# Pathways towards a fair, inclusive and innovative Data Economy for Sustainable Food Systems

# D5.2: Impact assessment of scenarios and strategic options for uptake of data value propositions for the data economy for food systems

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# Data4Food2030 Consortium

| | Participant organisation name | Short name | Country |
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| 1 | STICHTING WAGENINGEN RESEARCH | WR | NL |
| 2 | REFRAME FOOD ASTIKI MI KERDOSKOPIKI ETAIRIA | RFF | EL |
| 3 | INSTITUT NATIONAL DE RECHERCHE POUR L'AGRICULTURE, L'ALIMENTATION ET L'ENVIRONNEMENT | INRAE | FR |
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| 24 | LUONNONVARAKESKUS | LUKE | FI |

# Glossary of terms and abbreviations used

| Abbreviation / Term | Definition | Relevance to the deliverable |
|---|---|---|
| Data | Any information collected and processed in digital form. | Conceive immaterial nature of data and the role of digital technologies in data value propositions. |
| DE / Data economy | An ecosystem in which data is gathered, organised, and exchanged by market companies, individuals and institutions to create economic value. DE involves the generation, collection, storage, processing, distribution, analysis, delivery and exploitation of data enabled by digital technologies. | Understand DE as an ecosystem in which data flows and data value propositions are shaped in interaction between various stakeholders. Develop a conceptual framework of data value stream among agrifood systems stakeholders and institutions. |
| FS / Food systems | All assets and activities related to producing, processing, distributing and consuming food, as well as their effects on economy, society, health, and environment, | Conceive FS as composed of core activities (production, processing, distribution, consumption of food), actors involved and their interactions, as well as drivers and outcomes of these activities. |
| DE4FS / Data economy of the food systems | A dynamic ecosystem that supports direct and indirect interactions between the Data Economy and the Food system | Explore interaction between DE and FS, conceive the framing conditions for data value propositions and their uptake in FS. |
| Stakeholders | The FS stakeholders include individuals and organisations who perform different roles in food provision. Four types of FS stakeholders can be distinguished: food value chain actors, food systems enabling actors, data actors, actors from adjacent sectors (D4.1.) The DE stakeholders are individuals and organisations who perform different roles in data flow. Six roles can be distinguished: data owner, data provider, data consumer, data user, data intermediaries, service provider. (D1.1.) | Differentiate stakeholder categories in DE4FS. Distinguish between FS and DE stakeholders. Explore data value, data value propositions, and strategic choices for the uptake of data value propositions from a stakeholder perspective. Embrace multi-actor and multi-role perspective on DE4FS. |
| Data value | The value that emerges through data flow, exchange and use in the FS context. | Establish diversity of values the data may have in relation to specific purposes of its use and different stakeholder needs. Relate data value to its quality and availability. |
| Data value proposition | The unique benefit that data-driven products or services offer to customers by explaining how they solve specific problems or meet particular needs. | Conceive data value propositions as technically and socially organised form of data exchange and data use that enhances economic, social and |

| | | |
|---|---|---|
| | | environmental benefits for stakeholders. Articulate data value propositions at individual stakeholder and FS levels. |
| Strategic options | One of several possible courses of action from which the one to be implemented is selected in a broader complex digitalization and data economy context for businesses or other organizations. | Consider options of data use available to stakeholders that maximise the societal and economic benefits while mitigating the risks. Identify choices for the uptake of data value proposition at stakeholder and food system levels. |
| WP | Work package | Interconnect the Deliverable 5.2 with research activities in other WPs of the Data4Food2030 project. Valorise results of WP1, and WP4 (Tasks 4.1, 4.2, 4.3) for D5.2 purposes. |

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# 1. Executive summary

**Purpose and methodology**

The purpose of D5.2 is to identify strategic options for data value propositions for stakeholder groups in the DE4FS (Data Economy for Food Systems) and to examine how stakeholder groups address these options. An equally important objective is to explore how these strategic options for uptake of data value propositions may materialise in different scenarios and pathways towards the data economy of the food systems. To meet the research objective, the following methodology has been used (Figure 1).

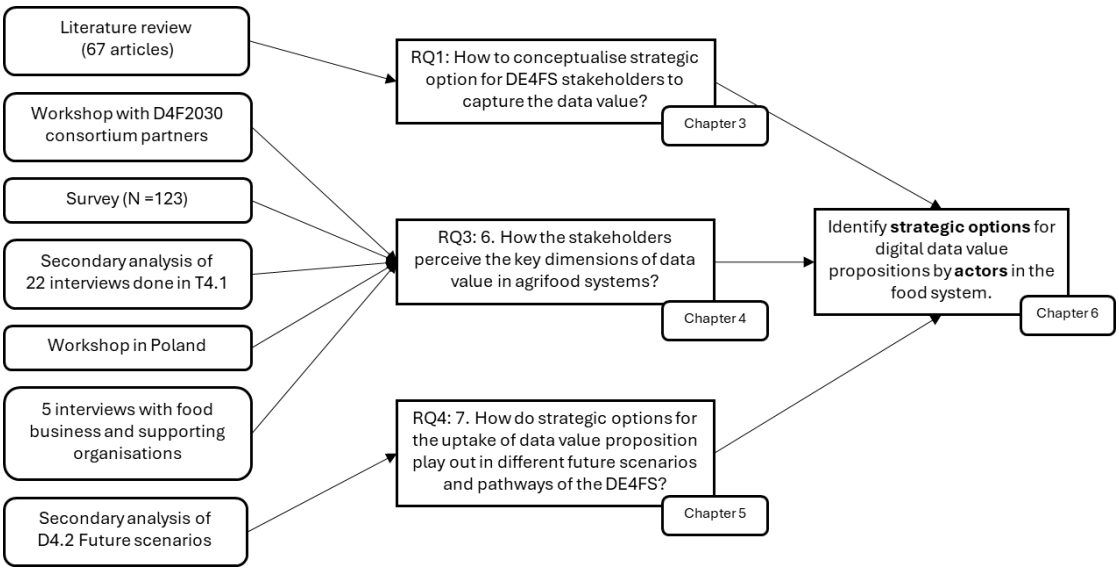


**Figure 1 Methodological framework**

**Methods of data collection and analysis**

- Literature study: systematic literature review approach, article search in SCOPUS and WoS databases, preliminary review of 210 articles, in-depth analysis of 67 articles retained, use of 15 prompts, analysis of papers with generative AI.
- Stakeholder workshop: 45 participants, facilitated discussion, documentation of discussion and post-its notes, dynamic picture of posters, thematic coding and clustering of post-its according to data value dimensions.
- Questionnaire survey of stakeholders: Questionnaire consisting of 29 statements about data value grouped in nine thematic categories, Likert scale, online survey using Lime survey platform, 128 respondents from Poland, Latvia and other countries, average scooring, ranking and crosstabulation of responses, cross-tabulation of data and differential statistical analysis (X2, df, p-value).
- Stakeholder interviews: 22 interviews with food system stakeholder organisations from different EU countries.
- Transcripts and interview summaries, analysis of interview reports with Atlas.ti 25 using a hybrid approach to qualitative coding.
- Stakeholder workshop on strategic options for data economy: 17 participants, facilitated workshop, multi-criteria analysis of results, prioritisation matrix, Pareto diagram, ranking of strategic actions.

- Additional five interviews with agri-food businesses and supporting organisations: Expert interview approach, qualitative thematic analysis of data.
- Secondary analysis of D4.2 Future scenarios of data economy of the food systems.

**Key findings**

According to literature review top 5 purposes of agrifood data use are:
1) Sustainability goals.
2) Efficiency optimization.
3) Informed decision making.
4) Environmental goals.
5) Resilience building.

The stakeholder workshop identified nine key dimensions of data value at food systems level which support the findings from literature: improve food systems governance; support decision making; improve efficiency; optimise activities; assure quality; support innovation; enhance outcomes; and address challenges.

The stakeholder survey prioritised these categories in the following order:
1) Enhance efficiency, value creation and value capture in FS.
2) Support FS governance.
3) Quality assurance and control, standardisation in FS.
4) Optimising, control, and monitoring FS activities and processes.
5) Enhancing FS outcomes (environment, health, information, well-being).
6) Support decision-making processes.
7) Manage performance attributes of the food system.
8) Support innovation ecosystem – digitalisation, AI, collaboration.
9) Enhance data sharing and free flow of data.
10) Address challenges, risks and opportunities in FS.

Top five statements (out of 29) regarding data value in food systems which received the highest mean scores in stakeholder survey were:
1) “Access to reliable data improves decision-making for individual stakeholders within the food chain (e.g., producers, processors, distributors, retailers and other actors).”
2) “Data on nutritional content, and production methods empowers consumers to make choices which benefit health.”
3) “Data helps companies to adapt and change their business models to better respond to market challenges.”
4) “Continuous access to up-to-date data is essential for making timely and informed decisions, ensuring responsiveness to market changes and emerging trends.”
5) The data analytics integrated in food supply chain activities enhances the precision and reliability of production monitoring processes, ensuring better quality control and compliance with safety standards.”

From literature review top five strategic decisions for stakeholders to capture the value of data relate: technology adoption; collaborative models and ecosystem; investment in AI/data integration; data integration, standardisation and interoperability; and infrastructure investment.

The stakeholder strategic options workshop identified a similar set of top five strategic actions in capturing data value:

5) Data-sharing.
5) Implementation of advanced food tracking technologies in the supply chain (barcodes, RFID tags, blockchain technology).
5) Using blockchain technology to collect and exchange data securely and transparently.
5) Implement farm management systems for data integration and decision support.
5) Government policies supporting the adoption of digital technologies (e.g. mobile applications, digital finance).

The analysis of future scenarios for the data economy in food systems by 2050, shows that: in Scenario A: “Personalised Healthy Diets” merging consumer data will enable the farmers to provide specialised products based on consumer needs. In Scenario B: “Local and Transparent Value Chains” sharing data through data exchange platforms will enhance the cooperation and provide insights for all value chain actors. In Scenario C: “Strictly Regulated High-Tech for Reduced Environmental Impact” data-driven decision-making to enhance food system's sustainability.

Stakeholder interviews identified system level conditions that enhance the uptake of data value propositions in FS are:

1) Regulation improvements.
2) Interoperability and data format standardisation.
3) Open data and common data sharing platforms.
4) Industry self-organisation.
5) Education and training.

Based on synthesis of findings from various methods recommendations for the uptake of data value propositions are formulated and clustered along following themes: diversity, balance, capacity, inclusivity, sharing.

# 2. Introduction

The rapid advancement of data and data-driven innovations is fundamentally transforming agrifood systems worldwide. From precision agriculture to supply chain optimization and personalised nutrition, data is becoming increasingly central to how food is produced, distributed, and consumed. In the context of agrifood systems, data plays an increasingly important role in informed decision-making, personalised customer experience, and generating value for both businesses and the society as a whole (Mazza, Papandreou, & Mavri, 2024). The capacity to collect, share, analyse, and use the data is becoming essential for strategic positioning and innovation for the businesses and society. The agrifood data economy is, however, embedded in a complex multi-actor ecosystem involving diverse stakeholders (Wolfert, Verdouw, van Wassenaer, Dolfsma, & Klerkx, 2023). In addition, the roles of data actors are dynamic, as they can simultaneously act as data generators, holders, and users. In addition, data value is not intrinsic, but emerges through its flow, exchange and use, the context in which it is applied, its quality, and its availability.

However, despite the growing generation and use of data, the structure and dynamics of the data economy within agrifood systems remain poorly understood. In the European Union, there is a growing recognition of a significant knowledge gaps concerning the objectives of the data economy (Kitsos & Pappa, 2024). In particular, there is limited insight into the value generated by data for different stakeholder groups and how this value aligns with the strategic options these stakeholders adopt.

Considering the economic value that the data use can potentially generate, combined with the drawbacks, risks and challenges, underscore the need for a more strategic and inclusive approach (Dolfsma, Isakhanyan, Rijswijk, & Wolfert, 2023; Isakhanyan, Galgo, Gemtou, & Pedersen, 2024). A deeper understanding how data holders and data users conceptualise, manage, extract and capture value from data, and the strategic options available to various stakeholder groups is therefore critical to designing effective policies and business models for the EU agrifood data economy. In addition, these insights are important to maximise the societal and economic benefits of data while mitigating the risks.

The increasing relevance of data use in agrifood systems has been reflected in a growing body of literature exploring digitalisation, data governance, and value creation (Brini, 2025; Dolfsma, Isakhanyan, Rijswijk, & Wolfert, 2023; Klerkx & Rose, 2020). However, these studies often fall short in addressing the strategic options of data value from a multi-actor perspective. Specifically, the understanding of how diverse stakeholders, e.g. farmers, agribusinesses, policymakers, and consumers, conceptualise data value within the broader context of sustainable and inclusive agrifood systems is limited. Moreover, the strategic options available to stakeholders for capturing data value in ways that align with both individual goals and systemic sustainability objectives are unknown.

To address this gap, the following research questions have been formulated to capture the strategic, perceptual, and future-oriented dimensions of data value in agrifood systems:

1. How to conceptualise strategic options for DE4FS stakeholders to capture the data value?
2. How the stakeholders perceive the key dimensions of data value in agrifood systems?

3. How do strategic options for the uptake of data value proposition play out in different future scenarios and pathways of the DE4FS?

RQ1 aims to conceptualise strategic options by identifying data value for data holders and other stakeholders, explore how these values have been strategized in agrifood systems. Therefore, we have chosen to map the current scientific articles on data value, digital transformation, and strategic management.

RQ2 aims to explore stakeholders' perception of the key dimensions of data value in agrifood systems. We triangulated three methods: (1) workshops to allow stakeholders elaborate on their perceptions, reflect discuss on their real-world experiences, (2) survey to collect structured data from a broad range of stakeholders, and (3) interviews with agri-food business and supporting organisation, and other stakeholders to reveal their experiences on data economy of agrifood systems.

RQ3 aims to sketch different future scenarios and pathways of the DE4FS based on the strategic options for the uptake of data value proposition. We conducted a focused analytical reading of the Deliverable 4.2 examining future scenarios for the data economy within the EU food system,

# 3. Conceptualisation of strategic options for the uptake of data value propositions in food systems

This section answers the first research question “How to conceptualise strategic options for DE4FS stakeholders to capture the data value” by conducting a structured scientific article review and meta-synthesis.

To answer this overarching question, we studied the following sub questions:

Sub-Question 1: What data is used in agrifood systems?

Sub-Question 2: How data flows /shared / exchanged?

Sub-Question 3: What purpose do data serve in agrifood and how is value created form data?

Sub-Question 4: What is the value of data for the data holders and other stakeholders?

Sub-Question 5: What strategies stakeholders choose to capture the data value?

Sub-Question 6: What strategic recommendations are known in the literature for the DE4FS stakeholders to capture data value?

Sub-Question 7: What are the risks and drawbacks of data economy?

By addressing these questions, the study seeks to explain the strategic options available for data value propositions in food systems and inform the development of a fair, inclusive and innovative EU data economy for agrifood.

**Finding relevant scientific articles: Search strategy**

A structured literature search was used to explore strategic options for data value propositions in food systems. The preliminary search produced an excessive number of initial results. Therefore, the search strings were refined and the following search strings were finalised as follows:

data AND value OR proposition OR use OR added OR agriculture OR food OR data AND applications OR data AND use OR data-driven OR sustainability OR data*driven OR digital* AND agriculture AND food AND europ*

The initial search resulted in 508 articles. A preliminary screening was conducted by reviewing the titles, abstracts, and keywords of each publication to identify studies relevant for further analysis. Based on this screening, 210 articles were retained. From this set, the articles that did not address the core themes of the data economy, digitalisation, or strategic options in the agrifood context were excluded. In addition, technical studies with no engagement in strategic or economic reflection were not considered. Specifically, studies focusing merely on technical aspects of 5G technologies, digital twins, or robotics - without a clear connection to data-driven strategies or economic implications - were excluded. In addition, the articles centred on precision agriculture tools, digital platforms, or similar technologies that did not address broader implications for strategic options or data value generation were excluded. Furthermore, working papers and lecture notes that were not peer-reviewed were removed from the selection. After applying these

exclusion criteria, 124 articles remained. A final selection was made based on inclusion criteria requiring that articles should be written in English, pertain to the food system, and be situated within the European agrifood context. This resulted in a final set of 67 articles for detailed analysis. We have downloaded these articles in .pdf format and saved them in the shared folder of WP5 team.

Next, we extracted specific variables from the final set of included articles based on the research question and the sub-questions. To speed-up the performance of bibliometric analysis significantly and take advantage of generative AI in micro-tasks (Korinek, 2023), we have tried various generative AI tools. The use of generative AI could help gain efficiency while maintaining methodological rigor in literature synthesis and research in the domain of economics (Bolanos, Salatino, Osborne, & Motta, 2024). Therefore, we have developed the specific prompt to ask the generative AI in a way that the articles are analysed through the lens of our research questions (Box 1).

**Box 1: The prompt used to analyse literature with generative AI**

*You are tasked with reviewing scholarly articles to support the development of a conceptual framework for strategic options related to data value propositions in the agri-food sector within the data economy. Read the article provided, systematically analyse and summarise the following elements:*

*1. Methodology Used:*
*Specify clearly if the study uses a literature review, experiment, case study, model development, qualitative approach, survey, or a combination thereof.*
*2. Part of the Food System Addressed:*
*Identify precisely which segment(s) of the agri-food system the article pertains to (e.g., plant production, horticulture, livestock, aquaculture, processing, distribution, consumption).*
*3. Type of Agrifood Data Examined:*
*Clarify the type of data discussed, classified from small-scale to large-scale (e.g., Statistical data, Digital Twins, FADN-FLINT, AI-generated data, IoT data, Blockchain data, crop-specific data, livestock-specific data, Geo-data).*
*4. Source of Agrifood Data:*
*Describe how agrifood data is collected or generated (e.g., sensors, IoT devices, remote sensing, farm management software, satellite imagery, manual reporting).*
*5. Data Flow/Sharing/Exchange:*
*Clearly state how data flows between stakeholders, specifying who is sharing data with whom, including methods, tools, or platforms utilised for exchange.*
*6. Stakeholders or Actors Involved:*
*Identify all stakeholders or actors studied or discussed (e.g., farmers, agri-tech companies, researchers, policy makers, distributors, retailers, consumers, cooperatives, industry associations).*
*7. Use of Agrifood Data:*
*Detail how data is used by actors / stakeholders (e.g., integration/manipulation, digital twin creation, statistical reporting, research activities, AI development, forecasting models, decision-support systems).*
*8. Purposes of Agrifood Data Use:*
*Outline clearly stated or implied purposes for the use of agrifood data (e.g., environmental management, efficiency optimisation, sustainability improvement, resilience building, new business model development, informed decision-making, achieving social objectives).*
*9. Value of Data to Data Holders:*

*Discuss explicitly what value or benefits the data provides to those who generate or originally hold the data.*
*10. Value of Data to Other Stakeholders:*
*Explain the benefits or value that other value-chain stakeholders or external actors derive from the data.*
*11. Strategic Options and Decisions for Capturing Data Value:*
*Identify strategic options and decisions highlighted or suggested in the article that stakeholders can employ to capture value from agrifood data.*
*12. Strategic Choices Made by Stakeholders:*
*Summarise strategic choices actually made by stakeholders or actors, or those recommended as potential viable choices by the authors.*
*13. Recommendations to Stakeholders:*
*Clearly present any recommendations or guidance the authors offer to stakeholders regarding maximising the value and effectiveness of agrifood data usage.*
*14. Risks, Drawbacks, and Challenges:*
*Identify and discuss explicitly any risks, potential drawbacks, limitations, ethical concerns, data security, privacy issues, or other challenges related to the collection, sharing, use, and value capture of agrifood data.*
*15. Important Relevant Notes:*
*Include any additional relevant insights, observations, limitations, or important contextual information from the article that could influence the conceptual framework for agrifood data value propositions.*

The data extraction process was guided by a set of research questions, each supported by specific components of the AI-generated prompt. Each prompt was supposed to respond to a sub-question (Table 1). Accordingly, we used the prompt, ensuring that the AI focused on retrieving only relevant information. This approach helped reduce manual bias, streamline the coding process, and maintain a structured overview across the selected literature.

**Table 1 Sub-questions by prompt number**

| N | Sub-Questions | Prompt N (Box 1) |
|---|---|---|
| **1.** | What data is used in agrifood systems? | 2, 3, 4 |
| **2.** | How data flows among actors and among the systems? | 5, 6 |
| **3.** | What purpose do data serve in agrifood and how is value created form data? | 7, 8 |
| **4.** | What is the value of data for the data holders and other stakeholders? | 9, 10 |
| **5.** | What strategies stakeholders choose to capture the data value? | 11, 12 |
| **6.** | What strategic recommendations are known in the literature for the DE4FS stakeholders to capture data value? | 13 |
| **7.** | What are the risks and drawbacks of data sharing? | 14 |

We experimented 4 generative LLMs to compare the analysis of the results: ChatGPT, Microsoft Copilot, DeepSeek, and AI Chat. Three experts have assessed and compared the AI responses to the same prompt based on the quality and precision of the generated responses. They agreed to use Microsoft Copilot (AI) because its responses appeared to be the most reliable and unbiased, as they were based solely on the uploaded document rather than the AI's general knowledge. To minimise potential bias arising from the AI's learning patterns based on document sequence, each article was analysed in a separate Microsoft Copilot chat window.

The outputs from all chats were collected and transferred into an Excel file, where the responses from each individual output were coded individually. Simultaneously, a manual check was conducted by the researchers to ensure the accuracy and usefulness of AI-generated outputs. Furthermore, the reliability and precision of the AI-assisted coding was checked for accuracy and relevancy by manual review and validation. The manual check resulted in removing some of the AI generated context and replacing it with the human created results.

Following, we generated codes using an inductive approach, which derives codes directly from the data. The inductive coding is particularly suitable for our exploratory research (Gough, Oliver, & Thomas, 2017). Once all the text was coded, we counted the frequencies of the codes. During the analysis process, we integrated some codes to improve clarity and reduce redundancy. In addition, we merged the two categories "*Strategic Options and Decisions for Capturing Data Value*" and "*Strategic Choices Made by Stakeholders*" as they yielded very similar results and lacked a clear distinction. The codes used per variable are presented in the Annex I.

**Literature data analysis results**

First of all, we explored what methodologies are used by the authors in the selected articles. The frequency of the methodology chosen in the studies is predominantly literature review itself, comprising 52 studies (Figure 1). This is followed by model development (16) and case studies (12), suggesting a growing focus on developing and contextualising existing knowledge. Literature review has been used to explore existing knowledge on digital agriculture developments. Described model developments included economic models, predictive analytics using machine learning, conceptual frameworks, and intelligent systems. These models were used to inter alia simulate farm-level-decision-making, integrate AI and data analytics/tools, and optimise resource use. Mixed methods (9) and conceptual papers (4) have been moderately used, while empirical methods such as experiments, surveys, expert opinion, and quantitative analysis are underrepresented, each accounting for 3 or fewer studies.

