, abrupt events, or even surprises. The term abrupt often refers to time scales faster than the typical time scale of the responsible forcing. However, not all abrupt climate changes need be externally forced. Some changes may be truly unexpected, resulting from a strong, rapidly changing forcing of a nonlinear system.

Adaptation

In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate.

Baseline/Reference

The baseline (or reference) is the state against which change is measured. It might be a 'current baseline,' in which case it represents observable, present-day conditions. It might also be a 'future baseline,' which is a projected future set of conditions excluding the driving factor of interest. Alternative interpretations of the reference conditions can give rise to multiple baselines.

Bias correction

Adjustment of modeled values to reflect the observed distribution and statistics. Bias correction is necessary to overcome large biases in climate models and avoid unrealistic results of applications that use climate data as an input (for example yield models or phenological models).

Bioclimatic variable

Variable derived from environmental climate variables that are related to the crop cycle. It can represent annual trends (e.g. mean annual temperature, annual precipitation), seasonality (e.g. annual range in temperature and precipitation), and extreme or limiting environmental factors (e.g. temperature of the coldest and warmest month, and precipitation of the wet and dry quarters of the year).

Biologically effective degree days

Sum of daily mean temperatures (TG) above 10°C and less than 30°C, over 10 days.

Climate

The average weather conditions prevailing at a specific region over a long period. It commonly refers to measurements of meteorological variables, such as temperature, precipitation, wind, etc.

Climate Change

A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

Climate data processing

The collection and manipulation of climate data in order to produce meaningful information, improve accuracy and facilitate data management.

Climate Extreme (extreme Weather Or Climate Event)

The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. For simplicity, both extreme weather events and extreme climate events are referred to collectively as 'climate extremes'.

Climate Feedback

An interaction mechanism between processes in the climate system is called a climate feedback when the result of an initial process triggers changes in a second process that in turn influences the initial one. A positive feedback intensifies the original process, and a negative feedback reduces it.

Climate Model

A numerical representation of the climate system that is based on the physical, chemical, and biological properties of its components, their interactions, and feedback processes, and that accounts for all or some of its known properties. The climate system can be represented by models of varying complexity, that is, for any one component or combination of components a spectrum or hierarchy of models can be identified, differing in such aspects as the number of spatial dimensions, the extent to which physical, chemical, or biological processes are explicitly represented, or the level at which empirical parameterizations are involved. Coupled atmosphere-ocean global climate models (aogcms), also referred to as atmosphere-ocean general circulation models, provide a representation of the climate system that is near the most comprehensive end of the spectrum currently available. There is an evolution toward more complex models with interactive chemistry and biology. Climate models are applied as a research tool to study and simulate the climate, and for operational purposes, including monthly, seasonal, and interannual climate predictions.

Climate prediction

A climate prediction or climate forecast is the result of an attempt to produce (starting from a particular state of the climate system) an estimate of the actual evolution of the climate in the future, for example, at seasonal, interannual or long-term time scales.

Because the future evolution of the climate system may be highly sensitive to initial conditions, such predictions are usually probabilistic in nature.

Climate risk

The probability, based on climatological statistics, that unfavorable weather will occur at a particular location or region over a certain period of time.

Climate Scenario

A plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships that has been constructed for explicit use in investigating the potential consequences of anthropogenic climate change, often serving as input to impact models. Climate projections often serve as the raw material for constructing climate scenarios, but climate scenarios usually require additional information such as about the observed current climate.

Climate System

The climate system is the highly complex system consisting of five major components: the atmosphere, the oceans, the cryosphere, the land surface, the biosphere, and the interactions between them. The climate system evolves in time under the influence of its own internal dynamics and because of external forcings such as volcanic eruptions, solar variations, and anthropogenic forcings such as the changing composition of the atmosphere and land use change.

Climate Threshold

A critical limit within the climate system that induces a non-linear response to a given forcing. See also abrupt climate change

Climate Variability

Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate at all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability). See also climate change.

Climatologist

A scientist who studies climate.

Climatology

The study of climate.

Cold spell duration index

Number of days per season with at least 6 consecutive days when $TN < TN^{10th}$, where TN is the daily minimum temperature and TN^{10th} is the calendar day 10th percentile.



