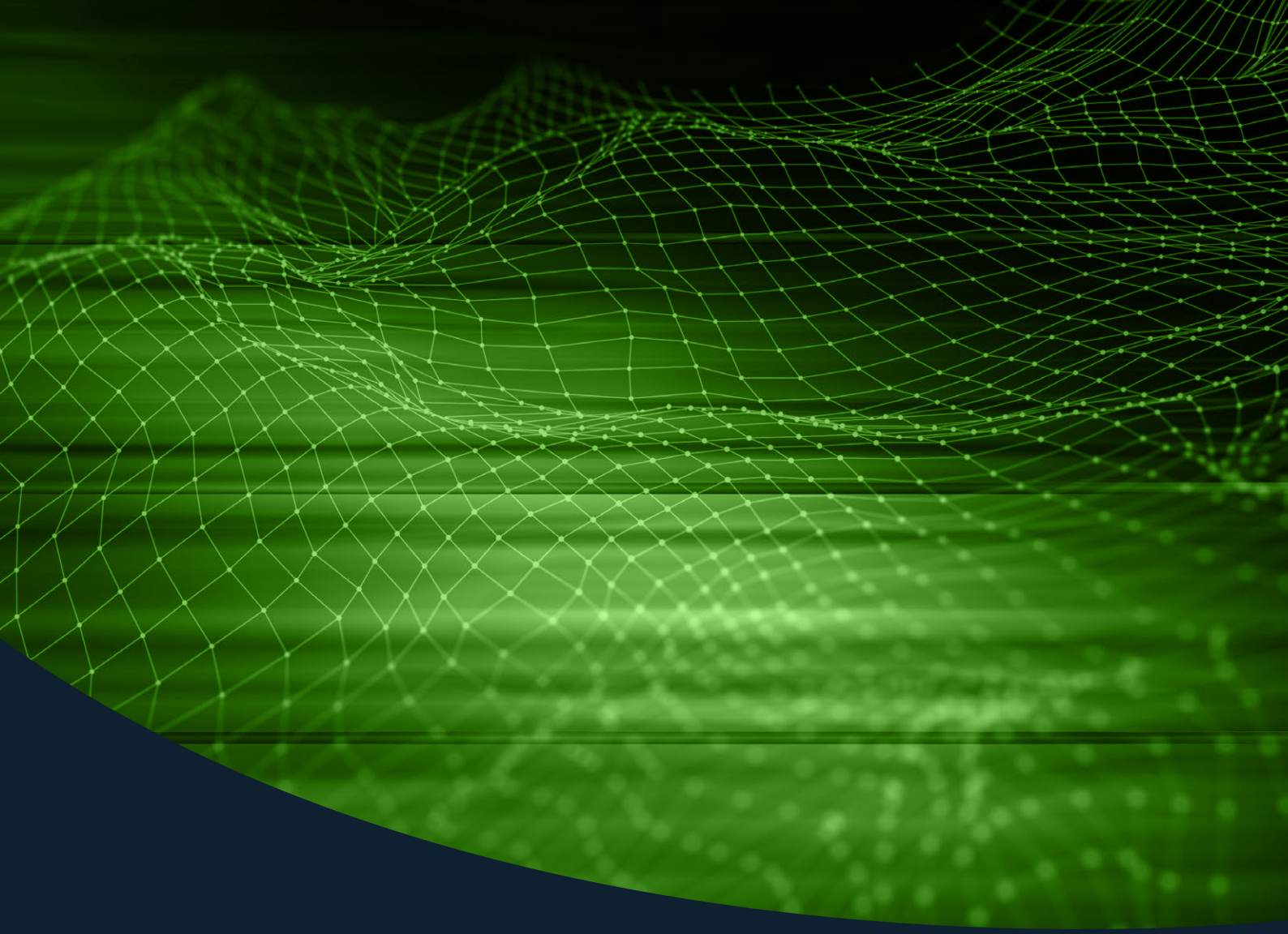


ALLIANCE

EARLY WARNING AND DECISION SUPPORT SYSTEM

HIGH LEVEL POLICY MATERIALS SERIES

PROJECT INFORMATION

The ALLIANCE project, a three-year initiative funded by the European Union's Horizon Europe program, aims to establish a comprehensive framework for ensuring data integrity, veracity, enhanced traceability, and transparency within quality-labelled food supply chains.
This framework is designed to foster evidence-based decision making for proactive interventions and actionable planning, ultimately strengthening the resilience and trustworthiness of the food sector.

ALLIANCE is developing systemic solutions that transcend current industry practices to improve traceability, guarantee authenticity, preserve quality, and eliminate fraud in food products. This involves deploying innovative methods and tools for on the spot adulteration detection and increasing transparency in quality-labelled supply chains—specifically for organic, Protected Designation of Origin (PDO), Protected Geographical Indication (PGI), and Geographical Indication (GI) foods—through advanced track-and-trace mechanisms. The project's ultimate goal is to provide food actors, farmers, public authorities, and policymakers with meaningful insights, demonstrated through seven diverse use cases.