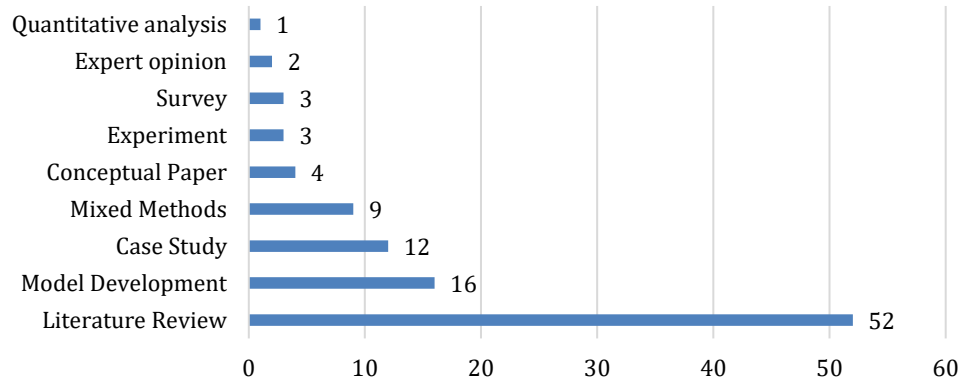


**Figure 2 Distribution of studies per type of methodology**

These findings highlight a clear research gap in empirical validation, suggesting that future work could benefit from more evidence-based methods to enhance practically validated strategic decision-making for data value capture.

***Part of the food system***

The distribution of studies across different parts of the food system highlight that most studies were conducted in the field of plant production (42) followed by distribution (29), processing (28), and the livestock sector (27). This distribution indicates a strong emphasis on the upstream and

midstream stages of the food value chain. In contrast, segments such as R&D (1) and retail (3) are significantly underrepresented (Figure 2).

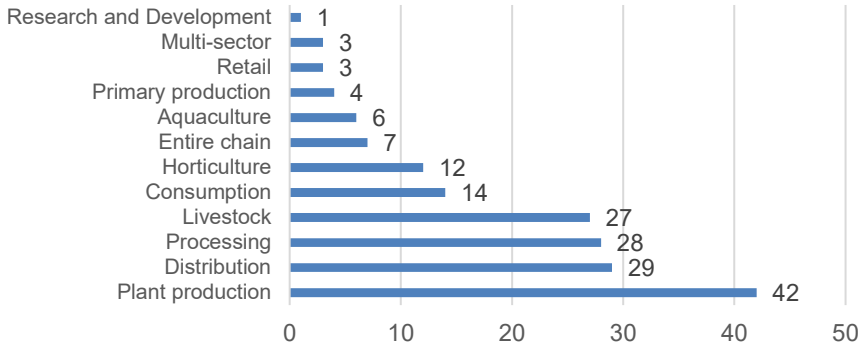


**Figure 3 Distribution of studies per part of the food system addressed by number of codes**

***Type of data***

Regarding the type of data studied in the reviewed literature (Figure 3), IoT data (49) and AI-generated data (44) remain the most frequently cited, followed by crop and/or livestock specific data (36) and geo data (34). In contrast, feed, food processing, consumer, energy and soil data appear in 1-3 studies, implying that these areas are comparatively underexplored. The growing number in blockchain data (25) might show interest in data traceability.

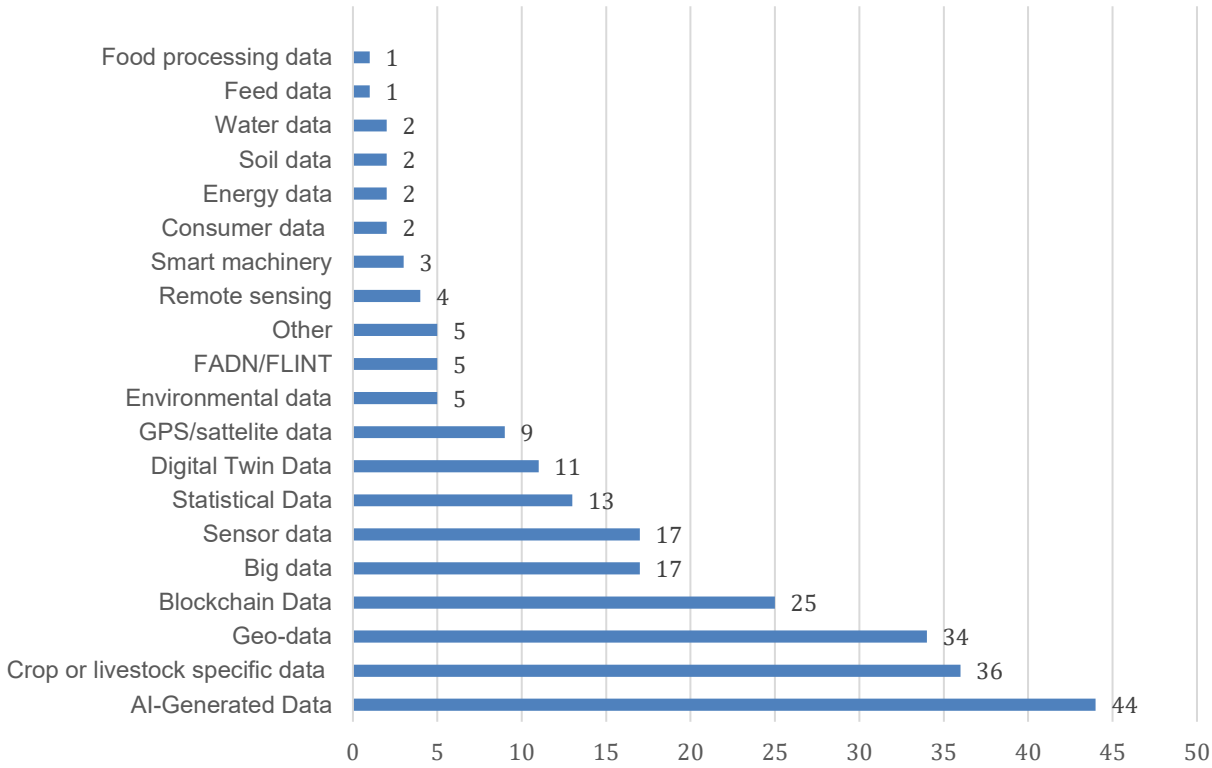


**Figure 4 Code counts - Type of agrifood data as study subject by number of codes**

***Data flow, exchange, share***

The agrifood data are mainly sourced from precision farming practices for which digital devices such as sensors (50), IoT devices (45), remote sensing tools (37) are used. In addition, data is sourced from farm management systems (39) and through manual reporting (42) indicating a strong reliance on both automated and human-input data collection methods. The reviewed

literature shows diverse and uneven adoption of technologies, with traditional and sensor-based methods still dominating the agrifood data landscape.
When analysing the data flow, data sharing and data exchange, we found “between systems” (73) as the most prominent category, highlighting the dominance of system to system communication. This is followed by data flow, sharing and exchange through blockchain technology which was coded as “among all supply chain actors” (29) and “among all stakeholders” (14).

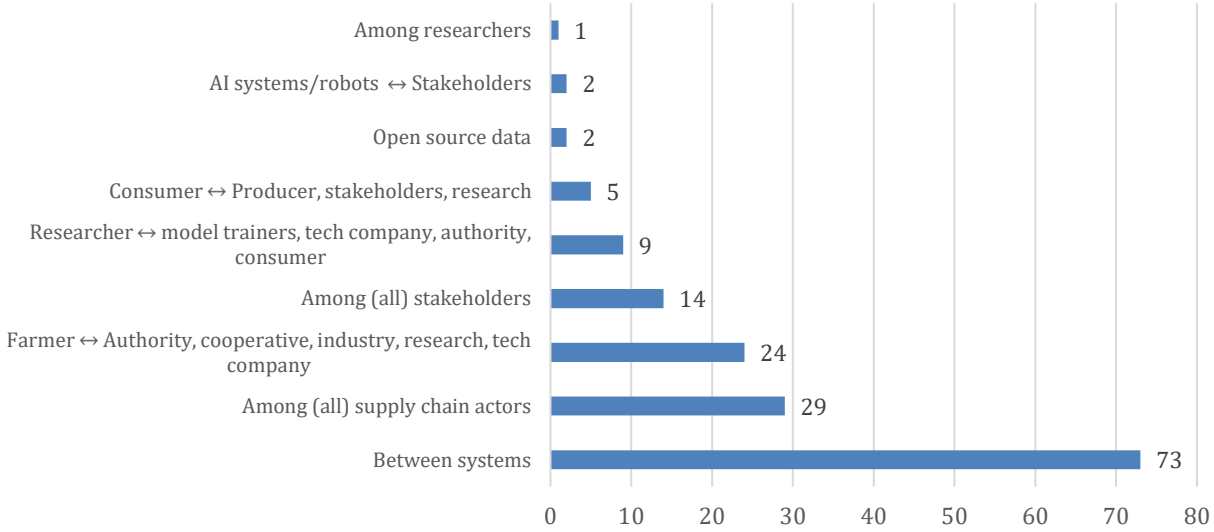


**Figure 5 Data flow, exchange, share**

We also found a moderate number of codes of data exchange between farmer and authority, cooperatives, industry, researchers and tech companies. Overall, we observe that farmers play a central role in many bilateral exchanges, while data flow involving consumers and researchers remain limited.

***Use of agrifood data***

The analysis of how data is used by actors and stakeholders, decision support systems (56) and research analysis and or modelling (52) appeared most frequent (Figure 6). This indicates that data is primarily used for strategic purposes and analytical functions. Predicting and forecasting using AI also appears frequently (34), indicating importance of data use for future insights. Data is also used for data integration purposes (29), AI development (28), statistical reporting (28), and digital twin creation (28), in combination of frequent use of the data representing the simulation of real agricultural systems or development of virtual models. Digital twin creation was often deployed in the context of improved decision making, yield optimization, and resource management. Another fundamental category of data use was the integration of data, often representing data integration and manipulation used to do further comprehensive analysis, as a basis for decision making or the use in precision agriculture. Remarkably, a relatively low use of data for operations optimisation (17) and monitoring and evaluation (6) might suggest that these areas are either less data intensive or less represented in the literature. In sum, the results highlight the wide array of data use for strategic decision making purposes and forecasting applications.

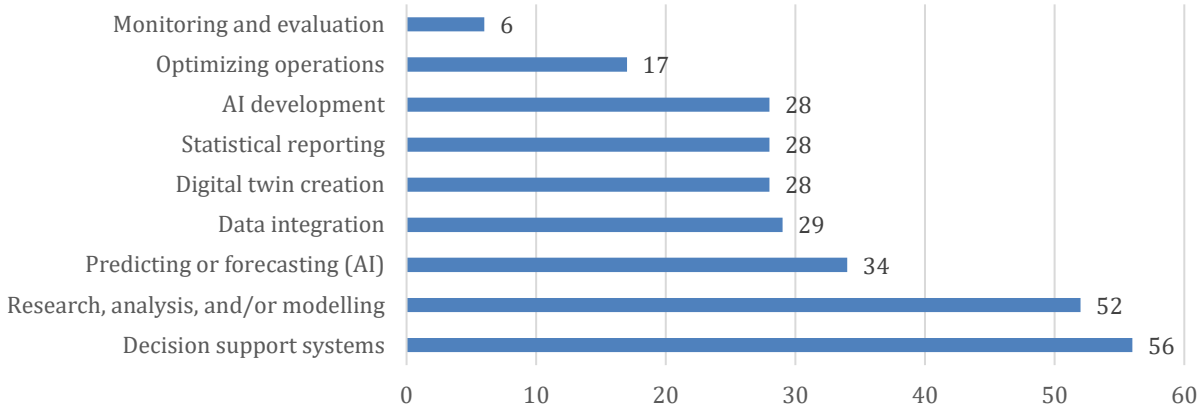


**Figure 66 The use of agrifood data**

***Purpose of data use***

When it comes to the purpose of the data, key purpose of agrifood data use is focused on the sustainability goals (65). As shown in Figure 7, we found high frequency of environmental goals (46). The second most popular goal is the efficiency optimization (62), and informed decision making (55). Efficiency optimization served as functions of optimizing the use of resources, farm productivity, and waste reduction – primarily mentioned in the context of precision agriculture.

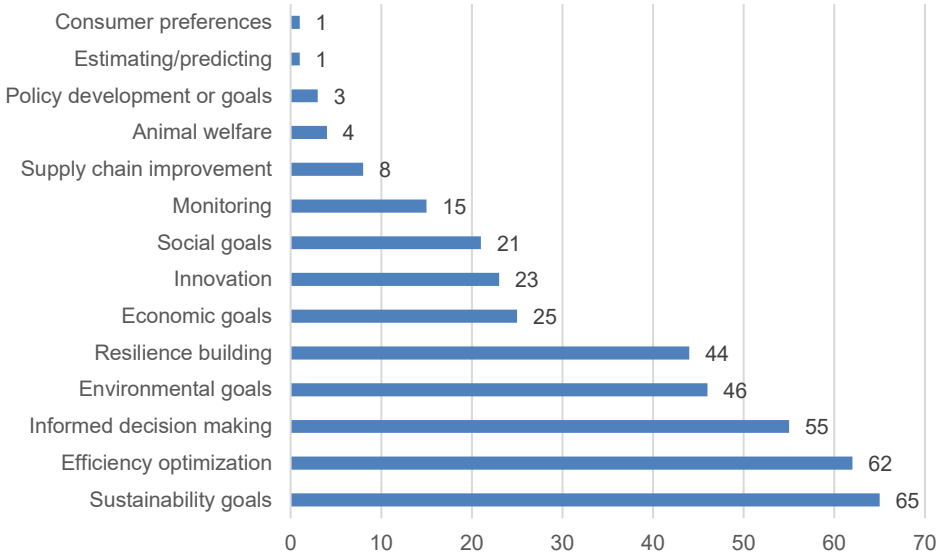


**Figure 7 Purpose of data use**

Less frequently coded purposes include monitoring and supply chain improvement, while animal welfare, policy development, consumer preferences, and predictive uses are rarely mentioned. These frequencies underscore a dominant emphasis on sustainability, attention to environment, efficiency, and resilience building in agrifood data purposes. The broader purpose of data to make informed decisions mostly served farmers in their farm management and policy makers in policy design.

***Value of data to data holders and other stakeholders***

Following, we analysed the value of data to data holders (Figure 6), and value of data for other stakeholders (Figure 7). The results reveal a clear distinction between the perceived value of

agrifood data generators or holders, such as farmers, and for external stakeholders across the food system. The value of data to data holders strongly focuses on immediate, tangible gains in performance and decision making (such as economic benefits) (n=51), increased productivity (n=41), informed decision making (n=36), resource optimization (n=18), and efficiency gains (n=15). Economic benefits were described in the context of increased profitability, reduced input use, improved yields, and enhanced market share. The value of informed decision-making, often supported by predictive tools, was frequently linked to improved on-farm management and strategic planning. Closely aligned with precision farming, resource optimization was discussed in relation to input allocation, irrigation efficiency, and enhanced environmental performance.

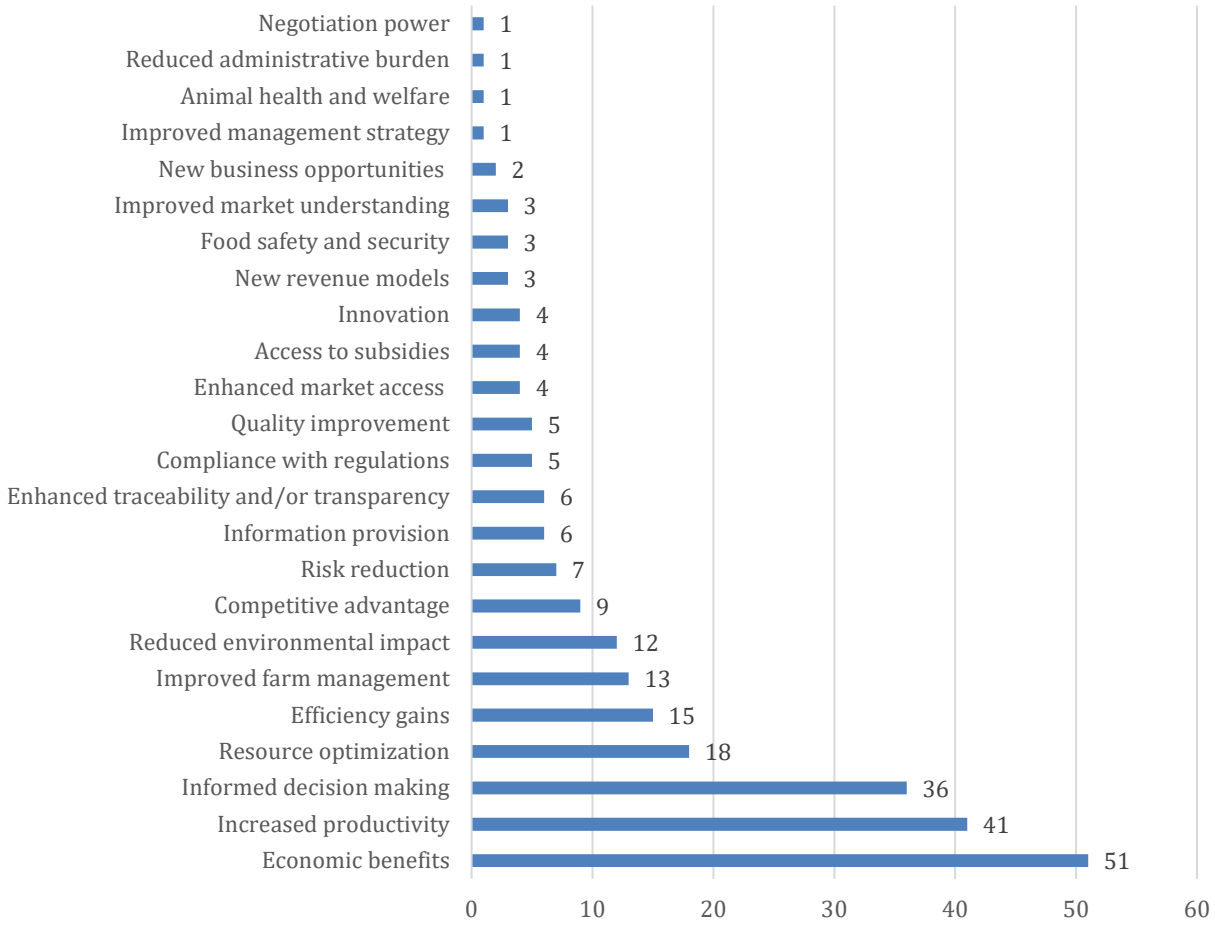


**Figure 8 data value to data holders**

In contrast, the value of data to stakeholders in the food system such as enabling actors, policy makers, consumers, actors from adjacent sectors frequently focuses on more systemic and policy-level interests (Figure 9). Better policy making (n=34), for instance, can be made by using data for evidence-based and targeted regulations. Within the supply chain, enhanced traceability and transparency (n=33) are related to building consumer trust through the use of blockchain technologies. Closely linked, the value of data for supply chain improvement (n=26) and consumer information provision (n=20) are inter alia achieved through data supporting the logistics, the enhanced accuracy of inventory, and providing consumers with high credible product data. Interestingly, while some values of data such a food safety and security, innovation, informed decision making, compliance with regulation, and competitive advantage appear to be values for both data holders and other stakeholders. However, the frequencies of these codes vary,

indicating differences in perspectives and incentives between data holders and other stakeholders.

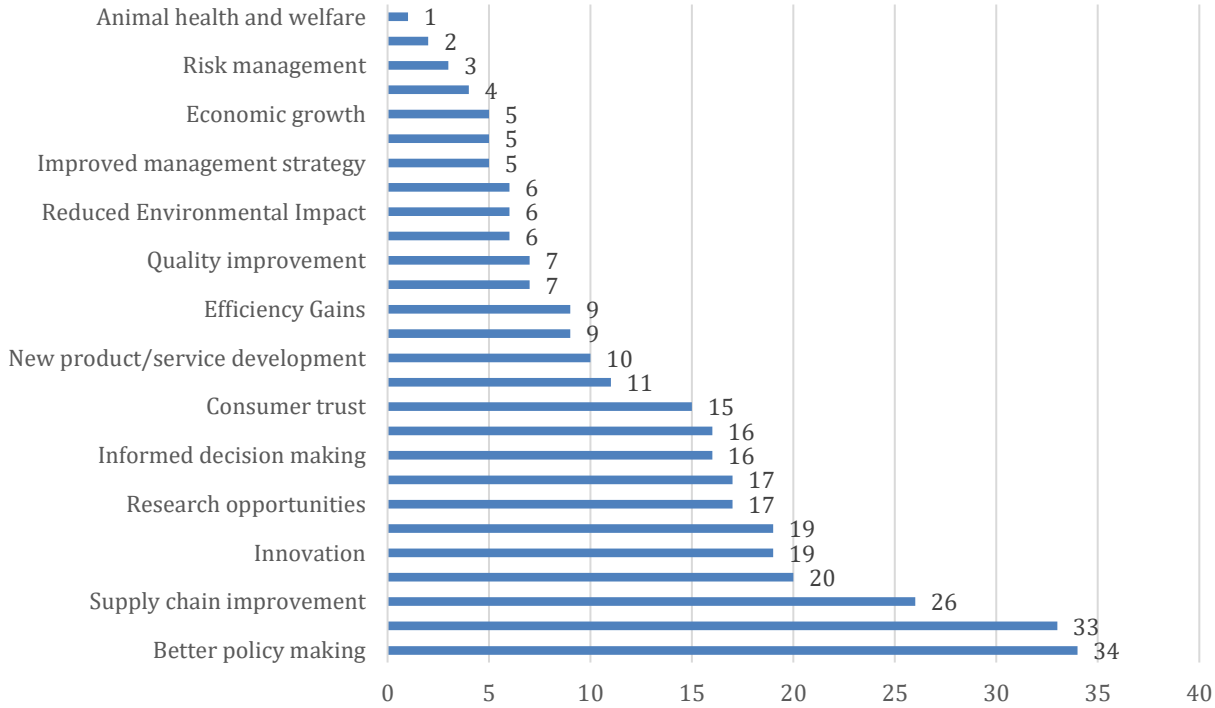


**Figure 9 Value of data to stakeholders**

### *Strategic options for stakeholder to capture data value*

From the literature it appeared that strategic decisions around capturing the value of the data are dominantly related to technology adoption (n=99), mentioned in relation to the use of IoT, AI, and blockchain data for enhanced decision making, precision agriculture, and supply chain transparency (Table 1). Following, the literature emphasises collaborative models and ecosystems as enabling strategies for data value capture. Investments in AI / data analytics (35) and infrastructure (n=32) pertained the investments in digital infrastructures, sensor networks, and platforms. For such infrastructures to enable proper data exchange, strategic solutions focused on data integration, standardization and interoperability (n=33). Data flow and exchange were linked to collaboration and ecosystem building (n=54), displayed through cross-sector partnerships, co-creation and cooperative models. To create value in the context of predictive modelling and automation, stakeholders invested in AI and data analytics tools (n=35). For farmers this encompassed practical tool adoption, while policymakers focussed on enabling environments and governance frameworks.