To calculate TN¹⁰th for each day, a 5-day window centered on each equivalent day in the 1981–2010 period is used to improve the statistical robustness from which the 10th percentile of the data is selected (e.g. for all 3rd of July days between 1981–2010, the 1st, 2nd, 3rd, 4th, 5th July are selected in the 5-day window). This indicator provides information on reduced blossom formation or reduced growth.

Confidence

Confidence in the validity of a finding, based on the type, amount, quality, and consistency of evidence and on the degree of agreement. Confidence is expressed qualitatively.

Correlation

In general, a mutual relationship between variables or other entities. In statistical terminology, it is a form of statistical dependence.

Downscaling

Derivation of local- to regional-scale (10-100 km) information from larger-scale modelled or observed data. There are two main approaches: dynamical downscaling and statistical downscaling.

Drought

A naturally occurring phenomenon that exists when precipitation has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land resource production systems.

Early Warning System

The set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities, and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss.

Ensemble

A collection of model simulations characterizing a climate prediction or projection. Differences in initial conditions and model formulation result in different evolutions of the modelled system. In the case of climate forecasts, these simulations may give information on uncertainty associated with model errors and errors in the initial conditions. For projections of longer-term climate change, these simulations provide can provide information on uncertainty associated with model errors and with internally generated climate variability.

Essential Climate Variable (ECV)

Physical, chemical or biological variable or a group of linked variables that critically contributes to the characterization of Earth' s climate. These include precipitation, temperature and pressure, among many others.

Exposure

The presence of someone or something in a place and setting that could cause them to be adversely affected. It can refer to: people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets.

Frost days

Number of days per 10 days when $TN < 0^{\circ}\text{C}$, where TN is the daily minimum temperature. This indicator provides information on frost damage.

Global Surface Temperature

The global surface temperature is an estimate of the global mean surface air temperature. However, for changes over time, only anomalies, as departures from a climatology, are used, most commonly based on the area-weighted global average of the sea surface temperature anomaly and land surface air temperature anomaly

Governance

The way government is understood has changed in response to social, economic, and technological changes over recent decades. There is a corresponding shift from government defined strictly by the nation-state to a more inclusive concept of governance, recognizing the contributions of various levels of government (global, international, regional, local) and the roles of the private sector, of nongovernmental actors, and of civil society.

Growing degree days

Growing Degree Days (GDD) is an index used to assess the accumulation of heat over time, which is crucial for plant development. It helps identify the most suitable crop varieties for a given location, or conversely, the most appropriate locations for cultivating a specific variety. In the context of climate change, GDD has become an essential tool for informing agronomic decisions, such as planting dates, crop selection, and management practices. The index gained popularity as climate change became a growing concern, offering a simple and intuitive way to understand how shifting temperatures may affect the viability and productivity of agricultural regions.

Growing season length

Number of days between the first occurrence after 1st January (1st July in southern hemisphere) of at least 6 consecutive days with $TG > 5^{\circ}\text{C}$ and the first occurrence after 1st July (1st January in southern hemisphere) of at least 6 consecutive days with $TG < 5^{\circ}\text{C}$, where TG is the daily mean temperature. This indicator provides an indication whether or not a crop, or a combination of crops, can be sown and subsequently reach maturity within a certain time frame.

Heat risk



The risk of temperatures that are higher or lower than normal conditions to the crop yield and quality, consequently affecting production and safety.

Heatwave

A period of abnormally hot weather. Heat waves and warm spells have various definitions and, in some cases, overlapping definitions. See also warm spell

Heavy precipitation days

Number of days per 10 days when $RR > 10\text{mm}$, where RR is the daily precipitation sum. This indicator provides information on crop damage and runoff losses.

Hindcast

Hindcast or retrospective forecast: A forecast made for a period in the past using only information available before the beginning of the forecast. Hindcasts can be used to calibrate the forecast system and/or provide a measure of the average quality (skill) that the forecast system has exhibited in the past as a guide to the skill that might be expected in the future.

Ice days

Number of days per 10 days when $TX < 0^{\circ}\text{C}$, where TX is the daily maximum temperature. This indicator provides information on frost damage.