MULTI-STAKEHOLDER COLLABORATION

- FOOD SUPPLY CHAINS
- INDUSTRY-SPECIFIC TECHNOLOGICAL DEVELOPMENT
- PUBLIC POLICY
- INNOVATION MANAGEMENT
- ACADEMIA
- PUBLIC ADMINISTRATIONS

HOLISTIC APPROACH TO ADDRESS FOOD FRAUD, SUPPLY CHAIN INTEGRITY

APP OVERVIEW

The AI-enabled Early Warning and Decision Support System (EWDSS), is designed to identify and mitigate instances of food fraud. It is composed of two main, complementary systems: the **AI Early Warning System (EWS) and the Decision Support System (DSS).**

EWS flags what the problem is and how severe the potential fraud risk is, and the DSS helps determine how to respond to that risk by evaluating different courses of action or tools.

Early Warning System

The main goal of the EWS is to detect anomalies and potential food fraud incidents in the food supply chain proactively by leveraging **Artificial Intelligence (AI)** and predictive analytics (specifically, the Mamdani Fuzzy Inference System) to analyze real-time and historical data from the food supply chain, providing **early warning signals** and actionable recommendations derived from multi-criteria decision analysis.

The EWS monitors the operational performance of the Food Supply Chains (FSCs) to assess fraud risk factors and actual fraud vulnerability. By identifying unusual patterns or unexpected changes, it determines the probability of food fraud occurring.
Its outputs are **early warning signals** and a **fraud score/risk level** (e.g., Low, Medium, High).

The EWS interacts with the Vulnerability Risk Assessment Management Framework (VRAMF). VRAMF continuously exploits the warnings produced by the EWS to identify and redefine the **Critical Control Points (CCPs)** within the FSCs, aiming to improve fraud detection efficiency.

Decision Support System

The DSS is the second component of the EWDSS. Fed by early warning signals generated by the EWS, it serves to support decision-making processes, providing recommendations to respond to conditions of uncertainty or risk.

There are two main operational modes of the DSS: **human-in-the-loop** and **automated evaluation**.

The **Human-in-the-loop approach (AHP)** mode considers expert opinions and preferences for consistency when prioritizing risks or selecting mitigation strategies. This utilises the Analytic Hierarchy Process (AHP), where users define a hierarchy (Goal → Criteria → Alternatives) and express their subjective preferences using **pairwise comparisons** (e.g., comparing "Economic impact" to "Feasibility") on a 1-9 scale.

Users are guided to answering three key questions:

- With respect to the overall goal, which criterion is the most important in the decisionmaking process?
- For a given criterion, which alternative is the most preferred?
- Based on the priorities of the criteria and the alternatives under each criterion, how are the alternatives scored and ranked overall?

The system calculates the consistency ratio (CR) to validate the human judgements, ensuring transparent and reliable strategic choices.

The DSS then generates Global Scores to rank the alternatives (e.g., mitigation strategies), effectively integrating expert judgement and qualitative factors such as reputation risk and feasibility. The human-in-the-loop approach ensures that organizational priorities and expertise are systematically applied and validated when responding to EWS alerts.

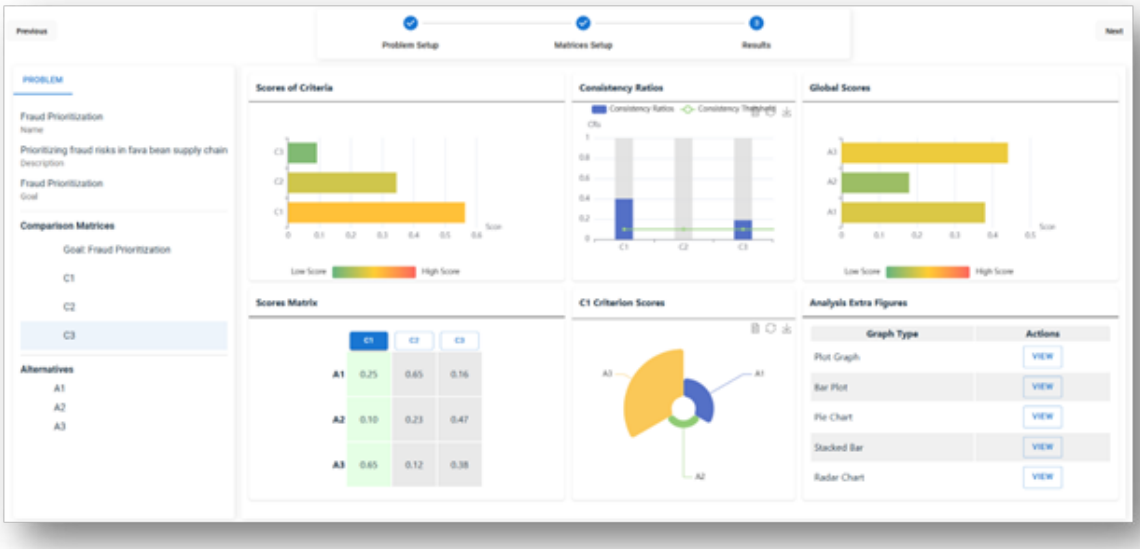
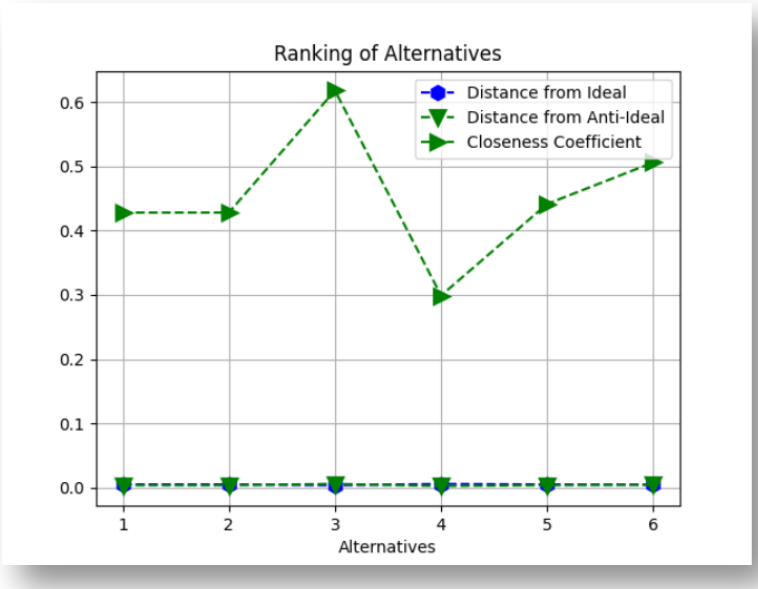