**Table 2 Strategic options/decisions for capturing data value**

| *Code* | *f* | *Code* | *f* |
|---|---|---|---|
| Technology adoption | 99 | Model development | 6 |
| Collaborative models & ecosystems | 54 | Data-driven management | 6 |
| Invest in AI/data analytics | 35 | New business models | 6 |
| Data integration, standardisation & interoperability | 33 | Regional strategies | 6 |
| Infrastructure investment | 32 | Targeted communication, tailored solutions, personalization | 6 |
| Integration (platform, blockchain & other tech) | 28 | Data monetization | 3 |

| | | | |
|---|---|---|---|
| Decision support & predictive analytics | 26 | Data integration | 3 |
| Precision agriculture and smart farming practices | 26 | Edge and cloud computing | 3 |
| Data sharing | 20 | Low-cost solutions | 3 |
| Innovation | 18 | Scale-up | 2 |
| Capacity building & digital literacy | 15 | Interactive apps | 2 |
| Data collection frameworks | 15 | Data repositories | 2 |
| Sustainability, environmental & social impact | 14 | Marketing of high-tech in agrifood | 2 |
| Governance, ethics & data sovereignty | 11 | Financial incentives | 2 |
| Development and participation in data platforms | 11 | Target high value market | 1 |
| Policy & regulatory support, policy design | 11 | Leveraging ROI | 1 |
| Building partnerships | 7 | Support vulnerable areas | 1 |
| Data management | 7 | Start-ups | 1 |
| Digital twin | 7 | Promotion/discounts | 1 |

Surprisingly, economic triggers, such as data monetization, low-cost solutions, financial incentives, and promotions/discounts appear less frequently in the literature indicating the challenges of integrating data value in the revenue models.

### *Recommendations to stakeholders*

Next, we analysed the strategic or management recommendations or guidance the article authors offer to stakeholders regarding maximising the value and effectiveness of agrifood data usage (Table 3).

**Table 3 Recommendations to stakeholders**

| *Recommendation Code* | *f* |
|---|---|
| Invest in training & capacity building | 27 |
| Ensure data privacy and security | 24 |
| Promote cross-sector collaboration | 23 |
| Focus on sustainability/resilience | 21 |
| Invest in digital/ICT infrastructure | 19 |
| Develop user-friendly/adapted technologies | 18 |
| Enhance data interoperability & standardization | 17 |
| Support inclusive & smallholder-friendly solutions | 16 |
| Improve data collection methods & quality | 15 |
| Adopt AI, Big Data, IoT, digital tools | 14 |
| Encourage data-driven decision-making | 13 |
| Support policy & regulatory frameworks | 13 |
| Increase funding & financial support | 12 |
| Foster digital literacy / technical education | 12 |
| Support data sovereignty & fair ownership | 10 |

According to Table 3, investing in the training and capacity building is the most dominant recommendations. In addition, we observe a huge attention to data privacy, security, and sustainability in general.

Compared to what literature found in terms of strategic options and decisions for capturing data value (Table 2) with the recommendations authors provide to the stakeholders (Table 3), we find that investment in technology adoption, in AI and data analytics, in infrastructures, as most frequently appearing strategic options. Following, collaborative models and ecosystems where not only actors are interconnected, but also the systems are integrated seem urgent.

However, we observe a difference between the strategies stakeholders adopt and recommendations provided by the authors. The major gap here is the capacity building and, ethical governance and inclusive policies, which might leverage long-term trust and unlock more value of data in digital agriculture.

#### *Risks, drawbacks and challenges*

Risks, drawbacks and challenges can be categorised:

- Data privacy
- Ethical concerns
- Data quality
- Economic barriers
- Adoption challenges
- Technical limitations
- Environmental impact

Regarding the risks, data privacy is by far the most cited risk, followed closely by ethical concerns related to data use, ownership, access, digital divide, inequalities and potential biases. Another concern related to data use is the quality of data, specifically, the availability, accuracy and reliability of data. This is followed by economic barriers, such as high initial costs and high investment costs unavailable for the SMEs. In terms of adoption challenges, articles refer to digital literacy, lack of training and technical expertise, technophobia and resistance to change. In terms of technical challenges, article refer to integration, interoperability and lack of appropriate infrastructure issues. Regarding the environmental impact, issues related to impact of AI infrastructure of environment, electronic waste, and digital infrastructure are discussed.

To ensure an efficient capture to data value, stakeholders need to address to the risks, drawbacks and challenges in their strategies. For instance, to address ethical concerns, articles suggest developing ethical guidance, include diverse stakeholders, and promote transparencies via technologies, such as blockchain. In line with strategic options/ decision (Table 2) articles suggest, multi-stakeholder, multi-layered collaborative models and ecosystems as mechanisms to protect sensitive data, build trust and ensure compliance with regulations.

### *Conceptual framework*

Based on the structured scientific article review and meta-synthesis, we have constructed a conceptual framework, which is an abstract model to explain the key concepts, variables, relationships that explain the strategic options and decisions to capture data value in agrifood systems (Figure 10). This framework reflects the multiple stakeholder groups across institutional, and business levels, visualising strategic decisions for data value creation across the agrifood system. The framework highlights the interconnections among the stakeholders, institutions and

data flow, reflecting the data economy of agrifood systems as an eco-system network. The data economy in food systems is about the (free) flow of data between institutions, systems, organisations, and stakeholders that are part of those agrifood system.

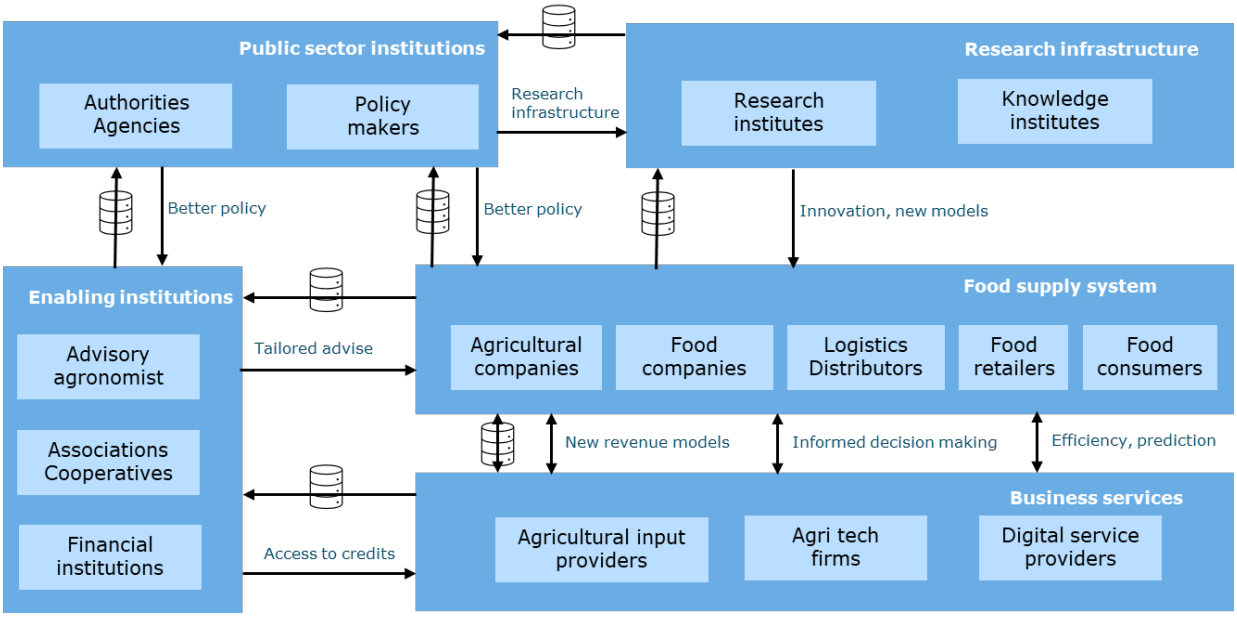


**Figure 10 Conceptual framework of data value stream among agrifood systems institutions**

*Note:*  *- data flow. Value propositions of data presented in the figure are illustrative. For more value propositions, see Figure 6 and Figure 7*

Figure 10 presents an systemic overview of interdependencies among institutional actors, service providers and the food supply system. The five core domains integrated in the figure are (1) public sector institutions, (2) enabling institutions, (3) business services, (4) research institutions, and, central to agrifood, (5) food supply system itself. Public sector institutions, including governmental authorities, agencies and policymakers are expected to use data for better policy making, and for creating infrastructures. Enabling institutions, such as advisory services, cooperatives, associations, and financial institutions (banks, insurance companies) use data to facilitate collaboration, provide tailored advise, enhance decision making capacity and ease targeted credits. Business services, including agricultural input providers, agri-tech firms and digital service providers are strongly linked to food supply chain in terms of two-sided data flow, new revenue models, efficiency and prediction for food producers, distributors and retailers, and informed decision making. This conceptual framework (Figure 10) enlightens the data flow and sharing of value propositions that can be enabled in cross-sectoral collaborations.

### *Conclusions*

Based on the comprehensive review and meta-synthesis of scientific articles, Section 3 aims to answer the research question: "How to conceptualise strategic options for DE4FS stakeholders to capture the data value?" To conceptualise strategic options/ decisions for DE4FS stakeholders so that they can capture the value of data, it is essential to consider agrifood data economy as a dynamic and interconnected ecosystem. Literature clearly indicates that data value can be

created by technology adoption, collaborative business models, and strategic investments, especially in infrastructures. Literature also clarifies specific choices various group of stakeholders can make. For instance, the urgency for farmers is in engagement in digital literacy and training programmes, participation data sharing networks and platforms. Whereas, policy makers are advised to create enabling environment through infrastructures, targeted subsidies and new research opportunities, ensure data protection via governance and laws, invest in education and research. Technology providers are recommended to design affordable, interoperable, and scalable solutions that are user- friendly and support smallholders. Finally, the collaboration at all levels is needed to integrate in strategies to enable data value capture.

The conceptual framework developed (Figure 10) therefore, highlights the core domains that play important role, namely public institutions, enabling institutions, business services, research institutions and food supply systems itself.

# 4. Data value from food systems' stakeholders perspective

While Section 3 explores value of data and strategic options of data use based on structured mapping of knowledge from scientific articles, Section 4 investigates data value empirically by consulting food system and data economy stakeholders and asking their opinion. Section 4 addresses RQ2: "How the stakeholders perceive the key dimensions of data value in agrifood systems?"

To address this overarching question, we formulated five sub questions and explored them by conducting five smaller empirical studies (four original studies and a secondary analysis of data collected in Task 4.1). Each study applied specific method of consultation with stakeholders. Table 4 gives an overview of sub questions, methods and groups of stakeholders consulted in those empirical studies. The sub questions used in stakeholder consultation correspond to those applied in literature study although they are not identical. It should be also noted that each individual study approached slightly different subsets of food system stakeholders while taking into consideration the overarching definition and categorisation of FS and data economy stakeholders, as outlined in glossary. By using this approach, we tried to maximise the coverage of stakeholder groups in consultation process.

**Table 4 Research questions and methods in stakeholder consultation**

| Sub questions | Methods | Stakeholder groups consulted |
|---|---|---|
| Sub-Question 1: What value do data propose in food systems? | Stakeholder workshop on data value in agrifood systems. | Consortium partners, researchers, data companies, innovation support agencies, advisory services, NGOs. |
| Sub-Question 2: How do stakeholders prioritise data value in food systems? | Stakeholder survey about data value in agrifood systems. | Farmers, food processors, retailers, caterers, IT specialists, researchers, FS enabling actors. |
| Sub-Question 3: Why data are valuable for different stakeholders? What solutions would allow beneficial use of data and minimise damages for many stakeholders? | Secondary analysis of Task 4.1 stakeholder interviews about their experiences of data economy of food systems. | Primary producers, processors, distributors, policy, food safety, health, retailers, researchers, data actors, advisors, input, other. |
| Sub-Question 4: How do stakeholders prioritise options towards implementation of data economy of food systems? | Stakeholder workshop on strategic options for the implementation of data economy in food systems. | Farmers, processors, researchers, data actors, advisors, HoReCa. |
| Sub-Question 5: How do non-farmer stakeholders see data value proposition in specific sectors? | Interviews with processors and business support organisations in dairy sector. | Veterinarian, feed company manager, dairy manager, researcher, animal breeding specialist. |

Section 4 is organised in five sub sections which present rationale, methodology and results of five interrelated smaller empirical studies. Altogether section 4 contributes to understanding of strategic options of data value by taking stakeholder perspective who operate in wider food systems composed of institutions, actors, activities, outcomes, and interaction.

## 4.1 What are key dimensions of data value in food systems in stakeholder opinion?

This section answers sub question 1: What value do data propose in food systems?
The empirical investigation of stakeholder opinion about data value in food systems started with a workshop “What value do data propose in food systems”? The purpose of the workshop was to identify key dimensions of data value in food systems. It aimed to reveal bottom-up perspectives on data value, which later were compared with results of a more top-down oriented literature analysis and served as input for preparation of s stakeholder survey.

The workshop was organised during the Data4Food2030 project consortium meeting in Barcelona in October 2024. Altogether 45 participants took part in discussion. They represented a wide spectrum of stakeholders from the project consortium organisations including research institutes, data companies, innovation support agencies, advisory services, NGOs and other. The discussion was organised in seven groups. The workshop started with individual reflection on the question “Based on your involvement and experiences in Data4Food2030 project this far, what do you see as the main value of data in food system? Can you give some examples?”. The participants used yellow post-its to document experiences. The individual reflection was followed by group discussion focussing on question “How do different values of data captured relate to different food system stakeholders?" Green post-its were used to highlight benefits, risks, challenges. The workshop results were documented on seven posters containing 127 notes that reflect stakeholder opinions, reflection and answers to the questions posed (Figure 11).

**Figure 1111 Stakeholder workshop post-its**

Analysis of workshop results started with transferring post-its on Microsoft Whiteboard to produce a dynamic picture of posters. This allowed a further grouping, regrouping and clustering of discussion results. Various aspects of data value articulated were grouped along common themes. Thus, the first level codes were identified. As coding and clustering continued, more embracive themes of data value emerged. At this point inductive coding was complemented by theoretically informed coding using the food systems definition which emphasises core activities (production, processing, distribution, consumption of food), actors involved and their interactions, as well as drivers, outcomes and feedback of these activities. As data flows permeate all these activities and actor relationships, we used in data interpretation also the conceptual model of data value stream, elaborated in Section 3 (Figure 10). The value of data for stakeholders was contextualised at food systems level.

**Workshop results**

The stakeholder workshop identified nine general dimensions of data value in food systems that can be common for multiple stakeholders: improve food systems governance; support decision making; improve efficiency; optimise activities; assure quality; support innovation; enhance outcomes; and address challenges. Based on post-it notes we reconstructed stakeholder narratives regarding these dimensions of data value:

1. Improve FS governance. Narrative: Data helps to improve policies. Data is used in policy planning to set new priorities and targets of FS. Functioning and interoperability of government data bases reduce administrative burdens on stakeholders. interoperability of governance data systems is key.
2. Support decision-making. Narrative: Data improves decision-making in terms of improved awareness, understanding of FS processes, activities, interconnections, outcomes, and the stakeholder role in it. Data helps to make better informed decisions and actions of stakeholders leading to more efficient as well as more sustainable activities. Value of data for decision-making refers not only to individual businesses but also wider actor configurations, f.i. short food supply chains.
3. Improve efficiency. Narrative: Data improves efficiency, value creation and value capture in FS. Efficiency is tied not only to economic performance but also to social, ethical and health performance of FS. Data may be used by companies to strengthen their market power (might lead to power imbalances). Therefore, transparent and fair data sharing

matter. Smart data use might help companies to adapt and change their business models and create new value propositions.

4. Optimise FS activities. Narrative: Data helps optimisation, control, monitoring of FS activities and processes. May refer to farmer dashboards and other data-based business intelligence and decision support systems and tools. Use of data for benchmarking, monitoring, forecasting.
5. Improve FS performance. Narrative: data is used to manage and improve particular FS performance attributes, such as traceability, safety, transparency.
6. Assure quality. Narrative: data helps to assure quality, control quality and enforce standardisation.
7. Support innovation. Narrative: Data supports FS innovation through digital ecosystem development, digitalisation and use of digital technologies and tools, including AI. Data proposes value for interdisciplinary and transdisciplinary research and multi-actor collaboration which is essential for FS innovations. Data helps to improving AKIS services (e.g. farmer advice) and functioning of food system knowledge and innovation system. Value of data is related to both product, market, financial, organisational innovations, i.e. data enable these kinds of innovation.
8. Enhance FS outcomes. Narrative: data enhances FS outcomes, such as food security, health, environment, consumer information, sustainability, wellbeing. Data allows to achieve the desired outcomes of FS 'systematically'. Data may be used to strengthen links between economic, technological and social processes and relations in FS. Data enhances consumer information and awareness. Data helps to make informed consumer choices and improve dietary habits.
9. Address challenges of FS. Narrative: Contemporary FS are vulnerable. Data helps addressing FS challenges, risks and opportunities, in terms of economic, environmental and social challenges. At the same time data economy poses its own challenges such as fair and transparent data use which have to be addressed.

Table 5 provides some stakeholder quotes from the workshop, characterising data value dimensions and narratives in stakeholder wording.

**Table 5 Key dimensions of data value in food systems**

| Dimensions of data value | Stakeholder quotes |
|---|---|
| 1. Improve FS governance | *"Data is valuable as input for government policy."*<br>*"Reducing administrative burdens on stakeholders."*<br>*"Enable the prioritization of potential important areas."* |
| 2. Support decision-making | *"Data has value, e.g., for banks when the decision concerning a loan is going to be made."*<br>*"Data supports decision making, analysis of costs, markets."*<br>*"Data supports integral decision making, including all steps of the value chain."* |
| 3. Improve efficiency | *"More economic and efficient food production."*<br>*"Digital farming efficiency."*<br>*"For companies - new data insights help to increase market share".* |

| | |
|---|---|
| 4. Optimise FS activities | *"Enable the identification of systematic errors or problems."*<br>*"Data collection is essential to benchmark."*<br>*"Monitoring activities, evaluating their impacts."* |
| 5. Improve FS performance | *"Data has potential to increase transparency of value chains which results in fairness."*<br>*"Food safety, traceability, sustainability."*<br>*"Food traceability from farm to work."* |
| 6. Assure quality | *"Data allows for quality control and certification."*<br>*"Proof on meeting quality requirements in the food chain."*<br>*"Data collection is prerequisite for standardisation."* |
| 7. Support innovation | *"Data allows for automated steering of processes. For instance, with climate control."*<br>*"Data is the basis for science and understanding phenomena."*<br>*"Thinking about data (economy) helps nowadays to understand working interdisciplinary with colleagues, partners."* |
| 8. Enhance FS outcomes | *"Consumer led data on food can be combined with data on health and behaviour to understand how consumers make decisions."*<br>*"Improve nutritional value and options for consumers (potential crowd-sourcing data)."*<br>*"Making environmental impact of food systems visible and actionable".* |
| 9. Address challenges of FS | *"Possibility to combine different data sources to counteract on false communication or fraud in food systems."*<br>*"Main value of data - to answer to new emerging threats to food security (climate change, pandemics, global conflict, overpopulation)."*<br>*"Keeping stakeholders updated with the recent trends in business."* |

The nine dimensions of data value established in workshop present universal purposes of data use that can be common for different stakeholders at food systems level. In other words, they can be considered strategic directions of data value that stakeholders consider when operating in food systems. Governance, decision-making, efficiency, optimisation, processes improvement, quality, innovation, outcomes enhancement, challenges handling were mentioned as main themes. However, the workshop results did not allow to rank or prioritise these themes. Therefore, decision was made to explore these themes further in stakeholder survey.

## 4.2 How do stakeholders prioritise data value in food systems?

This section addresses sub question 2: How do stakeholders prioritise data value in food systems?

The workshop outcomes and the identified nine dimensions of data value served as input for the next method in stakeholder consultation – a stakeholder questionnaire. To address the research

question outlined in the title, a survey was conducted targeting various stakeholder groups involved in the food system. The survey aimed to collect opinions on the importance of data for various applications in the broadly understood Food System and Food Economy. The survey consisted of statements, and respondents were asked to determine the extent to which they agreed or disagreed with each one. The purpose of the questionnaire survey was to gain a deeper and more nuanced insight into the data value dimensions established during the workshop.

In total, 128 individuals took part in the survey. The sample mainly included respondents from Poland (75.8%). The study also involved stakeholders from other European countries (Latvia, Moldova, and the United Kingdom).

The questionnaire was developed, reviewed and refined in cooperation with the Data4Food project team. Several pilot interviews were conducted to finalise the questionnaire. To ensure accessibility for all respondents, the survey was available in three languages: English, Polish, and Latvian. The survey was fully anonymous, with no possibility of identifying individual respondents or tracing responses to specific sources. The survey questionnaire including respondents' answers to all 29 statements is included in Annex II.

The survey was designed as an exploratory study, employing a convenience sampling approach. Multiple outreach channels were used to reach potential respondents representing all key segments of the food system, as well as experts in digital technologies, academics, and representatives from regional governments.

In the first stage, the survey targeted participants from previous Data4Food workshops, ensuring a high level of diversity within the sample. To generate a snowball effect, these respondents were asked to forward the survey invitation to colleagues and contacts within their professional networks.

Another significant group of respondents was recruited via email outreach. The mailing list was compiled using contact information from participants in previous research projects conducted by the research team, with a primary focus on farmers. Additionally, contact details for processing and trading companies were sourced through online searches.

The sample was further supplemented by a group of participants from the Executive International MBA in Agribusiness Management program, with respondents from both Poland and Moldova. All participants from this group had relevant professional experience, with most holding managerial positions in agribusiness companies. The convenience sampling used is a non-probabilistic method, meaning that it is not representative but allows to learn what opinions do stakeholders from different categories have. The research team estimates that response rate was up to 80%, however it varied per language of questionnaire. The response rate to invitations sent out in Polish was higher than response rate to invitations in Latvian.

The survey was conducted online using the LimeSurvey platform. A dedicated questionnaire developed specifically for this study, consisted of 29 statements (excluding demographic characteristics questions), grouped into nine thematic categories, as established in section 4.1. An additional 10$^{th}$ category "Data sharing and free flow of data" was added based on the research team considerations to include legal aspects. For each of the categories three statements were elaborated for stakeholder assessment. To enable the quantitative analysis of respondents' opinions, a Likert 7 points scale from -3 (strongly disagree) to +3 (strongly agree) with a 0/neutral in the middle was applied.

**Results of stakeholder survey**

Table 6 presents the structure of the research sample. In line with the research design, the sample of respondents was characterised by considerable diversity, including individuals with a wide range of professional backgrounds, varying ages, and different positions within the hierarchical structure of their respective companies and organizations.

**Table 6 Structure of the sample of respondents**

| Sample characteristics | Number of respondents | Share (%) |
|---|---|---|
| Total | 128 | 100,0 |
| *of which: Polish respondents* | *95* | *74,2* |
| **Gender** | | |
| Male | 75 | 58,6 |
| Female | 53 | 41,4 |
| **Category of stakeholders** | | |
| Farmers | 42 | 32,8 |
| Food processors, retailers, catering | 14 | 11,0 |
| IT specialists | 30 | 23,4 |
| Researchers | 25 | 19,5 |
| Other (e.g., Input suppliers, public, administration, finance sector, education, health service, waste management) | 31 | 24,2 |

The research sample consisted of 128 respondents, of whom 74.2% were Polish respondents. Men made up 58.6% of the total sample. Among stakeholder groups, farmers represented the largest share at 32.8%, followed by IT specialists at 23.4%, indicating their significant presence in the sample. The consumer category was intentionally excluded from the study, based on the rationale that everyone is a food consumer regardless of their participation in the food system or the specific role they play. The Food System, for which farming, retail or catering were considered the boundaries, served as the primary source of income for 43.8% of respondents.
Respondents reported a wide range of professional experience. The average duration of work experience was 14 years, with a median of 10 years, ranging from one to 55 years.