Impacts

Effects on natural and human systems. In this report, the term 'impacts' is used to refer to the effects on natural and human systems of physical events, of disasters, and of climate change

Indicators

Something observed or calculated that shows what conditions are.

Land Surface Air Temperature

The air temperature as measured in well-ventilated screens over land at 1.5 to 2 m above the ground.

Land Use And Land Use Change

Land use refers to the total of arrangements, activities, and inputs undertaken in a certain land cover type (a set of human actions). The term land use is also used in the sense of the social and economic purposes for which land is managed (e.g., grazing, timber extraction, and conservation). Land use change refers to a change in the use or management of land by humans, which may lead to a change in land cover. Land cover and land use change may have an impact on the surface albedo, evapotranspiration, Source: s and sinks of greenhouse gases, or other properties of the climate system and may thus have radiative forcing and/or other impacts on climate, locally or globally.

Likelihood

A probabilistic estimate of the occurrence of a single event or of an outcome, for example, a climate parameter, observed trend, or projected change lying in a given range. Likelihood may be based on statistical or modeling analyses, elicitation of expert views, or other quantitative analyses.

Long term

Climate events occurring further into the future, typically ranging from the next months to years or centuries.

Maximum number of consecutive dry days

Longest period of consecutive days when $RR < 1\text{mm}$, where RR is the daily precipitation sum. This indicator is used for drought monitoring.

Maximum number of consecutive frost days

Longest period of consecutive days when $TN < 0^{\circ}\text{C}$, where TN is the daily minimum temperature. This indicator is used as a general frost damage indicator.

Maximum number of consecutive summer days

Longest period of consecutive days when $TX > 25^{\circ}\text{C}$, where TX is the daily maximum temperature. This indicator provides information on drought stress or on optimal growth for C_4 crops (crops that use the C_4 carbon fixation pathway, e.g. maize).

Maximum number of consecutive wet days

Longest period of consecutive days when $RR > 1\text{mm}$, where RR is the daily precipitation sum. This indicator provides information on drought, oxygen stress and crop growth (i.e. less radiation interception during rainy days).

Maximum of daily maximum temperature

Maximum value of TX over 10 days, where TX is the daily maximum temperature. This indicator provides information on long-term climate variability and change.

Maximum of daily minimum temperature

Maximum value of TN over 10 days, where TN is the daily minimum temperature. This indicator provides information on long-term climate variability and change.

Mean of daily maximum temperature

Mean value of TX over 10 days, where TX is the daily maximum temperature. This indicator provides information on long-term climate variability and change.

Mean of daily mean temperature

Mean value of TG over 10 days, where TG is the daily mean temperature. This indicator provides information on long-term climate variability and change.

Mean of daily minimum temperature

Mean value of TN over 10 days, where TN is the daily minimum temperature. This indicator provides information on long-term climate variability and change.

Mean of diurnal temperature range

Mean value of the daily difference between TX and TN (TX–TN) over 10 days, where TX and TN are daily maximum and minimum temperature respectively. This indicator provides information on climate variability and change. It also serves as a proxy for information on the clarity (transmittance) of the atmosphere.

Minimum of daily maximum temperature

Minimum value of TX over 10 days, where TX is the daily maximum temperature. This indicator provides information on long-term climate variability and change.

Minimum of daily minimum temperature

Minimum value of TN over 10 days, where TN is the daily minimum temperature. This indicator provides information on long-term climate variability and change.

Mean squared error

The average (mean) squared difference between the observed values and the values estimated by climate models.

Mitigation (of Climate Change)

A human intervention to reduce the Source: s or enhance the sinks of greenhouse gases.

Modes Of Climate Variability

Natural variability of the climate system, in particular on seasonal and longer time scales, predominantly occurs with preferred spatial patterns and time scales, through the dynamical characteristics of the atmospheric circulation and through interactions with the land and ocean surfaces. Such patterns are often called regimes, modes, or teleconnections.

Nonlinearity

A process is called nonlinear when there is no simple proportional relation between cause and effect. The climate system contains many such nonlinear processes, resulting in a system with a potentially very complex behavior. Such complexity may lead to abrupt climate change. See also predictability.