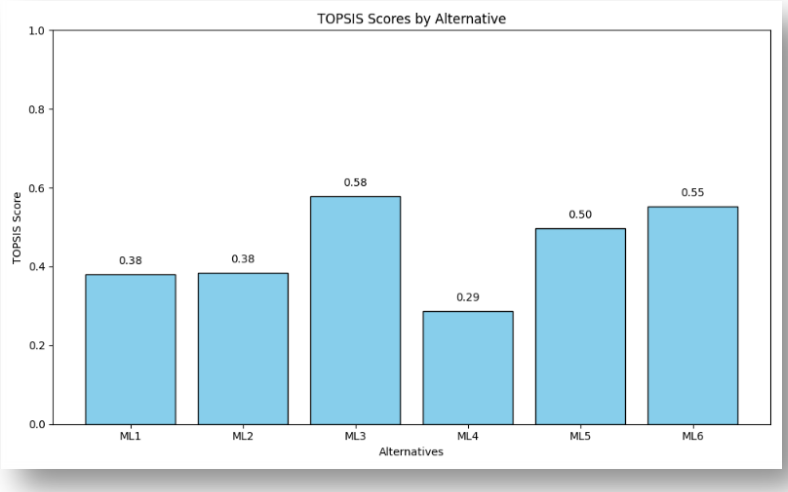
Figure 1: DSS results dashboard (prioritizing fraud risk)

The Automated evaluation mode (Technique for Order Preference by Similarity to Ideal Solution TOPSIS) ranks and selects the most suitable machine learning algorithms for fraud detection based on performance metrics like accuracy, precision, and recall. Its objective is to select the single most suitable machine learning model (the "champion") from a set of trained algorithms (the "alternatives") for deployment in an operational environment. This is essential for ensuring that the EWS uses the best performing predictive model. TOPSIS works by ranking alternatives based on their distance from an ideal, theoretical solution.



An application example is the evaluation of six different modeling pipelines for fava bean fraud detection against nine or ten performance criteria to determine which is the optimal model to run the analysis.

Figure 2: Line plot for illustrating how each alternative performs relative to others



In essence, the dual approach ensures the DSS is flexible: the AHP component ensures the strategy and priorities of the organization are logically consistent, while the TOPSIS component ensures the technical tools supporting that strategy are objectively the best performers.

Fig 3: Bar chart comparing alternatives in the fava beans use case

Relevance of the app beyond ALLIANCE

The EWDSS presents high exploitation potential across the agri-food sector due to its proven capability to integrate real-time data analysis with structured decision-making.
By combining the Early Warning System's (EWS) ability to detect anomalies using fuzzy logic in real time with the Decision Support System's (DSS) tools for multi-criteria evaluation (AHP and TOPSIS), the system provides smart, interoperable, and risk-aware solutions.

This allows stakeholders to proactively identify Critical Control Points (CCPs) for intervention, select the optimal fraud detection algorithms, and justify their preventive actions, significantly strengthening the resilience and transparency of quality-labeled value chains.

Currently populated with synthetic datasets mirroring real-world conditions and simulating common types of fraud that occur in milk production, the system is designed to empower stakeholders to utilize their own datasets to achieve more realistic and actionable insights.

Its potential applications go beyond the use cases of the ALLIANCE project, including other quality-certified agri-food supply chains (i.e. products bearing a geographic and/or an organic certification), as well as other products at high risk of fraud or spoilage, including non-food items such as pharmaceuticals.

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DOWNLOAD ALL HIGH-LEVEL POLICY MATERIALS

https://alliance-heu-project.eu/high-level-policy-materials

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