*Mean Data Value Scores for Individual Survey Questions*

Table 7 presents the average values of assessments, calculated as mean scores for each category of statements. The table suggests that top five categories of data value in food systems in stakeholder opinion are: efficiency, governance, quality, optimisation and FS outcomes. The three lowest ranked categories are innovation, data sharing and challenges. The overall mean score across all respondents and statements was 1.68, placing it midway between “slightly agree” and “agree” on the assessment scale.

**Table 7 Average values of the assessment indicators for categories of statements by specified groups of stakeholders**

| Data value dimensions | Total | Farmers | Researchers | IT | Other |
|---|---|---|---|---|---|
| Category 5: Efficiency, value creation and value capture in Food System | 2,02 | 2,17 | 1,84 | 2,22 | 1,76 |
| Category 1: Food System Governance | 1,96 | 1,86 | 1,95 | 2,13 | 1,92 |
| Category 8: Quality assurance and control, standardisation in Food System | 1,92 | 1,85 | 1,84 | 2,00 | 2,03 |
| Category 6: Optimising, control, and monitoring Food System activities and processes | 1,88 | 1,94 | 1,81 | 1,82 | 1,91 |
| Category 4: Food System Outcomes (environment, health, information, well-being) | 1,80 | 1,67 | 1,64 | 1,90 | 2,01 |
| Category 2: Decision-making processes | 1,79 | 1,78 | 1,72 | 1,89 | 1,79 |
| Category 3: Managing performance attributes of the food system | 1,69 | 1,63 | 1,45 | 2,07 | 1,60 |
| Category 7: Innovation ecosystem – digitalisation, AI, collaboration | 1,59 | 1,79 | 1,40 | 1,63 | 1,44 |
| Category 10: Data sharing and free flow of data | 1,17 | 0,98 | 0,89 | 1,71 | 1,12 |
| Category 9: Key challenges, risks and opportunities in European Food System Data Spaces | 1,09 | 1,31 | 0,85 | 1,12 | 0,95 |
| **Total Survey** | **1,68** | **1,69** | **1,27** | **1,84** | **1,70** |

The highest average data value assessments were given by representatives of the IT sector, with a mean score of 1.84 across the entire set of statements, and the highest ratings in 8 out of 10 statement categories. This likely reflects the knowledge and experience of this group, who are professionally involved in the development and application of digital tools.

Notably, the lowest average scores were recorded among the relatively large group of respondents from the academic sector. Explaining this phenomenon would require in-depth interviews, which were not feasible in this survey due to the anonymity of respondents. One possible explanation is that researchers may tend to be more cautious in forming opinions unless supported by sufficient knowledge and scientific evidence.

The lowest-rated categories—categories 9 and 10—received scores clearly below the overall average across all statements. This was primarily due to responses from researchers and farmers, particularly regarding data-sharing. While these professional groups generally recognise the value of using data for various purposes, they—apart from the IT sector—are highly reluctant to share their own data. This is especially evident in the "science" group, which gave an average score of just 0.89. Although they are strongly oriented toward disseminating the results of their research, this low score may reflect their attitude of protecting the original data collected during their studies.

Annex III provides detailed information on the assessments of all 29 statements included in the survey questionnaire. The mean scores for individual statements varied widely, ranging from 0.24 to 2.33 on a scale from -3 to +3. Both the standard deviation and coefficient of variation were relatively high, indicating a substantial spread and diversity of opinions among respondents. Significant differences in assessments were particularly evident among professional groups for several statements (Table 8).

**Table 8 Statements with significant discrepancies in assessments among respondent groups**

| Statement | Farmers | Science | IT | Other | Total |
|---|---|---|---|---|---|
| **Category 2: Decision-making processes** | | | | | |
| Decisions in food systems should be based on data, even if it means disregarding traditional knowledge and experience | 0,88 | **0,48** | **1,33** | 1,16 | 0,98 |
| ***Comment:*** *The scores from the "Science" and "IT" groups are strikingly different. The very low ratings from researchers may reflect a more social or market-oriented perspective (e.g., awareness of high consumer demand for traditional and local food), whereas the IT specialists likely take a more technically driven approach.* | | | | | |
| **Average for Category 2** | **1,78** | **1,72** | **1,89** | **1,79** | **1,80** |
| **Category 3: Managing performance attributes of the food system** | | | | | |
| The collection and sharing of detailed data on food production and distribution should be mandatory… | 0,81 | **0,49** | **1,63** | 0,71 | 0,91 |
| ***Comment:*** *The divergence between "Science" and "IT" ratings is even more pronounced in this case, clearly indicating that IT professionals view data as a foundation of the data economy and a prerequisite for effective use of digital tools. In contrast, researchers appear to be guided by the belief that data owners should have democratic rights to decide whether or not to share their data.* | | | | | |
| **Average for Category 3** | **1,63** | **1,45** | **2,07** | **1,60** | **1,69** |
| **Category 7: Innovation ecosystem – digitalisation, AI, collaboration** | | | | | |
| Reliance on AI in food systems often leads to wrong decisions | 1,50 | 0,48 | 0,97 | 0,58 | 0,95 |
| ***Comment:*** *The substantial, two-directional discrepancies in assessments across respondent groups are difficult to interpret without conducting in-depth interviews. However, it is plausible that they stem from a lack of experience with AI and a cautious* | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| *attitude (as seen in the "Farmers" group), a positive outlook on AI's potential for non-commercial applications (among "Science" respondents), and a generally optimistic—albeit careful—assessment by IT professionals, grounded in their practical experience with AI across various domains.* | | | | | |
| **Average for Category 7** | **1,79** | **1,40** | **1,63** | **1,44** | **1,59** |
| **Category 9: Key challenges, risks and opportunities in European Food System Data Spaces** | | | | | |
| The EU Common Agricultural and Food Policies are primarily data-driven (not political/social) | 0,79 | -0,36 | 0,27 | -0,03 | 0,24 |
| ***Comment:*** *One particular statement received the lowest average score overall, and it was the only one for which the average scores among some respondent groups were negative ("Science" and "Other"). This suggests broad, consistent scepticism- especially among researchers, and to a lesser extent among farmers - regarding the role of "hard" data in shaping European agricultural policy, which is subject to strong and often conflicting lobbying pressures.* | | | | | |
| **Average for Category 9** | **1,31** | **0,85** | **1,12** | **0,95** | **1,09** |
| **Category 10: Data sharing and free flow of data** | | | | | |
| Unrestricted data sharing is a key enabler for new business models and the implementation of new technology | 1,07 | 0,60 | 1,53 | 0,87 | 1,04 |
| Data sharing should be incentivised through mechanisms that ensure fair compensation for data providers | 1,12 | 0,88 | 1,87 | 1,29 | 1,29 |
| ***Comment:*** *These two statements again highlight a degree of scepticism among researchers and a strong engagement from IT professionals, who consider that the usefulness of data in digital applications justifies offering financial incentives for data sharing.* | | | | | |
| **Average for Category 10** | **0,98** | **0,89** | **1,71** | **1,12** | **1,17** |

*Statements with the Highest and Lowest Ranking Scores.* Table 9 below presents the ratings for the 10 highest-scoring survey items, as well as the 5 items that received the lowest scores from respondents.

**Table 9 Ranking of Survey Questions with the Highest (Top 10) and Lowest (Bottom 5) Mean Data Value Scores**

| No | **Category/statement** | Mean | Standard Deviation | Coefficient of Variation |
|---|---|---|---|---|
| | **Top 10** | | | |
| 4. | Access to reliable data improves decision-making for in-dividual stakeholders within the food chain (e.g., producers, processors, distributors, retailers and other actors). | 2,33 | 0,879418 | 37,8% |

| | | | | |
|---|---|---|---|---|
| 12. | Data on nutritional content, and production methods empowers consumers to make choices which benefit health. Data on nutritional content, and production methods empowers consumers to make choices which benefit health. | 2,25 | 0,963916 | 42,8% |
| 14. | Data helps companies to adapt and change their business models to better respond to market challenges. | 2,20 | 0,842368 | 38,4% |
| 17. | Continuous access to up-to-date data is essential for making timely and informed decisions, ensuring responsiveness to market changes and emerging trends. | 2,19 | 0,911432 | 41,7% |
| 16. | The data analytics integrated in food supply chain activities enhances the precision and reliability of production monitoring processes, ensuring better quality control and compliance with safety standards. | 2,17 | 0,914532 | 42,1% |
| 1. | Data-based insights are essential for dealing with food crises (i.e. shocks that lead to disruptions and cause food insecurity). | 2,14 | 1,032804 | 48,2% |
| 7. | Data plays role in enhancing food safety by enabling better monitoring and risk management. | 2,11 | 1,005766 | 47,7% |
| 5. | Data supports decision-making across all stages of the food supply chain, from production to consumption and waste management. | 2,08 | 0,968881 | 46,6% |
| 22. | Data analytics helps quality control in food production. | 2,06 | 1,092206 | 53,0% |
| 8. | Data helps to establish food **traceability fr**om farm to fork. | 2,05 | 1,05636 | 51,6% |
| **Lowest 5** | | | | |
| 26. | The free flow of data in the food system creates a major the risk of data misuse (improper) and/or unauthorised access (e.g. by not eligible parties, unethical). | 1,00 | 1,5724 | 157,2% |
| 6. | Decisions in food systems should be based on data, even if it means disregarding traditional knowledge and practices. | 0,98 | 1,662295 | 170,2% |
| 21. | Reliance on information on food systems provided by AI (artificial intelligence) often leads to wrong decisions. | 0,95 | 1,551526 | 162,8% |
| 9. | The collection and sharing of detailed data on food production and distribution (transparency) should be mandatory even if it compromises trade secrets and undermines competitive advantages. | 0,91 | 1,911537 | 209,1% |

| | | | | |
|---|---|---|---|---|
| 25. | The EU Common Agricultural and Food Policies are primarily data-driven, rather than driven by political or social considerations. | 0,24 | 1,959214 | 809,0% |

Analysis of the survey showed notable discrepancies in the perceived value of data across professional groups. Respondents were clustered based on their average score per statement into three: Low (above 2 points), Moderate (1–2 points) and High (below 1 point). As shown in Table 5, the majority of workshop participants rate the importance of data positively: 45.7% fall into the Moderates category and 37.9% into the Supporters category, while only 16.4% are classified as Opponents (table 5).

Table 5: Respondent cluster typology

| **Stakeholder Group** | **Low (%)** | **Moderate (%)** | **High (%)** |
|---|---|---|---|
| Farmers | 13.8 | 51.7 | 34.5 |
| IT | 6.9 | 37.9 | 55.2 |
| Others | 17.2 | 55.2 | 27.6 |
| Scientists | 27.6 | 37.9 | 34.5 |
| **Total** | **16.4** | **45.7** | **37.9** |

The IT specialists stand out with the highest share of strong evaluations (55.2%), and together 93.1% for moderate and high scores, reflecting their professional familiarity with data-driven processes. Farmers and the “Others” group (including food processors and distributors) also show a high combined positive rating (approximately 85–87%), albeit slightly lower than that of the IT experts. In contrast, responses from scientists are more evenly distributed, with 27.6% of evaluations at the Low level. This relatively larger segment may stem from the inherent critical rigor and rational scrutiny characteristics of scientific practice. Table 10 presents selected statistics on opinions expressed by stakeholders through statements.

**Table 10 Statistics for statements with the most and least significant differences in opinion among stakeholders**

| **Statement** | **$\chi^2$** | **df** | **p-value** |
|---|---|---|---|
| **With the most significant difference of opinion among stakeholders** | | | |
| 29: Data sharing should be incentivised through mechanisms that ensure fair compensation for data providers | 9,651 | 3 | 0,022 |
| 21: Reliance on information on food systems provided by AI (artificial intelligence) often leads to wrong decisions | 9,125 | 3 | 0,028 |
| 28: Data security measures (e.g., encryption and access controls) should be prioritised over the speed and ease of data flows | 8,522 | 3 | 0,036 |
| **With the least significant difference of opinion among stakeholders** | | | |

| | | | |
|---|---|---|---|
| 24: Data is essential for identifying emerging threats to food security | 1.018 | 3 | 0.797 |
| 26: The free flow of data in the food system creates a major the risk of data misuse (improper) and/or unauthorised access (e.g. by not eligible parties, unethical | 0.387 | 3 | 0.943 |
| 23: Using data analytics to demonstrate compliance with quality standards and certification schemes helps farmers gain trust from buyers and secure market opportunities | 0.299 | 3 | 0.960 |

Kruskal–Wallis tests indicate that, out of 29 assessed statements, the responses of the four stakeholder groups (farmers, IT, science, and others) differ significantly in only three cases at the $\alpha = 0.05$ significance level. All other opinions regarding other statements (e.g., efficiency, traceability, environmental impact, quality of control, etc.) do not differ significantly between the groups ($p > 0.05$), indicating a consensus among them.

Results presented in Table 11 show that in every category women respondents rate the importance of data in food systems higher than male participants of the survey. Results show that women respondents particularly value data use in such categories of "Food System Governance" and "Efficiency, Value Creation, and Value Capture" (2.10 and 2.14, respectively).

**Table 11 Mean Scores of categories by Gender**

| **Category** | **Mean (Female)** | **Mean (Male)** | **Mean (All)** |
|---|---|---|---|
| Category 1: Food System Governance | 2.10 | 1,86 | 1.96 |
| Category 2: Decision-making Processes | 1.92 | 1.70 | 1.79 |
| Category 3: Managing Performance Attributes of the Food System | 1.74 | 1.66 | 1.69 |
| Category 4: Food System Outcomes | 2.07 | 1.61 | 1.80 |
| Category 5: Efficiency, Value Creation and Value Capture in Food Systems | 2.14 | 1.94 | 2.02 |
| Category 6: Optimising, Control, and Monitoring Food System Activities | 1.92 | 1.85 | 1.88 |
| Category 7: Changing Food System Innovation Ecosystem through Data-driven Collaboration and AI | 1.70 | 1.52 | 1.59 |
| Category 8: Enabling Digital Innovation and Data-driven Transformation | 2.08 | 1.81 | 1.92 |
| Category 9: Key Challenges, Risks and Opportunities towards Fair, Inclusive and Resilient Food Systems | 1.18 | 1.03 | 1.09 |

| | | | |
|---|---|---|---|
| Category 10: Data Sharing and Free Flow of Data | 1.30 | 1.08 | 1.17 |
| **Total survey** | **1.79** | **1.60** | **1.68** |

The smallest gap between men's and women's opinions appears in Category 6: Optimising, Control, and Monitoring, suggesting participants agree that data improves quality control. The largest gap is in Category 4: Food System Outcomes (Mean Female = 2.07 vs. Mean Male = 1.61), suggesting that women have a stronger conviction that data delivers environmental, transparency, and health-related benefits. Table 12 presents selected statistics on opinions expressed by stakeholders of both genders through statements.

**Table 12 Statistics for statements with the most and least significant differences in opinion among stakeholders of different genders**

| **Statement** | **$\chi^2$** | **df** | **p-value** |
|---|---|---|---|
| **With the most significant difference of opinion among stakeholders** | | | |
| 10: The data provides insight into the environmental impacts of the food system | 5.718 | 1 | 0.017 |
| 28: Data security measures (e.g., encryption and access controls) should be prioritised over the speed and ease of data flows | 5.457 | 1 | 0.019 |
| 3: Data serves as a critical input for developing effective government policies | 4.696 | 1 | 0.030 |
| 11: Data helps to create new relationships and solidarities between consumers and producers through information exchange and due to enhanced consumer trust | 4.515 | 1 | 0.034 |
| 12: Data on nutritional content, and production methods empowers consumers to make choices which benefit health | 4.446 | 1 | 0.035 |
| 13: Data-driven decision-making significantly enhances operational efficiency in food production and distribution | 4.100 | 1 | 0.043 |
| **With the least significant difference of opinion among stakeholders** | | | |
| 26: The free flow of data in the food system creates a major the risk of data misuse (improper) and/or unauthorised access (e.g. by not eligible parties, unethical | 0.036 | 1 | 0.849 |
| 1: Data-based insights are essential for dealing with food crises (i.e. shocks disrupting market supplies and threatening food security | 0.031 | 1 | 0.861 |

| | | | |
|---|---|---|---|
| 20: Data is essential for different actors such as universities, producers, investors, regulatory bodies and others to collaborate on food issues | 0.002 | 1 | 0.963 |

In the comparative study of women's and men's opinions on the role of data in the food system, a single-factor $\chi^2$ test (df = 1) was used for 29 statements. Statistically significant differences were observed in 5 assessments of statements concerning data. These differences concerned opinions on better monitoring of the impact of activities on the environment (statement 10; p= 0.017), the advantage of security over the speed of information flow (statement 28: p = 0.019), the role of data in shaping public policies (statement 3; p = 0.030), building relationships and consumer trust (statement 11; p = 0.034), the impact of information on nutritional values on health choices (statement 12; p = 0.035) and improving the operational efficiency of the food chain (statement 13; p = 0.043).

There were no differences in respondents' opinions regarding the importance of data for crisis management (statement 1), the balance between open flow and the risk of fraud (statement 29), and the value of cross-sectoral cooperation (statement 20).

From a practical perspective, these results suggest the need for differentiated messages to increase the acceptance and effectiveness of digital initiatives in the food sector, addressing both the specific concerns of different groups and the common interests of all participants in the system. Table 13 presents selected statistics on opinions expressed by stakeholders from Poland and other countries through statements.

**Table 13 Mean scores across categories from Polish and foreign respondents**

| **Category** | **PL** | **Other** | **Mean (All)** |
|---|---|---|---|
| Category 1: Food System Governance | 1.92 | 2.06 | 1,96 |
| Category 2: Decision-making Processes | 1.72 | 2.01 | 1,79 |
| Category 3: Managing Performance Attributes of the Food System | 1.64 | 1.83 | 1.69 |
| Category 4: Food System Outcomes | 1.74 | 1.97 | 1.80 |
| Category 5: Efficiency, Value Creation and Value Capture in Food Systems | 1.98 | 2.16 | 2.02 |
| Category 6: Optimising, Control, and Monitoring Food System Activities | 1.87 | 1.90 | 1.88 |
| Category 7: Changing Food System Innovation Ecosystem through Data-driven Collaboration and AI | 1.51 | 1.84 | 1.59 |
| Category 8: Enabling Digital Innovation and Data-driven Transformation | 1.86 | 2.12 | 1.92 |
| Category 9: Key Challenges, Risks and Opportunities towards Fair, Inclusive and Resilient Food Systems | 1.05 | 1.20 | 1.09 |
| Category 10: Data Sharing and Free Flow of Data | 1.05 | 1.52 | 1.17 |
| **Total survey** | **1.63** | **1.85** | **1.68** |

In all categories of statements the scores from Polish respondents were slightly lower than those from other countries, about 12% less on the average.

**Conclusions**

The results show a general consensus among respondents on the key role of data in food systems. Across areas such as decision-making, efficiency, optimisation, monitoring, quality assurance, and administrative processes, respondents expressed high acceptance and recognition of the importance of data. The results are reflected in high average scores, low variability, and a predominance of positive responses, confirming that effective information management and analytics are seen as essential for modern and efficient food systems.

The survey results indicate that respondents generally view the use of data and digital technologies positively across a wide range of applications. However, in the case of more controversial statements, differences in opinions emerged—particularly between researchers and IT specialists. These differences may stem from the specific nature of their professions, as well as varying levels of experience and knowledge regarding data usage. While the observed divergences in opinions among different respondent groups appear to have reasonable explanations, objectively clarifying them would require in-depth interviews and analysis, which were not feasible due to limited resources and the survey's commitment to full respondent anonymity.

## 4.3 How can data be valuable for most food systems stakeholders?

This section answers Sub-Question 3: Why data are valuable for different stakeholders? What solutions would allow beneficial use of data and minimise damages for many stakeholders?
The section is based on secondary analysis of stakeholder interviews about their experiences of data economy of food systems carried out under the task 4.1. While performing secondary analysis, we took into consideration findings of D4.1 "Infographics" (Šūmane et al 2024). This study tried to capture both individual or stakeholder specific as well as collective dimensions of data value focusing on conditions under which data bring most value for many FS stakeholders.

The analysis of 22 interview reports was conducted with Atlas.ti 25, using a hybrid approach to qualitative coding. In the first cycle, three pre-defined code categories were applied: (1) data value: qualities and processes (sub-codes: inclusiveness, transparency, interoperability, enhancement, sustainability, innovation, and governance); (2) stakeholder type (sub-codes: primary producers, processors, distributors, policy, food safety, health, retailers, researchers, data actors, advisors, input, other); (3) stakeholder benefit scope (sub-codes: multiple, individual). Code co-occurrence analysis of stakeholder type and individual benefit was conducted to answer the first question on specific stakeholder data values. In the second cycle, inductive coding was applied based on emerging themes related to second research question on collective stakeholder benefit solutions. Codes from both cycles were integrated to develop the final synthesis of results. Table 14 refers to stakeholder interviews analysed and their breakdown by stakeholder categories.

**Table 14 Stakeholder interviews analysed**

| Stakeholder category | Interview ID |
|---|---|
| Primary producers | D9 |
| Policy / Food safety* / Health** actors | D13, D14 / D11* / D10** |
| Data actors / Advisor* / Input** | D4, D5, D6, D7, D8 / D1* / D12** |
| Researchers | D16, D17, D18, D19, D20 |
| Retailers | D21, D22 |
| Consumers | D2, D3 |
| Processors / Distributors | D15 |

**Results of stakeholder interview analysis**

Further we present key insights from interview analysis summarising them according to research sub questions posed.

*Why data are valuable for different stakeholders?*

Figure 12 summarises benefits of data use and sharing that emerge as common within and across different stakeholder categories. A full interview report analysis is presented in Annex IV. Enhancement, governance, and sustainability emerged as the primary areas where data benefits were identified for the majority of stakeholders across respondent groups.

For primary producers, retailers, and processors/distributors, operational and production optimisation advantages were highlighted the most, with many also linking enhancement and governance benefits with supporting sustainability objectives. Specific to each group – multiple stakeholders cited precision farming benefits for primary producers (farmers), while for retailers and processors/distributors business oversight, supply chain transparency for enhanced risk management were indicated.

For policy, health, and food safety stakeholders, key advantages were identified in governance and interoperability domains. The main advantage cited is the capacity to obtain aggregated data from different actors, which can be applied for improved policy planning, risk mitigation, and achieving sustainability goals. In addition, one policy actor reported novel ways of monitoring that reduce administrative load.

For consumers, transparency was indicated as the main benefit, allowing for more agency to make decisions regarding product purchases. The increased decision-making capacity was also tied to addressing sustainability concerns, both environmental and in terms of personal health. For researchers, the value of data was indicated in areas of enhancement, innovation, and interoperability. Specifically, improved research process efficiency and collaboration capacity among diverse actors enhance the value of research outcomes.

In regard to data actors, respondents tended to speak more in general terms about the data economy, focusing more on the benefits for other stakeholders. For data actors themselves, cited benefits centred on enhancement, innovation, and interoperability. Specifically, enhanced processing of data, which allows for innovation and development of new data solutions, and interoperability that enables value creation through aggregating data from various sources.