Number of heat stress days (SU35)

Annual count of days when daily maximum temperatures exceed 35°C. 35°C is the average established threshold for photosynthesis to occur in most of the crops. Above this temperature, the plant closes its stomata affecting yield, quality and plant health.

Parameterization

In climate models, this term refers to the technique of representing processes that cannot be explicitly resolved at the spatial or temporal resolution of the model (sub-grid scale processes) by relationships between model-resolved larger-scale flow and the area- or time-averaged effect of such sub-grid scale processes

Percentile

One of a set of numbers on the random-variable axis that divides a probability distribution into 100 equal areas; it is a quantile equal to one one-hundredth of a total population.

Predictability

The extent to which the future state of a system may be predicted based on knowledge of its current and past states. Predictability is inherently limited, since knowledge of the system's past and current states is insufficient, and the models that utilize this knowledge to produce a prediction are generally imperfect. Even with arbitrarily accurate models and observations, there may still be limits to the predictability of a physical system.

Probability

The chance that a prescribed event will occur, expressed as a pure number in the range of 0-1. A probability of zero indicates an impossible event, while a probability of 1 indicates an inevitable event.

Probability Density Function (PDF)

A probability density function is a function that indicates the relative chances of occurrence of different outcomes of a variable. The function integrates to unity over the domain for which it is defined and has the property that the integral over a sub-domain equals the probability that the outcome of the variable lies within that sub-domain. For example, the probability that a temperature anomaly defined in a particular way is greater than zero is obtained from its pdf by integrating the pdf over all possible temperature anomalies greater than zero. Probability density functions that describe two or more variables simultaneously are similarly defined.

Projection

A projection is a potential future evolution of a quantity or set of quantities, often computed with the aid of a model. Projections are distinguished from predictions in order to emphasize that projections involve assumptions concerning, for example, future socioeconomic and technological developments that may or may not be realized, and are therefore subject to substantial uncertainty.

Proxy Climate Indicator



A proxy climate indicator is a local record that is interpreted, using physical and biophysical principles, to represent some combination of climate-related variations back in time. Climate-related data derived in this way are referred to as proxy data. Examples of proxies include pollen analysis, tree ring records, characteristics of corals, and various data derived from ice cores. The term 'proxy' can also be used to refer to indirect estimates of present-day conditions, for example, in the absence of observations.

Regional model

Regional Climate Models (RCMs) are climate models which run over limited area at a high spatial resolution instead of the considering the entire planet at a lower resolution. They are used in downscaling global model simulations over specific regions.

Reanalysis

Reanalyses are atmospheric and oceanic analyses of temperature, wind, current, and other meteorological and oceanographic quantities, created by processing past meteorological and oceanographic data using fixed state-of-the-art weather forecasting models and data assimilation techniques. Using fixed data assimilation avoids effects from the changing analysis system that occur in operational analyses. Although continuity is improved, global reanalyses still suffer from changing coverage and biases in the observing systems.

Return Period

An estimate of the average time interval between occurrences of an event (e.g., flood or extreme rainfall) of (or below/above) a defined size or intensity.

Return Value

The highest (or, alternatively, lowest) value of a given variable, on average occurring once in a given period of time (e.g., in 10 years).

Scenario

A plausible and often simplified description of how the future may develop based on a coherent and internally consistent set of assumptions about driving forces and key relationships. Scenarios may be derived from projections, but are often based on additional information from other Source: s, sometimes combined with a narrative storyline.

Seasonal forecast

A seasonal forecast is considered a climate prediction that provides an estimate of the actual evolution of the climate system for the next few months (up to a year). These forecasts are probabilistic and can be used for decision-making in various sectors like agriculture, energy, and health.

Short term

Weather and climate events occurring within a short period of time in the future, typically the following days or weeks.

Skill score

Statistical measure that assesses the performance of a prediction in relation to some standard (e.g. climatology, persistence, etc.). These values are based on the performance of the system in the past.

Spring total precipitation

Total rainfall from April 21st to June 21st (Northern Hemisphere). Dry springs will delay vegetative growth and reduce vigour and leaf area total surface. Fungal disease pressure will be lower and therefore there will be less need for protective and / or curative treatments, translating as less costs. Wet springs will promote higher vigour, increase the risk of fungal disease and disrupt operations as it may prevent machinery from getting in the field due to mud.