Notably, inclusivity received limited attention across all groups, with the exception of a research respondent highlighting online networking opportunities for business innovation for farmers who cannot harness precision farming advantages due to lack of resources.

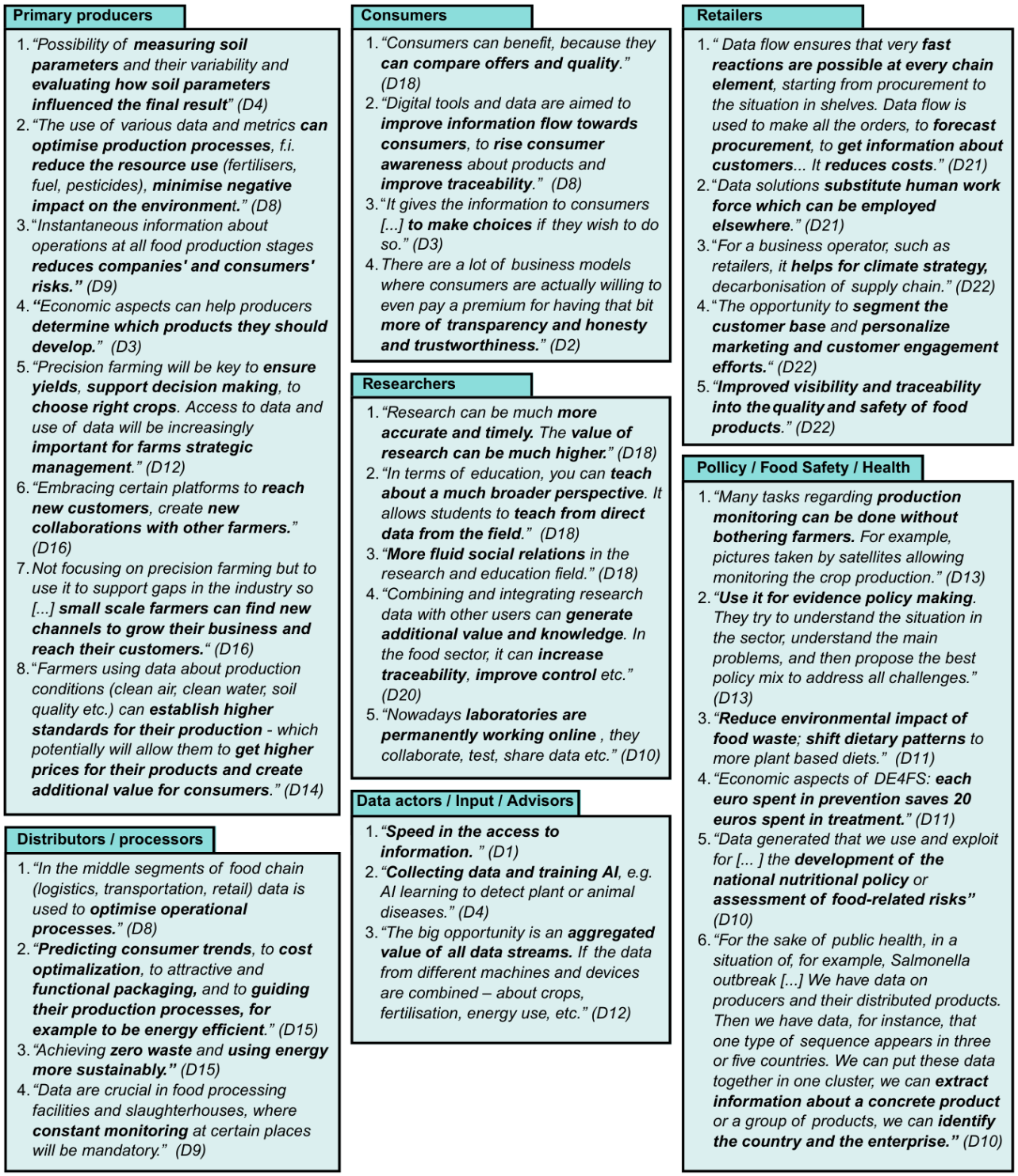


**Figure 12 Stakeholder benefits from data use**

*Conditions and solutions for enhancing data value for multiple stakeholders*

At a more aggregated food systems level the interview analysis suggests that gains from data use and data exchange for as many stakeholders as possible is associated with implementing comprehensive solutions. The stakeholder interview data suggest the following conditions and solutions that enhance benefits of data use for multiple stakeholders: regulation improvements, interoperability and data format standardisation; open data and common data sharing platforms; industry self-organisation; and education and training. Below we briefly characterise each precondition for enhancing data value for different food systems stakeholder groups (for citations, see Annex V).

- **Regulation improvements – balanced gains for different stakeholders** Several stakeholders emphasise the need for public bodies at national and EU levels to lead reforms in regulatory frameworks, fostering a fairer data economy that addresses the asymmetry between actors with greater capacity and influence and those without (D1, D3, D13, D18). Key to this is improving data ownership rights regulations, with respondents highlighting concerns that current legal frameworks benefit data holders rather than smaller actors, especially consumers and farmers (D9, D12, D17). Proposed solutions include improving intellectual property rights for farmers – for instance, applying Creative Commons Policy (CC) to seed varieties (D17), and ensuring that data generated by farming equipment is not solely owned by machinery companies (D5, D13). In regard to monitoring adherence to regulations, a policy actor proposed that legal frameworks should be developed with the aim to incentivise participation, through providing gains, rather than punishing participants (D8).
- **Interoperability and data format standardisation**: Multiple respondents identify lack of interoperability and data standards as major challenges that hinder efficiency and development in the data economy. Proposed solutions include introducing mandatory interoperability obligations (D6), common data format rules (D6, D18, D19), as well as harmonisation of vocabularies (D6). Some respondents indicate that decentralised solutions (peer-wise data management, blockchains) may help with interoperability challenges (D6, D14). A data actor suggests AI as a potential solution for semantic interoperability (D5). From an inclusivity standpoint, a researcher respondent suggested adapting more accessible data formats – words and practices – so that they are understandable for more actors across the value chain (D17).
- **Open data and common data-sharing platforms**: As for technical solutions, respondents suggest establishing common data sharing platforms to improve access to data for a broader scope of stakeholders. Specific suggested solutions include: expanding functionalities for existing platforms (AJAX system), for instance, to allow farmers to use it for analytics and operational optimisation (D5); developing data platforms modelled after ones with demonstrated benefits for multiple stakeholders (AGRIBALYSE) (D22); creating common platforms where users can set sharing conditions (D5); reducing data access barriers (legal, technical) to facilitate performing public functions and research (D7; D10; D11).
- **Industry self-organisation**: Some respondents suggest that industry self-organisation would help address standardisation challenges in legal and technical aspects (D1, D6, D9, D12). Data intermediaries and solution developers highlighted that they are already addressing such issues (by developing and testing practices) through several approaches:

creating ready-made software applicable in different contexts, influencing the vocabulary, translating data for different stakeholders, as well as monitoring and mediating stakeholder transactions in data spaces (D1, D2, D12), contributing to the establishment of a common code of conduct in the industry via successful exemplary solutions (D2, D12, D16).

- **Education and training**: Several respondents emphasise the need for more education and training are needed to improve data use proficiency across all data economy stakeholder groups. This would enable users to derive more benefits and promote efficiency. While the issue was generally cited in relation to end-users – consumers, producers, retailers, researchers and policy actors (D7, D8, D12 D13, D18, D22) –, an advisory respondent highlighted it affects data experts as well (D1). Education is also cited as necessary to raising awareness of ethical and data safety aspects (D7, D1).

## 4.4 How do stakeholders prioritise options towards implementation of data economy of food systems?

This section answers sub question 4: How do stakeholders prioritise options towards implementation of data economy of food systems?

For this reason, we organised a strategic options workshop entitled “Identification and selection of strategic options for the uptake of key data value propositions”. It was run in Warsaw on June 17th 2025. The workshop aimed to formulate and assess possible strategies for implementing digital technology solutions and, ultimately improving decision-making processes and better integrating Food System operators and organizations into the Data Economy. It was a collective effort, and a multi-actor approach bringing together stakeholders representing not only the Food System and other sectors of the economy, but also science and public administration.

Twenty-one stakeholders were invited using the list from the national scenario workshop. As many previous participants had other commitments, we sought new representatives. 17 participants attended the workshop representing the following stakeholder groups: farmers, processors, researchers, data actors, advisors, HoReCa. Several participants represented more than one group. Food value chain actors made a strong representation. 15 men and six women participated in the workshop.

The conceptual basis for conducting the workshop was twofold. First, we used a list of so-called “strategic options” identified in section 3 through a detailed analysis of 124 scientific publications. The literature review in section 3 yielded a list of strategic options or decisions for capturing data value (Table 2 in section 3). These findings informed the workshop methodology. Second, the literature analysis yielded a list of approximately 400 terms and keywords, each denoting a solution (tool, device, approach, or technology) that could be translated into specific actions or business activities to support the implementation or development of digital technologies and data use. This allowed to elaborate a list of strategic activities in data value capture that was piloted at the workshop. A full list of strategic activities in data value uptake are provided in Annex V.

For the workshop, we adopted two basic definitions. “Strategy,” which according to A. Chandler “…is the determination of the basic long-term goals of an enterprise, and the adoption of courses of action and the allocation of resources necessary for carrying out these goals” (Chandler 1962) or, in other words, simply “a directed course of action to achieve an intended set of goals” (Mintzberg et al 1998). “Strategic option,” in strategic-management terminology, is one of several

possible courses of action (variants) from which the one to be implemented is ultimately selected. Implementing an individual digital solution or tool can thus be viewed as a single element of a broader, complex digitalization and data economy strategy for businesses or other organizations.

The task of the workshop participants was to choose the most useful and value creating individual strategic actions and then to formulate overarching digitalization and data use strategies for business entities and institutions in the areas of farming, food processing, HoReCa, science and extension and agricultural and food policies. Both the individual actions and overall strategies were evaluated using a Prioritization Matrix to determine their perceived usefulness and importance.

Prior to the workshop, a small team of researchers shortened the original list of 400 activities down to 99 by removing duplicates, as well as those already in widespread use or of limited relevance to advancing digital technology deployments. For terms deemed by the organisers to be less familiar or potentially confusing concise explanations were provided.
Prior to the workshop, a small team of researchers shortened the original list of 400 activities down to 99 by removing duplicates, as well as those already in widespread use or of limited relevance to advancing digital technology deployments. For terms deemed by the organisers to be less familiar or potentially confusing concise explanations were provided.

The workshop proceeded as follows:

- Presentation of the workshop's objectives and instructions for participants';
- Selection and ranking of strategic actions deemed most significant and practically useful by the participants — individual work;
- Development of possible variants of comprehensive strategies (strategic options) for implementing or advancing digital technologies — team work;
- Evaluation of strategic options using the prioritization matrix — team work
- Discussion and workshop wrap-up.

The prioritization matrix (Figure 13) used for the evaluation of various strategic options is a simple yet useful management tool for determining preferred courses of action using multi-criteria mapping.

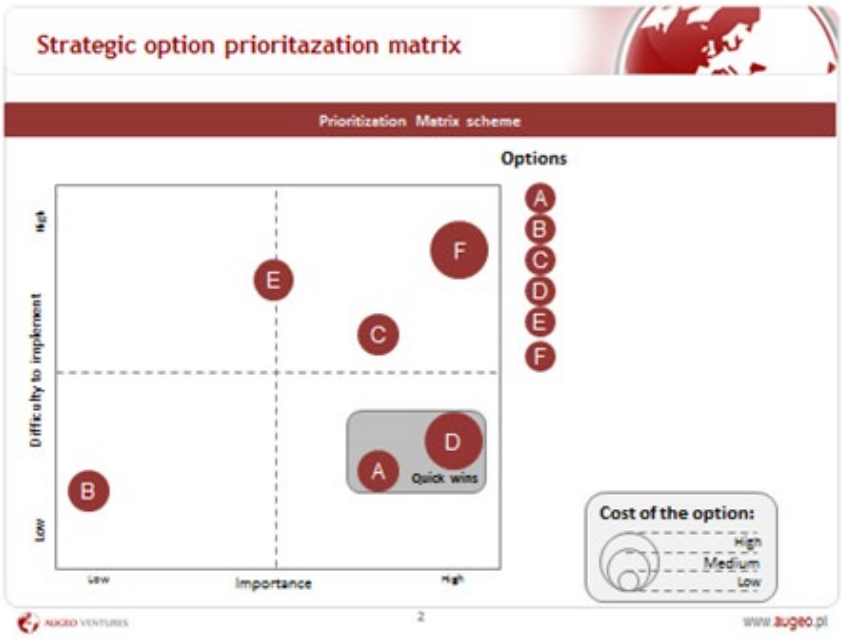


**Figure 13 Strategic options prioritization matrix – illustration scheme.**

### Selection and ranking of strategic activities

Based the reviewed list of 99 strategic actions, each stakeholder was asked to choose, independently from other participants of the workshop, 20 actions considered the most essential and applicable (i.e., realisable in their areas of professional activities, such as farming, food processing, HoReCa, research or administration). The following step was to allocate 50 points across selected actions, providing greater number points to those actions perceived as most important or impactful. At least one point should be allocated to a single action. There was no ceiling on the number of points attributed to other actions allowing participants to indicate the relative importance of each action.

After aggregation of individual scores, a ranking of strategic activities was created. Figure 14 arranged in the form of Pareto diagram with a cumulative Lorenz curve, presents the share of grouped into categories of activities (A–G). A Pareto chart is a graphical tool combining bars and a cumulative line graph to identify the most significant factors in a dataset. Bars, arranged in descending order, show the frequency, share, or other measure of each category on the left axis, while the right axis displays the cumulative percentage. Based on the Pareto principle, named after economist Vilfredo Pareto it reveals that a small number of causes often account for most of the effect (known as a 20/80 rule, e.g., addressing the top three issues might resolve 78% of effects).

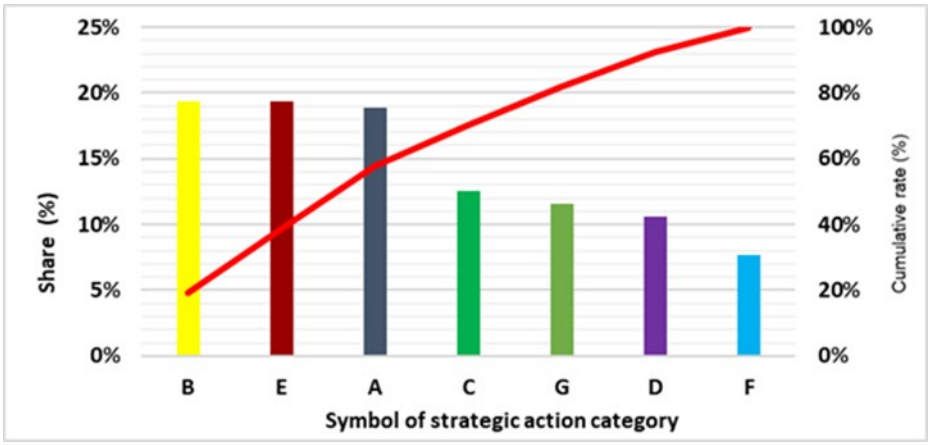


**Figure 14 Pareto diagram: share of categories in the ranking of strategic activities**
(A – Data, B – General Digital Technologies; C – Digital Technologies for farming sector, D – Collaboration, E – Policies to support DT developments, F – Research, G – Actions for DT developers)

Activities belonging to first three categories dominated the ranking, each contributing 19–20% of the total score. It appears justified to claim that the significant share of activities from the categories “General digital technologies” and “Data” results from the fact that the individual activities within them are largely understandable for workshop participants and most often are the subject of practical implementations, with known or presumed usefulness. On the other hand, the large share of activities in the “Policies to support DT developments” category reflects the common expectation of financial support enabling businesses and the entire civil society to participate to a greater extent in digitalization processes.

Figure 15 shows a Pareto Diagram constructed for all individual activities selected by workshop participants to the ranking.

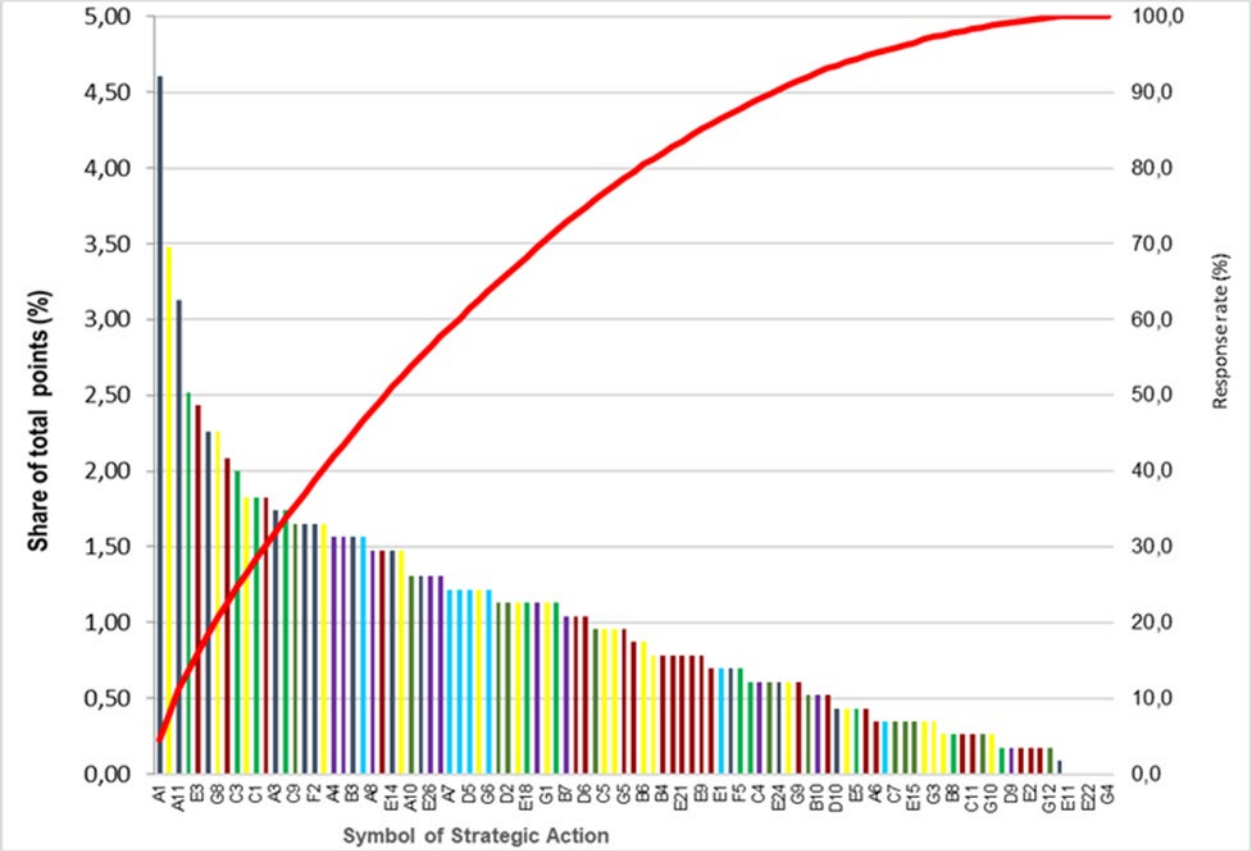


**Figure 15 Pareto diagram: share of strategic actions in the ranking**

The diagram presents more details, pointing out an importance attributed to individual strategic actions. Although the classic Pareto rule was not achieved, one-third of the activities account for 60% of the ranking. Table 15 lists the top 10 highest scoring strategic activities in the ranking (Annex V presents detailed ranking results.

**Table 15 Top 10 strategic activities in the ranking**

| Code | Strategic action | Average score | Share in the ranking |
|---|---|---|---|
| A1 | Data-sharing | 3,47 | 4,61% |
| B15 | Implementation of advanced food tracking technologies in the supply chain (barcodes, RFID tags, blockchain technology) | 2,86 | 3,48% |
| A11 | Using blockchain technology to collect and exchange data securely and transparently | 3,60 | 3,13% |
| C6 | Implement farm management systems for data integration and decision support | 2,64 | 2,52% |
| E3 | Government policies supporting the adoption of digital technologies (e.g. mobile applications, digital finance) | 2,15 | 2,43% |
| G8 | Data standardization for data consistency and interoperability | 3,71 | 2,26% |

| | | | |
|---|---|---|---|
| B2 | Implementing digital technologies such as artificial intelligence, IoT, and blockchain | 3,43 | 2,26% |
| E25 | Establishing rules for ensuring data quality and security | 4,00 | 2,09% |
| C3 | Application of autonomous agricultural machinery | 3,29 | 2,00% |
| B5 | Use of digital platforms | 2,10 | 1,83% |

Among the top 10 highest-scoring or most frequently ranked activities, as many as four relate to data–sharing (A1), collecting and exchange (A11), quality and security (E25), and standardisation (G8). Complementing this set are tools and solutions that enable the practical use of data, along with an expressed expectation for policy support in implementing digitalisation processes (E3).

**Crafting and evaluating strategic options**

This section presents the results of the workshop's primary task: to propose and evaluate a set of strategic options—defined as alternative strategies for introducing digital technology solutions into real-life business or organizational settings. Each strategic option consisted of selected strategic activities from the ranking list, designed to form a coherent overall strategy type. Five teams were formed, each focusing on one of the following areas:

- Farming
- Processing
- Science and DT developers,
- Policy and Advisory Services
- HoReCa (Hotels, Restaurants, and Catering)

(The workshop participants decided to combine science and digital technologies developers and policy and advisory services as they found these areas closely related.)

Table 15 presents the Strategic Options developed during the workshop. Each option includes a brief description of the strategy, a list of associated strategic activities, the anticipated effects of its implementation, and the X, Y coordinates used for evaluation within the Prioritization Matrix.

Three types of the matrix were constructed, each with the use of the following criteria:

- Implementation Difficulty vs. Financial Benefits;
- Deployment Costs vs. Environmental Impact
- Implementation Difficulty vs. Competitiveness

The visual representation of the evaluation is shown in Figures 16–20 below the Table 16.

**Table 16 Digitalization strategies and coordinates for strategy evaluation with the use of Prioritization Matrix**

| Code | Strategy name | Strategic activities | Strategy description | Expected effects of implementing the strategy | Coordinates | | |
|---|---|---|---|---|---|---|---|
| | | | | | M1 | M2 | M3 |
| | | | | | **X; Y** | **X; Y** | **X; Y** |
| **Strategies developed by the "Farm" team** | | | | | | | |
| **F_I** | **Digitization of fruit harvest records (strawberries)** | A3<br>A9 | Digital tools (e.g., QR codes) to record amounts harvested by individual workers. Entries in the Farm Management System allow to calculate salaries automatically. | Elimination of manual on-field recording, lower labour costs, less errors and complaints from pickers, faster and more accurate reporting of harvest results | 1,25<br>2,25 | 1,5<br>1,25 | 1,25<br>1,5 |
| **F_II** | **Digital system for managing milk production process (large scale)** | A3<br>C4<br>C5<br>C8<br>D5 | System to manage milk production on large farms. It includes integration of production and environmental data, sensors, IoT systems, and predictive models to optimise feeding, monitor health, and control milk yield in cows. | Higher milk yield, feeding optimization, reduction of methane emissions, better control of herd health and reduction of veterinary costs, increased efficiency of the entire milk production process | 4<br>3,5 | 4,5<br>2,75 | 4<br>3,75 |
| **F_III** | **Digital Technologies for Precision Farming** | B14<br>C1<br>C5<br>C10 | Advanced digital technologies to support the implementation of Precision Farming - remote sensing technologies, decision support systems, IoT sensors, and variable rate technology (VRT) combined with Global Positioning and Geographic Information systems. | Optimal doses of chemical inputs, greater precision of cultivation procedures, higher yields and profitability. Benefits for natural environment (lower losses of nutrients, reduction of nitrogen leaching, lower environmental burden with pesticide residues. | 2,75<br>4,25 | 3,75<br>4 | 2,75<br>3,75 |
| **F_IV** | **Large farm – digital management support system** | A7<br>B3, B5<br>C6, C9<br>D1<br>D5 | Advanced decision support systems for large farms. Includes the use of advanced analytical technologies, artificial intelligence, IoT systems and sensors to monitor production processes on an ongoing basis. The system ensures the integration of data from various sources. | Access to real-time data, better resource management, optimization of production processes, improved profitability and competitiveness. Environmental benefits (lower nutrient losses, reduced GHG emissions);<br>Lower costs of administrative work. | 3<br>4,25 | 3,75<br>3,25 | 3<br>4,25 |
| **F_V** | **Using digital technologies to manage a small farm** | A8<br>C6 | Strategy for small farms, focusing on the use of available, low-cost digital tools to improve management. The use of simple digital services and Farm Management Systems | More informed decisions, better planning, optimised operations and processes, increased efficiency. | 1,75<br>2,25 | 2,5<br>1,75 | 1,75<br>2,5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **F_VI** | **Short-chain management support system** | A1<br>B5<br>B17 | Digital platforms and consumer contact applications are of particular importance to facilitate communication and support active participation in short food supply chains. | Shortening the time of product delivery, better adaptation specific requirements and local demand, increased incomes, building relationships with consumers. | 2<br>3 | 2<br>1,75 | 2<br>4,25 |
| **Strategies developed by the "Processing" team** | | | | | | | |
| **FP_I** | **Establishment of the Digital Technology Applications Department (Large Scale)** | A1, A2, A7, B1, B2, B15, B16 D5 D6 | Establishing a separate organizational unit responsible for the implementation and use of digital technologies. The integration of data from various stages of production, the use of artificial intelligence tools, IoT technology, blockchain, and advanced analytical systems. | Real-time data analysis, optimised processes, increased efficiency of production and logistics, faster implementation of digital innovations, better food quality and safety, lower operating costs, increased competitiveness, more resilient company. | 4,5<br>4,75 | 5,25<br>2,75 | 4,5<br>5,25 |
| **FP_II** | **Digitalization to support ver-tical integra-tion processes** | A1, A3 A10,A11 B1; B15 D6 | Integration of data from various stages of the value chain (raw material production, transport, processing, distribution), the use of analytical platforms, and traceability systems. | Quicker response market changes, improved planning, optimised supply, better coordination, reduced lead time, improved traceability, reduced wastes. | 4,75<br>5 | 4<br>2,5 | 4,75<br>5,5 |
| **FP_III** | **The use of digital technologies to manage production processes** | A3<br>A4<br>A7<br>B3<br>B6 | The strategy is to implement advanced digital technologies to monitor, analyse, and optimise production processes in food processing companies. It includes the integration of data from different stages of production, real-time data collection, and the use of artificial intelligence for prediction and decision-making. The use of digital twins supports the optimization of production processes. | Increased efficiency, reduction of energy and raw materials consumption, better quality control of production quality, lower wastes. Reduced response time to failures and deviations in the processes, ability to quick adaptation to changing market demand - Support in the creation of new products and recipes - Reduction of costs, increase of efficiency and improvement of product quality. | 3,75<br>3,75 | 3<br>2,25 | 3,75<br>4,25 |
| **Strategies developed by the "Science and IT" team** | | | | | | | |
| **SE_I** | **Cooperation strategy in the development of digital technologies in the Quintuple Helix context** | A1, B3, B6, B10, B13 D3, D4 D7 E8, E17 F4 G9 | Applying the Quintuple Helix concept to enhance cooperation in the development and implementation of digital technologies for the agri-food sector. It includes joint R&D projects, collaborative platforms, open access to data, and involvement of local communities and NGOs, to ensure ethical data management, good practices dissemination, | Enhanced transfer of knowledge between science and business, more innovative digital solutions for Agri-food sector, emergence of new models of cooperation (e.g. Living Labs, AgTech startups), development of digital competences among farmers and entrepreneurs, growing number of studies on the effects of digitization (social, environmental, economic). | 5,25<br>5,25 | 4,75<br>3,5 | 5,25<br>6 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | and promoting environmentally friendly innovations. | | | | |
| **SE_II** | **Cooperation between science and consulting in the dissemination of digital technologies** | A1, B5<br>D2<br>D9<br>E21<br>E23<br>F2<br>F7<br>G11 | Building an effective system of cooperation of scientific and advisory institutions to accelerate the implementation of digital technologies in the agri-food sector. Key activities include training, creation of open databases, development of digital platforms for knowledge sharing and support for advisory initiatives related to digital technologies. | Strengthening digital competencies, easier access to new solutions, faster dissemination of digital technologies, easier access to data exchange platforms and digital tools for small and medium-sized enterprises. Increased number of implementations of digital technologies at the operational level, higher quality of knowledge transfer. | 3<br>3,5 | 3,5<br>1,75 | 3<br>3,25 |
| **Strategies developed by the Policy and Advisory team** | | | | | | | |
| **AFP_I** | **Creating a regulatory and legislative framework** | E2<br>E3<br>E8<br>E13 | Adaptive legal frameworks with active input from stakeholders to enable development of digital technologies, ensure data protection, ethics and international compliance, and promote regulatory transparency. | Comprehensibility and stability of legal regulations, adaptation to technological and market challenges, protection of the rights of data users and producers, facilitating the implementation of innovative technologies | 2,5<br>1,75 | 1,75<br>1 | 2,5<br>1,25 |
| **AFP_II** | **Implementa-tion of uniform standards and norms for EU** | A13<br>E2, E11<br>E15,<br>E25<br>E27 | Uniform standards and norms for digital data. Assuring interoperability of the systems used by different market players, and at quality and safe exchange of data between operators | System interoperability, scalable and flexible solutions, seamless data exchange, simplified system updates, enhanced data quality and security control and full regulatory compliance. | 2,25<br>2 | 2,25<br>1 | 2,25<br>2,25 |
| **AFP_III** | **Creating digital security systems** | A14<br>E8<br>E14<br>E25<br>E26 | A comprehensive digital security framework, covering technological, organizational and ethical aspects. Establishment of uniform standards for the storage, sharing and processing of data and the implementation of privacy and information security policies. | Secure collaboration and data sharing, enhanced privacy protection, minimised data leaks and unauthorised access, increased trust from partners and consumers, compliance with data-security regulations, and fewer errors from system incompatibilities. | 4,25<br>5 | 4,5<br>1 | 4,25<br>4 |
| **AFP_IV** | **Institutional and financial support for DT sector** | E3, E6,<br>E9, E19<br>E22,<br>E23<br>E28 | Creating financial, institutional and capacity-building support mechanisms through grants, tax incentives, investment funds, training programs and public–private partnerships. | Fostering creation of start-ups, new business models and innovative technology projects, acceleration of the digital transformation process. | 4<br>4,75 | 4<br>1,25 | 4<br>3 |
| **AFP_V** | **Sectoral cooperation on a national** | A1, D1,<br>D3, D4, | Partnerships of DT providers, businesses, research, public administrations and NGOs to develop, deploy and transfer innovative | It boosts competitiveness by adapting and co-developing innovations, expanding networks and experience sharing. It also | 4,75<br>5,5 | 5,5<br>3,5 | 4,75<br>5,75 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **and European scale** | D5, D7, D8, D10, E16, E21, E27, F2 | digital solutions. Support for open data platforms and cross-border data exchange. | drives EU-wide standardization and interoperability, enabling alignment with regulations and EU digital policies. | | | |
| **AFP_VI** | **Shaping digi-talisation poli-cies with the inclusion of civil society and environ-mental issues in line with the Quintuple Helix approach** | D5<br>D7<br>D8<br>E4<br>E8<br>E13<br>E14<br>E20 | Adopting the Quintuple Helix model to create digitalization policies, with the involvement of a wide range of stakeholders (civil society, the public sector, science and business) and taking into account environmental protection requirements and high ethical standards. It creates mechanisms for public consultations and monitor the impact of digitization on the natural environment. | Digital transformation of the agri-food sector which is technologically efficient, socially responsible and environmentally sustainable. Better adaptation of digitization policies to real social and environmental needs, social acceptance for the implementation of new technologies, reduced risk of digital exclusion among various social groups. Transparency of public administration activities in the area of digitization | 5,75<br>5,75 | 5<br>4,25 | 5,75<br>5,5 |
| **Strategies developed by the "HoReCa" team** | | | | | | | |
| **HRC_I** | **Using digital solutions to support food supply chain management** | A1, A3<br>B15<br>C5<br>D2<br>D6<br>D10 | Employing digital tools for food supply chain management enabling supplier data integration, traceability, demand forecasting and delivery monitoring to optimise HoReCa operations. | Streamlined supply and storage management, reduced food and raw material waste, orders aligned with actual demand, shorter lead times, faster response to shifts in demand and disruptions; greater customer satisfaction through stable supply and consistent quality. | 2<br>2,5 | 2,25<br>2,25 | 2<br>3 |
| **HRC_II** | **The use of digital techno-logies to build relationships with consumers** | A1<br>A6<br>B2<br>B15<br>D6<br>E25 | Use of digital tools to understand consumer needs, habits, preferences to personalise the offer, build customer loyalty. Solutions for customer relationship management, running marketing campaigns, tailor your offerings in real-time, while safeguarding personal information. | Better understanding of customer needs and expectations, personalization of product and service offerings, building trust and customers loyalty, effective data-driven marketing campaigns, faster response to new consumer trends; building a positive brand image. | 1,75<br>3,5 | 2,25<br>1,5 | 1,75<br>3,5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **HRC_III** | **Using artificial intelligence to automate routine (repetitive) processes** | B3<br>B4<br>B11 | Implementation of AI-based solutions to automate repetitive, time-consuming operational processes. This applies to demand forecasting, purchase planning, inventory management, staff scheduling or dynamic pricing. Implement historical data analysis to optimise future activities. | Reduced costs, less time for routine tasks and less human errors. Improved demand forecasting and inventory optimization. Increased staff productivity, faster operational decision-making. More flexibility in responding to market changes. | 1,5<br>2,5 | 2,75<br>2 | 1,5<br>2,75 |

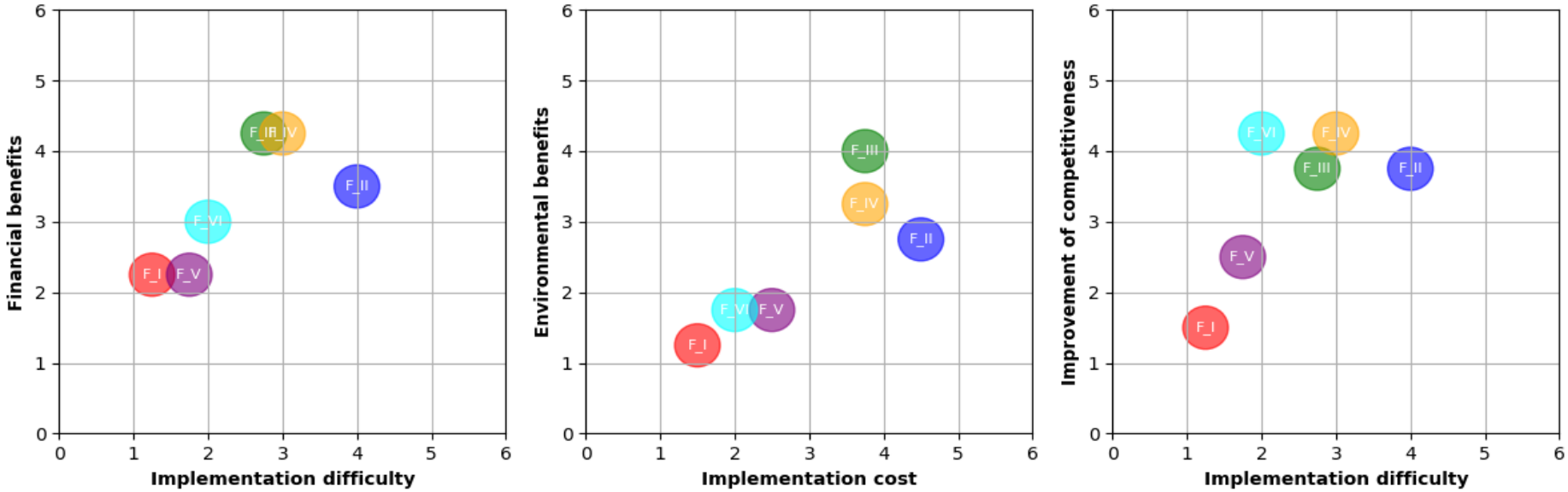


**Figure 16 Prioritization Matrix of Strategic Options for Farming**

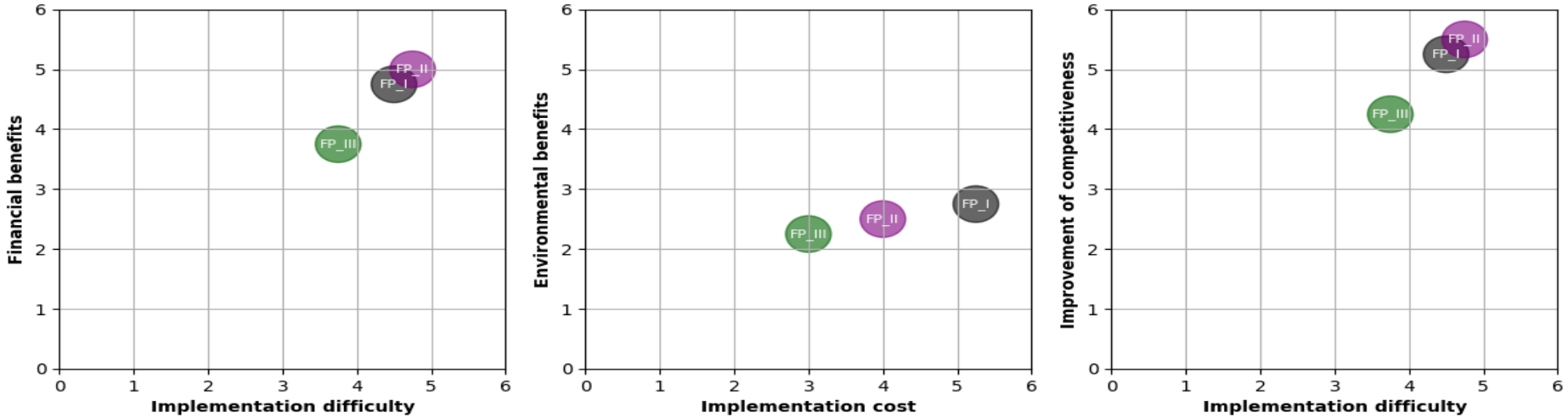


**Figure 17 Prioritization Matrix of Strategic Options for Food Processing**

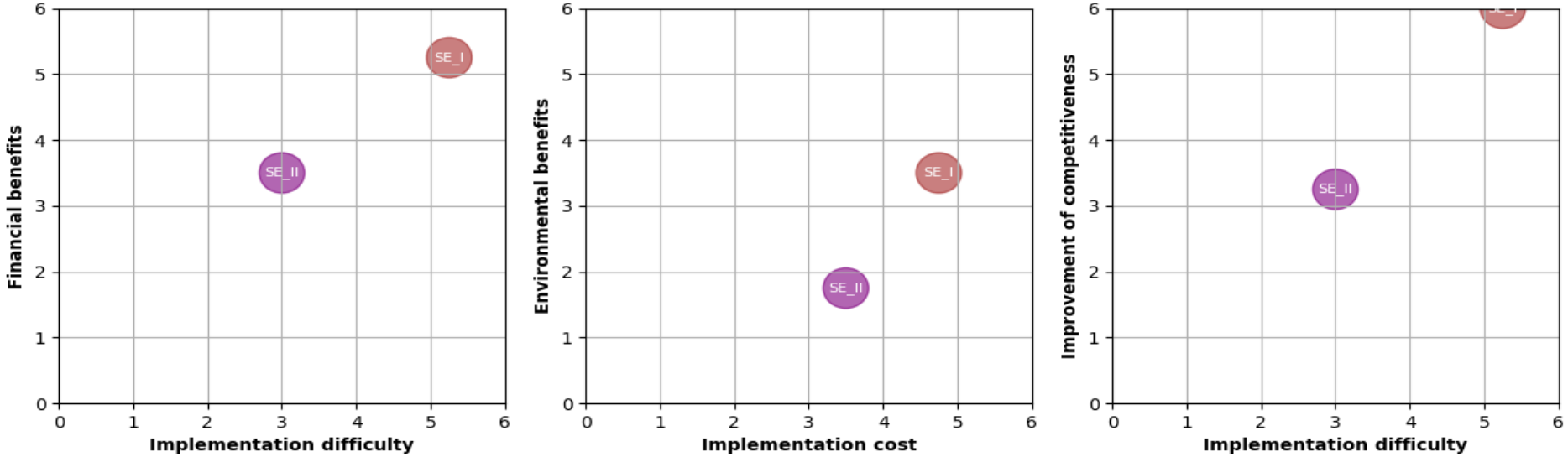


**Figure 18 Prioritization Matrix of Strategic Options for Science and Extension**

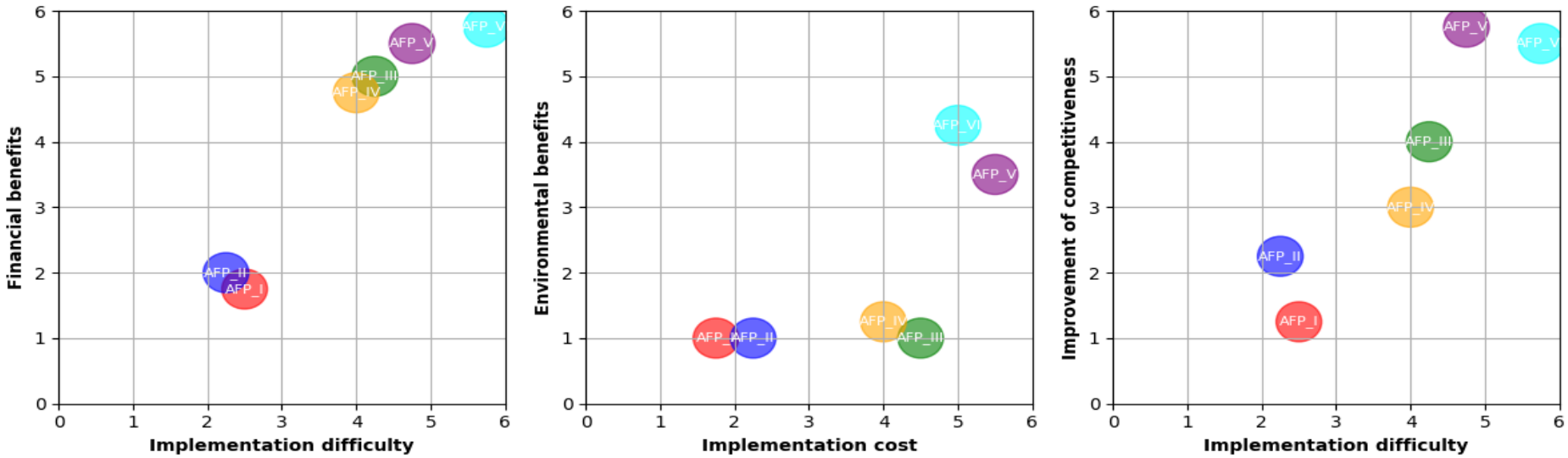


**Figure 19 Prioritization Matrix of Strategic Options for Agricultural and Food Policies**

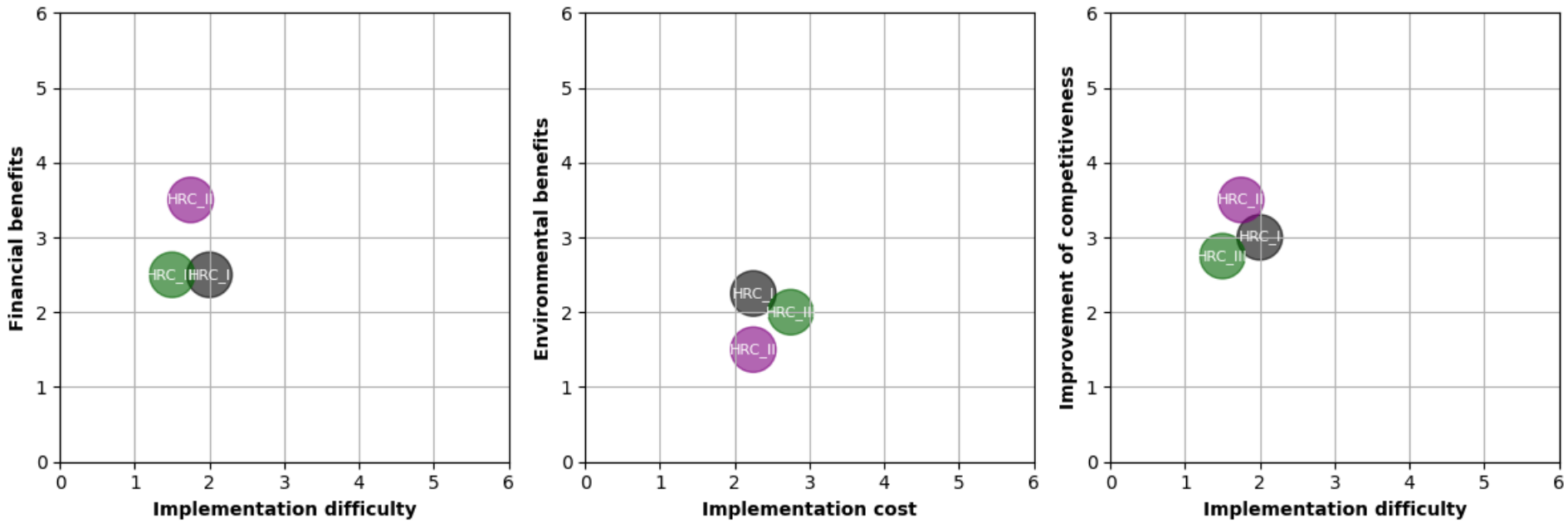


**Figure 20 Prioritization Matrix of Strategic Options for HoReCa**

To explain the findings reflected in Table 15 and the matrixes (Figures 16-20), the strategies vary in scope—from relatively simple solutions designed for a single business to large-scale approaches applicable across the European Union—as well as in their level of complexity, reflected in the diverse set of tools and strategic actions from which they are composed. The expected effects were formulated by the participants, drawing partly on their own experience and partly on the expertise of the Design Thinking specialists involved in the workshop. Although the effects were defined in broad terms—given the constraints of the workshop format—they are sufficiently clear to highlight the benefits of implementing the proposed strategies. The coordinates used in the Prioritization Matrices represent the subjective assessments of the team members.