Stakeholder

Anyone who has a stake or interest in the outcome of the project, as well as anyone one who is affected by the project.

Statistical significance

An indication of how reliable is the estimation of a statistical parameter. Results with a probability (P) value that is below the predefined significance level (commonly either 0.05 or 0.01) are considered to be statistically significant.

Summer days

Number of days per 10 days when $T_X > 25^{\circ}\text{C}$, where T_X is the daily maximum temperature. This indicator provides an indication of the occurrence of heat stress.

Sustainable Development

Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. | Source: IPCC

Teleconnection

A relationship between two distant weather events. The weather phenomenon el niño |

Tercile

Terciles are two values (lower and higher terciles) that divide a set of data (for example, the average temperature for the last 30 years) into three groups: one with the lowest 33% of values (those below the lower tercile), one with the highest 33% (those above the higher tercile) and the remaining 33%, centred around the middle value, between

both terciles. In climate science, values that lie below the lower tercile (lowest 33%) or above the upper tercile (highest 33%) are commonly considered as anomalies.

Total precipitation after booting

This index measures the total rainfall occurring after the booting stage in cereal crops—a critical phenological phase when the developing grain head is enclosed within the leaf sheath. Excessive precipitation during and after this period can significantly increase the risk of fungal infections, particularly foliar and head diseases such as Fusarium head blight, Septoria, and rusts. These pathogens not only compromise yield quantity but can also degrade grain quality through mycotoxin contamination, making the harvest less marketable or even unsafe.

Trend/Tendency

A climate change characterized by a reasonably smooth, monotonic increase or decrease of the average value of one or more climatic elements during the period of record.

Tropical nights

Number of days per 10 days when $TN > 20^{\circ}\text{C}$, where TN is the daily minimum temperature. This indicator provides an indication of occurrence of various pests.

Uncertainty

An expression of the degree to which a value or relationship is unknown. Uncertainty can result from lack of information or from disagreement about what is known or even knowable. Uncertainty may originate from many sources, such as quantifiable errors in the data, ambiguously defined concepts or terminology, or uncertain projections of human behavior. Uncertainty can therefore be represented by quantitative measures, for example, a range of values calculated by various models, or by qualitative statements, for example, reflecting the judgment of a team of experts. See also likelihood and confidence | Source: IPCC

Very heavy precipitation days

Number of days per 10 days when $RR > 20\text{mm}$, where RR is the daily precipitation sum. This indicator provides information on crop damage and runoff losses.

Warm and wet days

Number of days per 10 days when $TG > TG^{75\text{th}}$ and $RR > RR^{75\text{th}}$; where TG is the daily mean temperature, $TG^{75\text{th}}$ is the calendar day 75th percentile, RR is the daily precipitation sum and $RR^{75\text{th}}$ is the 75th percentile of precipitation on wet days. To calculate $TG^{75\text{th}}$ and $RR^{75\text{th}}$ for each day, a 5-day window centered on each equivalent day in the 1981–2010 period is used to improve the statistical robustness from which the 75th percentile of the data is selected (e.g. for all the 3rd of July days between 1981–2010, the 1st, 2nd, 3rd, 4th, 5th July are selected in the 5-day window).

This indicator provides an indication of occurrence of various pests and the crop development, especially leaf formation. (day)

Warm spell duration index

Number of days per season with at least 6 consecutive days when $TX > TX^{90th}$, where TX is the daily maximum temperature and TX^{90th} is the calendar day 90th percentile. To calculate TX^{90th} for each day, a 5-day window centered on each equivalent day in the 1981–2010 period is used to improve the statistical robustness from which the 90th percentile of the data is selected (e.g. for all the 3rd of July days between 1981–2010, the 1st, 2nd, 3rd, 4th, 5th July are selected in the 5-day window). This indicator provides an indication of the occurrence of heat stress.

Weather

The state of the atmosphere at a specific time and place. Usually includes information about precipitation, temperature, winds and relative humidity.

Wet days

Number of days per 10 days when $RR > 1mm$, where RR is the daily precipitation sum. This indicator provides information on intercepted reduction.