The Prioritization Matrices serve to visualize the analyses conducted using the previously defined criteria. Each of the presented strategies is plotted in Figures 16-20, where the circle representing a given strategy bears the same symbol as the one used in Table 15. The position of each circle corresponds to the evaluations made: the closer it lies to the boundary of the matrix defined by the value “0” on the horizontal (X) axis, the lower the scale of difficulty or implementation cost; the closer it is to the value “6” on the vertical (Y) axis, the greater the anticipated benefits of implementing the strategy.

As might be expected, strategies that are more difficult or costly to implement tend to offer potentially greater benefits. This relationship may be relevant when making implementation decisions, particularly in light of risk aversion or cost-related barriers.

Within the set of strategic options in the areas of “Processing”, “Science and Digital Technologies”, and “Policies and Advisory Services”, there are strategies characterized by a high level of implementation difficulty while offering substantial benefits. This may partly reflect the inherent nature of strategic solutions for Digital Technologies in these areas, given the scale and complexity of implementation as well as the technical sophistication of the applied technological solutions. However, caution should be exercised when comparing the workshop-generated solutions, as differences in participant creativity may have influenced the development of more ambitious strategies

**Conclusion**

The topic and tasks of the workshop sparked significant interest and engagement among participants. Although many of them — including professionals working with digital technologies had taken part in the three previous Data4Food workshops, translating general knowledge into concrete digital data deployment strategies proved to be a challenging exercise. One contributing factor was the limited time allocated for the tasks. Nevertheless, the workshop clearly highlighted two fundamental limitations:

- Only a fragmented understanding of the available solutions, tools, and technologies (though this applied far less to DT specialists);
- Incomplete awareness of how these digital solutions can be applied in practice — particularly in relation to more advanced technologies.

Based on the workshop outcomes and observations, the following key conclusions can be drawn:

- **There is a clear awareness among participants of the inevitability of the digital revolution**, along with the benefits associated with implementing digital technologies and data applications. The evaluation of strategies using the Prioritization Matrix revealed that many proposed initiatives were generally seen as having moderate implementation difficulty and cost, while their potential benefits were typically rated above average. Environmental benefits were rated the lowest, mainly due to the indirect nature of the impact and the energy consumption associated with DTs.
- **It is very likely that this level of digital awareness does not extend to all potential users of DTs**, highlighting the need for widespread training programs — especially for managerial staff — and broader outreach. This is particularly important for promoting the use of artificial intelligence beyond its more well-known, basic applications, extending into areas such as data analysis, modelling, and decision-making support.
- Workshop participants awarded high scores in the rankings for activities related to “data” (including data-sharing). This indicates an understanding of the essence of the Data Economy, which cannot exist without "data."
- Participants emphasised the **importance of tailoring digital solutions to the scale of operations**. For smaller economic entities — such as individual farms, small-scale processing units, or local retail — strategies based on integration and cooperation may prove effective. However, an economically viable alternative could be the development and delivery of digital services specifically designed for this segment.

Finally, in line with the Quintuple Helix model — which is both practical and philosophical — successful implementation and full exploitation of digital technologies require close collaboration among key stakeholder groups: science, business, and government. Importantly, this must also include civil society and take into account the imperative of natural resources protection.

## 4.5 How do non-farmer stakeholders see data value proposition? Example of dairy sector

This section answers research sub question - How do non-farmer stakeholders see data value proposition in specific sectors, taking dairy production as an example? It is based on five additional interviews with dairy companies and dairy business support organisations in June 2025.

The reason for conducting additional interviews was following. The previous research activities - literature review (section 3), initial stakeholder workshop (section 4.1) stakeholder survey (section 4.2), stakeholder interviews (section 4.3) as well as strategic options workshop (section 4.4), while taking a multi-actor perspective, quite substantially focussed on primary producers and their situation with regards to digitalisation, data collection, and strategic options of data use at farm level. To relatively lesser degree these methods yielded findings on how agricultural data generation at farm level creates value for stakeholders beyond the farm itself. Recognising this gap and understanding the need for enhancing strategic value of data for all participants in the food system we decided to carry out an additional small empirical study and investigate how non-farming actors perceive, access, and use farm-generated data. Due to resource limitations we chose only one sector for exploration which was dairy industry.

The team conducted five in-depth, semi-structured telephone interviews with non-farmer stakeholders in dairy sector. The interviewees comprised a veterinarian, a feed company representative, a manager from a dairy processing company, a research institute expert, and a specialist from an animal breeding institute. These stakeholders were chosen for their active engagement with farm data and their ability to provide sector-specific insights on the value and use of such data beyond direct farm operations. Interviews focused on: (1) the types of data generated by farm automation and digitalisation, (2) data storage, access, and control mechanisms, and (3) the expectations, needs, and uses of this data by organisations other than the farm itself. The guiding aim was to clarify how these distinct actors define and realise data value, moving the focus beyond the mere adoption of digital technologies.

**Findings—Sector-Specific Data Value Propositions**

- Milk Production:
    - *Dairy Processors* seek economic and production data from farms to inform price formation and advisory services. They already utilise data on milk quality, composition, and volume.
    - *Feed Companies* value access to feed intake, milk yield, and composition data, enabling the formulation of more precise and efficient rations tailored to specific animal groups or breeds.
    - *Veterinary Service Providers* would benefit from more granular health and behaviour data—such as rumination, body temperature, and water intake—potentially available through ingestible sensors. It could allow for earlier intervention in herd health, reduce reliance on antibiotic treatments, and improve survival rates.
    - *Animal Breeding Institutes* view performance, health, and genomic data as critical for making targeted sire recommendations, accelerating genetic progress, and supporting farm-level breeding programs.

These findings illustrate that the value of farm-generated data is perceived differently by dairy industry actors and enabling organisations. In dairy sector data presents a strategic resource for multiple actors—including processors, input suppliers, veterinarians, and breeders—each seeking to optimise their operations or contribute to broader system innovation. The results underscore the importance of designing data systems and sharing practices that consider the diverse expectations, values, and needs of all agri-food stakeholders, not just producers or technology adopters.

# 5. Value of data through the future scenarios for data economy for food systems perspective

This section aims to address the research question RQ4 “How do strategic options for the uptake of data value proposition play out in different future scenarios and pathways of the DE4FS”. It looks at the results of the future scenarios developed in WP4 and tries to cross-check the findings with the ones of the literature review. It also aims to look at balances and imbalances.

The following method was used in scenario analysis: (1) identifying strategic options that different stakeholder groups could pursue to adopt and benefit from data value propositions in future scenarios, (2) for each stakeholder category identified in the scenario report, we extracted and synthesised relevant information to construct targeted answers about their potential strategic pathways. (3) This approach allowed us to transform the broader scenario-based content into stakeholder-specific insights, essentially creating a structured analysis that looked at different actors in the food system and their opportunities for engaging with the value of data about the food system.

Siloed data might not have much value for stakeholders, in general. Often, the value of a particular data is seen through combinations with other data, in specific contexts. Thus, data can have different values for different stakeholders, based on the context used and which other types of data are combined with it. At the same time, the value of data could change over time due to contextual changes (e.g., technology developments, economic growth, etc.), new data or other external factors that could impact the food systems. Within the project, one of the reports, the deliverable D4.2 "*Future scenarios and pathways for the DE4FS*," explore potential pathways to achieve an inclusive and innovative data economy for sustainable food systems by 2050. The analysis considers three desirable future scenarios developed together with stakeholders from six European countries. These scenarios and the pathways they identified looked at the value of data for different stakeholders within the agri-food systems, highlight its potential value, the challenges that might arise, and some possible solutions to tackle them using various stakeholder input (Rijswijk et al., 2025). While data is the central element in these scenarios, and it is seen as a driver for transparency, efficiency, innovation and sustainability, the analytical focus of each scenario is slightly different:

- **Scenario A: Personalised Healthy Diets** focuses on the use of data to create personalised diet recommendations. Thus, in this case, the type of data targeted include individual consumer data, including DNA and personal characteristics. At the same time, the data-driven approach will aim to enhance food production efficiency by aligning it with consumer demand. Which means that by merging consumer data, an extra value and meaning will be added to the existing ones (e.g., from farm level) and will enable the farmers to provide specialised products based on consumer needs.
- **Scenario B: Local and Transparent Value Chains** focuses on how the data can be used to foster transparency and traceability for the food systems. In this case, the technologies (e.g., blockchain, data exchange platforms, etc.) could provide consumers with information about food origins and production methods. Moreover, sharing data through data exchange platforms will enhance the cooperation and provide insights for all value chain actors.
- **Scenario C: Strictly Regulated High-Tech for Reduced Environmental Impact** maximises the value of data by using it to achieve sustainable food production practices and environmental benefits, by supporting the innovation in the field. Thus, data itself

becomes an important product and adds value to food products. The data from on-farm technologies (e.g., IoT sensors, AI-powered robotics) are used to gain insights from value chain practices, helping support data-driven decision-making to enhance food system's sustainability.

It is important to remark that there are several factors that can determine the value of data. The type of stakeholder that uses the data may see its usefulness based on their needs and interests. As the context where the data is used impacts significantly its perceived value, the three scenarios try to look at this aspect also from stakeholders' perspective (e.g., producers, consumers, food processors, etc.). In all three scenarios, there are four types of stakeholders included in the analysis consistently - farmers, technology providers, government and regulators, and consumers. In addition to these stakeholders, each scenario includes some other type of stakeholders. For example, scenario A includes food processors and researchers, scenario B looks at environmental organisations and retailers, while scenario C considers food processors and environment organisation within its analysis.

In scenario A, the ***consumers*** could benefit from personalised nutritional advice, which could help them improve their health. But it also comes with concerns regarding data privacy, security, potential for misuse of sensitive data. For instance, food types not included in the individual's personalised diet would be more expensive and affordable for people with higher incomes. Thus, people would be actively encouraged to only consume what is considered “right” for them. This can generate potential social inequality and restriction of personal freedoms. Therefore, a key consideration in the scenario is the (lack of) dietary freedom, and how the use of personalised data could be linked with healthier lifestyles and early diagnosis of health conditions, without exacerbating socio-economic inequalities When it comes to scenario B, consumers could gain unprecedented access to information about their food across the entire value chain, helping them to make informed choices and build trust with the food providers. Transparency of food production can increase the environmental awareness for food systems’ stakeholders, especially, for consumers. However, the huge amount of information provided to them can lead to an overload, which might have the opposite effect on the consumers. The scenario C puts less emphasis on the role of the consumers. In this case, the main effect of the scenario on them will be potentially higher prices for food due to the costs associated with data-driven environmentally friendly production.

When it comes to ***farmers***, in scenario A, they gain value from using consumers' demand data to enhance the security of crop planning. It will also allow them to further specialise and differentiate the crop production and charge a premium for "healthy" or "good" food. At the same time, increased specialisation and subsidisation the focus on customers' demand might result in the disappearance of the free market and change radically the roles of farmers in the agri-food systems. In scenario B, farmers build customers' trust in their products through transparent business models (incl. access to data regarding the origins of their food, food production processes and value chain practices). In this case, digital literacy becomes an important element for technology and data sharing adoption and use. Sharing data could further help farmers better understand the value chain and increase coordination within. In scenario C, farmers benefit from increased agricultural efficiency and productivity facilitated by data generation and data sharing, potentially leading to higher incomes. Improvements in regulations pertaining to intellectual property rights and AI, and the integration of all value chain actors through data exchange create a conducive environment for data-driven approaches within the sector. The widespread use of technology allows farmers to increase efficiency and the

available farm data allow them to focus on strategic topics like biodiversity, but the increased use of technology raises concerns on farmers' dependency on technology providers and the potential shift of identity - from farmer to more like a "data manager." At the same time, technology costs play a significant role in its adoption and use, and, in this case, larger farmers might be more advantaged than the small ones.

Data sharing and use represent an important and lucrative opportunity for ***technology providers*** across all three scenarios. Based on the scenario specificity, the technology providers will be able to develop tailored services and tools for data analysis based on available inputs. For example, develop platforms for personal nutrition (Scenario A), maintain blockchain and data exchange platforms (Scenario B) and develop and provide on-farm technologies, AI-powered robots and data analytics services for food value chain stakeholders (Scenario C). The availability of data may also allow them to take on new and increasingly prominent roles in the food system. For instance, Scenario C foresees traditional farm advisors being replaced by artificial intelligence tools which make use of the large amounts of integrated value chain data.

Data can help ***governments and regulators*** to better understand the agri-food sectors context and support policymakers to tailor the policies to fit the needs of the food system (i.e., data-driven policies) and public health. In addition, governments could monitor and assess the stakeholders' compliance with regulations as well as the impact of the policy interventions on the food system. Data can help ensure accountability and traceability throughout the food value chain, build consumer trust and encourage responsible consumption (or actively discourage inappropriate food choices). However, the scenarios generally focus on the role of government and regulations, rather than the value of data for the government. At the same time, the role of government and regulators across scenarios is dependent on the focus and approach of each situation analysed. For example, in scenario A, government and regulators own the centralised data, ensure data security and privacy, and potentially provide data to farmers. A KPIs-based reward systems is set in place to support (incl. via subsidies) the development of sustainable and healthy food production, which aims to enhance the voluntary participation of stakeholders in the data sharing, an essential aspect of the scenario development, while also contributing to public health. In scenario B, the role of the government and regulators is more focused on setting stringent regulations mandating information sharing and promote local food and transparent choices. Thus, they are involved in the development of legislation for data exchange platforms, privacy, and security, but do not explicitly make use of data in the context of policy making. In scenario C, the government and regulators play a more central role, focused on setting up and enforcing regulations and ensuring fair data practices. At the same time, they will provide financial support for technology adoption and oversee the certification of sustainable practices.

When it comes to ***food processors***, they can benefit from better alignment with farmers through data sharing, leading to more sustainable production (scenario C). Also, they can produce specialised healthy food products based on consumer data (scenario A) to which they have restricted access, granted by the government. The producers within sectors associated with "unhealthy" foods might encounter some negative impacts due to scenario focus on healthy diets approach. The digitalisation of local supply chains can help retailers save time in the process of food delivery but also help them provide clear and accessible product information, ensuring traceability and transparency of food (scenario B).

***Environmental organisations*** will benefit from increased transparency along the entire value chain, helping reduce the environmental impacts and supporting a healthier environment

(scenario B). Moreover, the data-driven insights will help reduce and eliminate the environmentally harmful processes and products, enhancing food systems environmental sustainability (scenario C). In scenario A, researchers can utilise the data for research on personalised nutrition and health, further contributing to the overall wellbeing of the consumers, though this depends on the level of access granted by the government.

Overall, all three scenarios include a shared concern for enhancing the sustainability of food systems through reducing environmental impacts, promoting sustainable production practices, or supporting healthier diets. And technology is seen as a key enabler for the envisioned changes in the agri-food sector. But, to succeed, smart data governance and regulation is also important in addressing various challenges such as data privacy, security, fair access to data, and preventing misuse of data. Likewise, Scenario A in particular raises political questions about the level of centralised data collection about and involvement (government or otherwise) in personal dietary choices in the name of public health and sustainability.

At the same time, the three scenarios provide three different perspectives for the development of the data economy for food systems by 2050, by focusing on different main priority, level of intervention and market. In scenario A, the data is seen as the support to make possible highly curated and healthy personalised diets, with central focus on customers. The scenario considers a high level of intervention with personalised diets and regulated data sharing, shifting away from the free market towards more personalised and subsidised food options (e.g., rewards customers following the recommended choices for food options; adds a "penalty" for the foods not included in the initial diets). At the same time, in this scenario, the main challenges are linked to the potential risks to individual freedom, as well as accentuating the inequalities in access to food.

Scenario B puts more emphasis on local and transparent value chains, promoting the development of local and regional food systems. This approach favours a more hands-off attitude with decentralised data ownership. This approach highlights the importance of balance between empowering local production and enhancing food system's sustainability, considering that not all types of food can be produced locally or regionally.

Scenario C is centred on strictly regulated high-tech solutions for environmental sustainability. In this approach, strict regulation and monitoring to ensure compliance and sustainability are put in place, anticipating a transformation of the food production processes through technology and innovation. However, this focus on technology and high-tech solution could results in the exclusion of small farmers from the market as well as a potential increase in food prices.

While all three scenarios use different approaches to support the development of a sustainable data economy for food systems, one important aspect of the scenarios is to understand how data is valued by different food value chain stakeholders, and what are the potential challenges that might result from data use. Across the three scenarios, there are several overlapping themes such as securing sustainable livelihoods for farmers, the support the development of new business models, the essential role of the education, and the necessity of well-designed legislation in the data economy.

Data privacy and control are important aspects of the future development of the data economy for food systems, as they could significantly influence the power dynamics within the system and could disrupt the market, creating inequalities between stakeholders of the food system. For example, it could exclude small farmers from the market due to costs for new technology

adoption or high prices for food could limit access for certain types of consumers to food products.

Data standards enhance data interoperability between different databases, while adopting fair data practices facilitate further data use and re-use, supporting the development of new business models. Strengthening the legal frameworks and aligning data practices could help address some of the challenges of data use, while digital and data literacy could improve stakeholders trust in data sharing, enhancing the use of the data economy by all food systems' stakeholders.

To achieve the goals for a fair, inclusive and innovative data economy for sustainable food systems, eight pathways have been designed for the three future scenarios:

- Guaranteeing dietary freedom for consumers
- Building a thriving and healthy society
- Securing sustainable livelihoods for farmers
- Ensuring local food is accessible, available and affordable for all
- Driving strong and resilient local economies
- Uniting value chains to actively reduce the environmental impacts of food production
- Upholding full compliance in the agri-food sector by eradicating harmful products and practices
- Securing sustainable livelihoods for farmers

As mentioned previously, these scenarios and pathways are not mutually exclusive and often overlap in their objectives. For example, overlapping areas include securing sustainable livelihoods for farmers, developing new business models for various actors in the value chain, the importance of education across all scenarios, and the necessity of legislation related to the data economy. At the same time, there are also some contradictions and points for debate inherent to the scenarios and pathways for a fair, inclusive and innovative data economy for sustainable food systems. In this case, there are different views on the type of food to be produced (processed vs. local), the direction and impact of food prices, the preference for centralised versus decentralised databases, and the voluntary or involuntary nature of data collection, particularly when concerns the sensitive personal data.

On the other hand, it is interesting to notice how similar pathways are proposed to reach different desirable impacts of scenarios. For example, both scenario A and C aim to secure farmers' livelihoods, albeit through different lenses. Scenario A aims to reduce market risks via demand data, while scenario C propose to enhance efficiency and productivity via data-driven decisions. Similarly, new business models are seen as essential preconditions for desirable outcomes, encompassing everything from specialised healthy food products in scenario A to data as a tradeable product in scenario C.

Education and legislation are two important themes present in all three scenarios. Scenario A prioritises consumer education to promote healthy eating and build a thriving society. Scenario B focuses on educating consumers about food production to boost demand for local and "alternative" food networks, ensuring accessibility and reducing environmental impact. It also highlights digital education for value chain actors to foster strong local economies. Scenario C emphasises improving digital skills for all value chain actors, leading to better data-driven decisions, enhanced compliance, improved labour conditions, and new business models, ultimately supporting farmers' livelihoods.

On legislation, scenario A stakeholders emphasise secure DNA and consumer data databases through consent systems and protective infrastructures to enable nutritional advice and achieve dietary freedom. In scenario B, it is highlighted the need to align digital data exchange platforms with privacy and security legislation. Additionally, effective governance structures supporting farmer data control are proposed to ensure compliance and sustainable livelihoods.
Therefore, it seems that by targeting the overlapping aspects can lead to synergies in the realisation of the desirable impacts of the scenario.

First, to secure sustainable livelihoods for farmers is crucial for a fair, inclusive, and innovative data economy in food systems. Thus, high-quality data is key to this, enabling farmers to mitigate market risks through enhanced knowledge of food demand and to improve efficiency and productivity via data-driven input optimisation. While existing policies like the CAP Strategic Plan Regulation already aim for farm income improvement and fairer returns, they currently fall short in highlighting the role of high-quality data in achieving these goals. Therefore, ensuring farmers' access to high-quality data on both food demand and production, will enable them to support market risk mitigation and optimised planning, thereby securing their sustainable livelihoods.

Second, developing new, innovative business models across the entire food value chain is another crucial element for a fair, inclusive, and innovative data economy. For farmers, these models secure sustainable livelihoods. For technology providers, they are essential for creating combined, interoperable data exchange systems, such as one-stop-shop platforms with improved data standards. Food companies also benefit, as new business models for specialised healthy food production contribute to a thriving society. While existing policy documents like the Farm to Fork strategy mention supporting new business models for SME food producers and processors, they currently overlook the necessity of data-driven business models and the critical role of technology providers in developing integrated data exchange systems. Thus, it is important to foster the development of data-driven business models for all stakeholders within the food value chain.

Third, the education is a critical cross-cutting theme for achieving desired outcomes. Scenario A emphasises educating consumers for healthy food choices to build a thriving society. Scenario B expands on this, focusing on consumer awareness to drive demand for local and "alternative" food networks, ensuring accessibility and reducing environmental impact. Scenario B also highlights digital education to foster digitally literate value chain actors and resilient local economies. Scenario C stresses improved digital skills for all value chain actors to enhance data-driven decision-making, ensuring compliance and eradicating harmful practices in the agri-food sector. While consumer-focused education is supported by policies like front-of-pack nutrition labelling, the proportionality of campaigns promoting personalised diets based on sensitive data needs careful assessment due to potential legal conflicts. Digital education, aligning with the EU Green Deal's aim to boost digital literacy and adapt skills for digital transformation, also finds strong policy support. Therefore, strengthening digital and dietary knowledge through comprehensive education for all value chain actors is recommended to stimulate consumer awareness for sustainable and healthy food consumption and improve data-driven decision-making.

# 6. Synthesis and conclusion

The purpose of D5.2 was to identify strategic options for data value propositions for stakeholder groups in the DE4FS, to examine how stakeholder groups address these options, and explore how strategic options for the uptake of data value propositions may materialise in different scenarios and pathways towards the data economy of the food systems. This deliverable addresses the research gap - a limited insight into the value generated by data for different stakeholder groups and how this value aligns with the strategic options these stakeholders adopt. We conceptualise data value within the broader context of sustainable and inclusive agrifood systems. Moreover, the strategic options available to stakeholders for capturing data value in ways that align with both individual goals and systemic sustainability objectives are not well known.

Upon this background we formulated three research questions (two of them with sub questions):
RQ1 How to conceptualise strategic options for DE4FS stakeholders to capture the data value? (Includes seven sub questions.)
RQ2 How the stakeholders perceive the key dimensions of data value in agrifood systems? (Includes five sub questions.)
RQ3 How do strategic options for the uptake of data value proposition play out in different future scenarios and pathways of the DE4FS?

These questions were answered by conducting seven interrelated smaller studies which applied different methods of data collection and analysis. RQ1 was answered by conducting a literature review. RQ2 was addressed by engaging in stakeholder dialogue and applying five specific empirical methods (stakeholder workshop, survey, secondary analysis of stakeholder interviews, strategic options workshop, and additional interviews with stakeholders in dairy sector). RQ3 was examined by critical reading and assessment of future scenarios of DE4FS with regard to what data value options they foresee. The author team devoted substantial research effort: we reviewed 210 articles in literature analysis and consulted 217 stakeholders in workshops, interviews and survey.

The consecutive research activities or smaller studies had a common purpose, common methodology (Figure 1 in Executive summary) and common theoretical framework (Figure 10 in Section 3). They informed each other in terms of methodology, concepts, and findings. The outputs of one study served as inputs for another. The research groups working on specific studies coordinated their activities.

## 6.1 Strategic options for data value proposition: Comparison of results from literature review and stakeholder consultation

In this section we compare results obtained in literature analysis and different forms of stakeholder consultation and establish similarities and differences in findings. We use the following analytical categories to draw comparison and synthesis:

- Value of data,
- Strategic options.

**Value of data**

Often, the value of a particular data is seen through combinations with other data, in specific contexts. The data can have different values for different stakeholders, based on the context of use and other types of data it is combined with. The value of data may change over time due to contextual changes (e.g., technology developments, economic growth, etc.), new data or other factors that impact the food systems.

Literature study established top 5 purposes of agrifood data use, they are: sustainability goals; efficiency optimization; informed decision making; environmental goals; and resilience building. Less frequently coded purposes include monitoring and supply chain improvement.
Value of data for data holders, according to literature, relate (in rank order) to: economic benefits; increased productivity; informed decision making; resources optimisation; and efficiency gains. The value of data for stakeholders such as enabling actors, policy makers, consumers, actors from adjacent sectors frequently focuses on more systemic interests, such as: better policy making: supply chain improvement; and innovation.

Stakeholder workshop identified the key dimensions of data value at food systems level, these are: improve food systems governance; support decision making; improve efficiency; optimise activities; assure quality; support innovation; enhance outcomes; and address challenges.

Stakeholder survey ranked these categories of data value in the following order:
1) Enhance efficiency, value creation and value capture in FS.
2) Supports FS governance.
3) Quality assurance and control, standardisation in FS.
4) Optimising, control, and monitoring FS activities and processes.
5) Enhancing FS outcomes (environment, health, information, well-being).
6) Support decision-making processes.
7) Manage performance attributes of the food system.
8) Support innovation ecosystem – digitalisation, AI, collaboration.
9) Enhance data sharing and free flow of data.
10) Address challenges, risks and opportunities in FS.
The highest average scores in these categories of statements were given by representatives of the IT sector, followed by farmers. The lowest average scores were recorded among respondents from the academic sector. In every category women respondents rated the importance of data higher than male respondents. Women participants of the survey particularly emphasised data use in the category "Food System Governance".

Top five survey statements out of 29 which received the highest mean scores among all stakeholder groups were:
1) “Access to reliable data improves decision-making for individual stakeholders within the food chain (e.g., producers, processors, distributors, retailers and other actors).”
2) “Data on nutritional content, and production methods empowers consumers to make choices which benefit health.”
3) “Data helps companies to adapt and change their business models to better respond to market challenges.”
4) “Continuous access to up-to-date data is essential for making timely and informed decisions, ensuring responsiveness to market changes and emerging trends.”

5) The data analytics integrated in food supply chain activities enhances the precision and reliability of production monitoring processes, ensuring better quality control and compliance with safety standards."

The lowest scored statement among all stakeholders groups was "The EU Common Agricultural and Food Policies are primarily data-driven, rather than driven by political or social considerations."

Stakeholder interviews with regard to data value revealed that for primary producers, retailers, processors and distributors, the main advantage of data is associated with operational and production optimisation. Multiple stakeholders cited precision farming benefits for primary producers. For retailers, processors and distributors the business oversight, supply chain transparency and enhanced risk management were indicated as key value of data. For policy, health, and food safety stakeholders, key advantages of data were identified in governance and interoperability domains. For consumers, transparency was indicated as the main benefit of data, allowing for more agency and decision-making capacity. For researchers, the value of data was indicated in areas of FS enhancement, innovation, and interoperability. For data actors, cited benefits centred on innovation, interoperability, and enhanced processing of data, which allows for development of new data solutions and services.

**Strategic options**

Strategic options in data use and data value capture was one of the central categories across the studies.

From the literature, five top strategic decisions for stakeholders to capture the value of data are related to: technology adoption; collaborative models and ecosystem; investment in AI/data integration; data integration, standardisation and interoperability; and infrastructure investment.

Strategic options workshop illuminated complex nature of strategic options as several possible courses of action the stakeholders may have in the context of DE4FS. Out of 99 strategic activities in data use, stakeholders selected 20 strategic actions. The top 10 strategic actions in rank order are:

1) Data-sharing.
2) Implementation of advanced food tracking technologies in the supply chain (barcodes, RFID tags, blockchain technology).
3) Using blockchain technology to collect and exchange data securely and transparently.
4) Implement farm management systems for data integration and decision support.
5) Government policies supporting the adoption of digital technologies (e.g. mobile applications, digital finance).
6) Data standardization for data consistency and interoperability.
7) Implementing digital technologies such as artificial intelligence, IoT, and blockchain.
8) Establishing rules for ensuring data quality and security.
9) Application of autonomous agricultural machinery.
10) Use of digital platforms.

The data strategies vary in scope—from relatively simple solutions designed for a single business to large-scale approaches applicable across the European Union—as well as in their level of

complexity, reflected in the diverse set of tools and activities from which they are composed. Strategies that are more difficult or costly to implement tend to offer potentially greater benefits. The evaluation of strategies using the Prioritization Matrix revealed that many proposed initiatives were generally seen as having moderate implementation difficulty and cost, while their potential benefits were typically rated above average. However, for stakeholders in processing, science, digital technologies, policies and advisory sectors there are strategies characterized by a high level of implementation difficulty while offering substantial benefits. The workshop participants emphasised the importance of tailoring strategic solutions to the scale of operations. For smaller economic entities — such as individual farms, small-scale processing units, or local retail — strategies based on integration and cooperation may prove effective.

## 6.2 Implications for the uptake of data value propositions in food systems

In this section we reflect on implications regarding the uptake of data value propositions as suggested by comparative analysis of findings from different research activities including scenario analysis. The synthesis is done along the following analytical dimensions:

- Uptake of data value propositions in future scenarios of DE4FS,
- DE4FS integration conditions,
- Recommendations for the uptake of data value propositions.

**Uptake of data value propositions in future scenarios of DE4FS**

The analysis of future scenarios that were made in WP4 for the data economy in food systems by 2050, shows that: in Scenario A: “Personalised Healthy Diets” merging consumer data will enable the farmers to provide specialised products based on consumer needs. In Scenario B: “Local and Transparent Value Chains” sharing data through data exchange platforms will enhance the cooperation and provide insights for all value chain actors. In Scenario C: “Strictly Regulated High-Tech for Reduced Environmental Impact” data-driven decision-making to enhance food system's sustainability. Table 17 summarises some key insights regarding the value of data for specific stakeholder groups in different future scenarios.

**Table 17 Value of data for stakeholders in future scenarios**

| Stakeholders | Value of data | | |
|---|---|---|---|
| | Scenario A: “Personalised Healthy Diets” | Scenario B: “Local and Transparent Value Chains” | Scenario C: “Strictly Regulated High-Tech |
| Consumers | Health improvement. | Making informed choices, building trust with food providers, and increase environmental awareness. | Potentially higher prices for food due to the costs associated with data-driven environmentally friendly production. |
| Farmers | Using consumers' demand data to | Build customers' trust in farmer products | Increased agricultural efficiency and productivity facilitated |

| | | | |
|---|---|---|---|
| | enhance the security of crop planning. | through transparent business models. | by data generation and data sharing. |
| Technology providers | Develop platforms for personal nutrition. and develop and provide on-farm technologies, | Maintain blockchain and data exchange platforms. | Develop AI-powered robots and data analytics services for food value chain stakeholders. |
| Governments and regulators | Own the centralised data, ensure data security and privacy. | Setting stringent regulations mandating information sharing and promote local food and transparent choices. | Setting up and enforcing regulations and ensuring fair data practices. |
| Food processors | Produce specialised healthy food products based on consumer data. | Provide clear and accessible product information. | Better alignment with farmers through data sharing, leading to more sustainable production. |
| Environmental organisations | Utilise the data for personalised advice on nutrition, health and environmental wellbeing. | Reduce the environmental impacts and supporting a healthier environment. | Enhancing food systems environmental sustainability. |

**DE4FS integration conditions enhancing uptake of data value propositions**

Systemic approach to DE4FS is essential to create conditions and environment where multiple stakeholders can benefit from data. The WP1 frames DE4FS as “a dynamic ecosystem that supports direct and indirect interactions between the Data Economy and the Food system” (Piot-Lepetit et al 2023). The Data4Food2030 project develops the definition of DE4FS as “a spatial and temporal dynamic ecosystem, composed of numerous sub- ecosystems with loose boundaries, where resource-integrating, service-providing and value-creating actors are connected by direct and indirect interactions and shared institutional arrangements to create value propositions though resources, institutions, technologies, data, relationships…connecting data ecosystems and Food Systems, as well as the broader economic, societal, digital, technological, and natural environments in which they are embedded in and connected to.”

Building on this definition, we looked into system level conditions that enable stakeholders to engage in data flow and exploitation to improve economic, social environmental performance of individual firms as well as food chains and food systems at large.

Literature study when analysing data flow in system perspective found “between systems” as the most prominent category, highlighting the dominance of system to system communication in valorisation of data. This is followed by data flow, sharing and exchange through blockchain technology which was coded as “among all supply chain actors” and “among all stakeholders”. The literature review established that farmers play a central role in many bilateral exchanges, while data flow involving consumers and researchers remain limited.

Stakeholder interviews discovered conditions and solutions that may enhance data value for multiple stakeholders at an aggregated food systems level. These system level conditions include:
1) Regulation improvements.
2) Interoperability and data format standardisation.
3) Open data and common data sharing platforms.
4) Industry self-organisation.
5) Education and training.

**Recommendations for the uptake of data value propositions**

Data value proposition is a unique benefit that data-driven products or services offer to stakeholders by explaining how they solve specific problems or meet particular needs. Data value propositions are shaped in formal and informal interactions between stakeholders in which institutional and legal arrangements play role. The value of data is captured by stakeholders in wider DE4FS context depending also on stakeholder capacity (skills, resources, etc.). In this study we approached data value propositions as technically and socially organised form of data exchange with a double purpose – to enhance economic performance of firms in agri-food sector and to support sustainability of food systems.

Based on these premisses, we derived a number of recommendations from literature review, stakeholder consultation and scenario analysis.

In literature, top five strategic management recommendations to stakeholders regarding maximising the value and effectiveness of agrifood data usage are:
1) Invest in training and capacity building.
2) Ensure data privacy and security.
3) Promote cross sectoral collaboration.
4) Focus on sustainability/resilience.
5) Invest in digital/ICT infrastructure. T

The literature emphasises the major gap in capacity building, ethical governance and inclusive policies.

Stakeholder interviews articulated the following recommendations:
1) Introduce mandatory interoperability obligations.
2) Introduce common data format rules and harmonise vocabularies.
3) Deploy AI potential for semantic interoperability.
4) Adapt more accessible data formats – words and practices – so that they are understandable for more actors across the value chain.
5) Introduce more education and training to improve data use proficiency across all data economy stakeholder groups.

Strategic options workshop participants also emphasised the need for widespread training programs — especially for managerial staff. This is particularly important for promoting the use of artificial intelligence beyond its more well-known, basic applications, extending into areas such as data analytics, modelling, and decision-making support.

Interviews with stakeholders in dairy sector suggested the importance of designing data systems and sharing practices that consider the diverse expectations, values, and needs of all stakeholders in a given agri-food sector, not just producers or technology providers.

To summarise, it is possible to group recommendations thematically around several key themes:

- Diversity: Appreciation of different data value propositions as unique benefits that data-driven products or services offer to stakeholders by explaining how they solve specific problems or meet particular needs.
- Balance: Recognition of profit and no-for-profit nature that data value propositions may have, as well as individual and collective benefits the data generates. It is important that data value propositions are looked not only from the perspective of individual gains but also collective good.
- Capacity: Different methods used highlight that while stakeholders can capture data value by adopting technologies and making infrastructure investments, digital trainings and capacity building are also essential. Therefore, strategic options should go beyond purely technical solutions and include trainings, social awareness and cross-sector collaboration. Conceptualising strategic options, thus, involves aligning technological capabilities with institutional readiness, stakeholder inclusiveness and systemic trust-building mechanisms.
- Inclusivity: Across the methods used we found that successful exploitation of digital technologies and data require close collaboration among key stakeholder groups: science, business, and government. Importantly, this must also include civil society.
- Sharing culture: Our study evidences the need for collective approach to enhancing data value in food systems. Stakeholders called for mutuality and shared benefits from data exchange – a social contract on data economy.

Ability to balance gains and risks for different stakeholders, inclusivity of data spaces and fairness of data sharing were mentioned as important recommendations towards fair and inclusive data economy of food systems.

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# Annex I: Codes used per variable

**Methodology Used:** Literature Review, Case Study, Experiment, Model Development, Quantitative Analysis, Survey, Mixed Methods, Conceptual Paper, Expert Opinion/Elicitation, Scenario Analysis.

**Part of Food System Addressed:** Plant Production, Horticulture, Livestock, Aquaculture, Processing, Distribution, Retail, Multi-sector, Other, Entire Chain, Research and Development, Consumption, Primary Production

**Type of Agrifood Data Examined:** Statistical Data, Digital Twin Data, FADN/FLINT, AI-Generated Data, IoT Data, Blockchain Data, Crop or livestock specific data, Geo-data, Sensor Data, Environmental Data, GPS/satellite data, Remote Sensing, Big Data, Smart Machinery, Energy Data, Water Data, Food Processing Data, Soil Data, Feed Data, Seed Data, Consumer Data

**Source of Agrifood Data:** IoT Devices, Sensors, Satellite Imagery, Remote Sensing, Farm Management Systems, Manual Reporting, Mobile Apps, Other, Multiple, GPS, Smart Devices, Historical Data, Web Data, Survey Data

**Data Flow/Sharing/Exchange:** Farmer ↔ Tech Company, Farmer ↔ Cooperative, Farmer ↔ Researcher, Between Systems, Among (all) supply chain actors, Authority ↔ Research, Open Source Data, Farmer ↔ Authority, Researcher ↔ Tech Company, Among (all) stakeholders, Farmer ↔ Industry, Stakeholder ↔ Consumer, Researcher ↔ Model Trainers, Stakeholders ↔ AI systems/robots, Among Researchers, Consumers ↔ Researcher, Producer ↔ Consumer

**Stakeholders/Actors Involved:** Farmers, Agri-tech (Firms), Researchers, Policymakers or Authorities, Distributors, Retailers, Consumers, Associations, Industry Groups, Multiple/Other, Cooperatives, Advisors/Service Providers/Agronomists, (Model) Developers, Supply Chain Actors, Bank and Insurance Companies

**Use of Agrifood Data:** Data Integration, Digital Twin Creation, Statistical Reporting, Research, Analysis, and/or Modelling, Predicting or Forecasting (AI), Decision Support Systems, Monitoring and Evaluation, Optimizing Operations, AI Development, Multiple/Other, Monitoring, Policy Development or Goals, Estimating/Predicting, Supply Chain Improvement, Consumer Preferences

**Purposes of Agrifood Data Use:** Environmental Goals, Efficiency Optimization, Sustainability Goals, Innovation, Resilience Building, Social Goals, Informed Decision Making, Economic Goals, Animal Welfare, Policy Development or Goals, Estimating/ Predicting, Supply Chain Improvement

**Value of Data to Data Holders:** Improved Farm Management, Efficiency Gains, New Revenue Models, Enhanced Market Access, Risk Reduction, Increased Productivity, Compliance with Regulations, Economic Benefits, Market Information/Prediction, Animal Health and Welfare, Quality Improvement, Enhanced Traceability and/or Transparency, Resource Optimization, Reduced Environmental Impact, Access to Subsidies, New Business Opportunities, New

Product/Service Development, Innovation, Improved Management Strategy, Improved Market Understanding, Reduced Administrative Burden, Negotiation Power

**Value of Data to Other Stakeholders:** Enhanced Traceability and/or Transparency, Innovation, Sustainability Reporting, Consumer Information Position, Improved Collaboration, Supply Chain Improvement, Market Information/Prediction, Targeted Communication, Competitive Advantage, Research Opportunities

**Strategic Options and Decisions for Capturing Data Value:** Technology Adoption, Data Integration, Standardization & Interoperability, Governance, Ethics & Data Sovereignty, Collaborative Models & Ecosystems, Data Monetization, Decision Support & Predictive Analytics, Capacity Building & Digital Literacy, Policy & Regulatory Support, Sustainability, Environmental & Social Impact, Cross-sector Collaboration and Ecosystem Building, Data Collection Frameworks, Integration (Platform, Blockchain & Other Tech), Investment in R&D, Precision Agriculture and Smart Farming Practices, Sustainability and Environmental Monitoring, Start-ups, Marketing of High-tech in Agri, Living Labs/Pilots, Tailored Solutions/Personalization

**Strategic Choices Made by Stakeholders:** Technology Adoption, Development and Participation in Data Platforms, Investment in R&D, Promoting Sustainability and Resilience, Stakeholder Collaboration and Co-development, Policy and Regulatory Support, Market and Value Chain Innovations, Leveraging AI and Advanced Analytics Responsibly, Integration, Data Management, Policy Design, Data Sharing, Leveraging ROI, Risk Management, New Business Models, Regional Strategies, Support Vulnerable Areas, Data Integration, Digital Twin, Automation, Edge and Cloud Computing, Low-Cost Solutions, Interactive Apps, Data Repositories

**Recommendations to Stakeholders:** Investment in Infrastructure and Technologies, Capacity Building and Education, Data Governance, Privacy, and Sovereignty, Promoting Sustainability and Resilience, Infrastructure and Accessibility, Policy and Regulatory Support, Development of Inclusive and Accessible Solutions, Leveraging AI and Advanced Analytics Responsibly, Investment in R&D, Precision Agriculture and Smart Farming Practices, Sustainability and Environmental Monitoring, Start-ups, Market and Value Chain Innovations, Marketing of High-tech in Agri, Living Labs/Pilots, Tailored Solutions/Personalization, Financial Incentives, Promotion/Discounts

**Risks, Drawbacks, and Challenges:** Data Privacy, Security, and Ownership, High Costs and Economic Barriers, Technical Challenges and Interoperability, Ethical, Legal and Societal Concerns, Digital Divide and Inequality, Knowledge, Skills, and Adoption Barriers, Data Quality, Accuracy, and Model Limitations, Environmental and Ecological Risks

# Annex II: Questionnaire "Assessing the Value of Data in Food Systems" (including respondents' average responses)

*Dear Workshop Participant,*

*We invite you to complete this questionnaire on the value of data in food systems (FS).*
*The questionnaire is developed within the framework of the EU project "Pathways towards a fair, inclusive and innovative Data Economy for Sustainable Food Systems" -* ***Data4Food2030****.*

*The project explores multiple aspects of data in European food systems, in which data is not only a new economic asset but also a strategic good in the transition to sustainable food systems and a fair and inclusive society. In the box below, we explain some terms used in the questionnaire.*

***Data:*** *Data is factual information (such as measurements or statistics) collected and processed in digital form and used as a basis for reasoning, calculation and decision making.*

***Data economy****: A data economy is a digital ecosystem in which data is gathered, organised, and exchanged by a network of companies, individuals, and institutions to create economic value. Data economy involves the generation, collection, storage, processing, distribution, analysis, delivery, and exploitation of data enabled by digital technologies.*

***Food system:*** *Food system refers to all assets and activities related to producing, processing, distributing, consuming and regulating food, as well as their effects on economy, society, health, and environment.*

***Food system stakeholders:*** *Food system stakeholders are individuals and organizations who perform different activities and roles in food provision. Four types of stakeholders can be distinguished:*

***Food value chain actors*** *- input suppliers, farmers, processors, retailers, caterers, consumers, waste companies;*

***Food system enabling actors*** *- equipment manufacturers, advisors, researchers, policy makers, food control agencies, funding bodies, media;*

***Data actors*** *- providers of data solutions in food systems (e.g., digital platforms, digital technology and service providers, data sharing platforms, cloud service providers, etc.;*

***Actors from adjacent sectors*** *- health, environment, territorial development*

*The results of this survey will be used for scientific purposes and to formulate informed recommendations for the development of future policies.*

*Participation in this survey is on a voluntary basis and in accordance with the principles of informed consent.*

*All responses will be treated anonymously in accordance with GDPR regulations.*

Please read each of the statements below carefully. For each statement, assess whether you disagree or agree with it. Use the following scale to indicate your level of agreement:

| -3 | -2 | -1 | 0 | +1 | +2 | +3 |
|---|---|---|---|---|---|---|
| Strongly Disagree | Disagree | Slightly Disagree | Neutral | Slightly Agree | Agree | Strongly Agree |

Please circle the number that best represents your opinion for each statement.

| Statement | | Your assessment | | |
|---|---|---|---|---|
| ***Category 1: FS governance*** | | | | |
| 1. | Data-based insights are essential for dealing with **food crises** (i.e. shocks that lead to disruptions and cause food insecurity). | 2,14 | 1,032804 | 48,2% |
| 2. | The use of data gathered in government databases helps to ease **administrative procedures** for practitioners. | 1,81 | 1,253342 | 69,1% |
| 3. | Data serves as a critical input for developing effective government **policies**. | 1,92 | 1,227053 | 63,8% |
| ***Category 2: Decision-making processes*** | | | | |
| 4. | Access to reliable data improves decision-making for **individual stakeholders** within the food chain (e.g., producers, processors, distributors, retailers and other actors). | 2,33 | 0,879418 | 37,8% |
| 5. | Data supports decision-making across all stages of the **food supply chain**, from production to consumption and waste management. | 2,08 | 0,968881 | 46,6% |
| 6. | Decisions in food systems should be based on data, even if it means **disregarding** traditional knowledge and practices. | 0,98 | 1,662295 | 170,2% |
| ***Category 3: Managing performance attributes of the food system (e.g., traceability, safety, transparency)*** | | | | |
| 7. | Data plays role in enhancing **food safety** by enabling better monitoring and risk management. | 2,11 | 1,005766 | 47,7% |
| 8. | Data helps to establish food **traceability** from farm to fork. | 2,05 | 1,05636 | 51,6% |
| 9. | The collection and sharing of detailed data on food production and distribution (**transparency**) should be mandatory even if it compromises trade secrets and undermines competitive advantages. | 0,91 | 1,911537 | 209,1% |
| ***Category 4: FS outcomes*** ***(e.g., food security, health, environment, consumer information, sustainability, wellbeing)*** | | | | |

| | | | | |
|---|---|---|---|---|
| 10. | Data makes **environmental** impact of the food system visible. | 1,74 | 1,262706 | 72,5% |
| 11. | Data helps to create new **relationships** and solidarities between consumers and producers. | 1,41 | 1,366226 | 96,6% |
| 12. | Data on nutritional content, and production methods empowers consumers to make choices which benefit **health**. | 2,25 | 0,963916 | 42,8% |
| ***Category 5: Efficiency, value creation and value capture in FS*** | | | | |
| 13. | Data-driven decision-making significantly enhances operational **efficiency** in food production and distribution. | 1,98 | 1,019374 | 51,4% |
| 14. | Data helps companies to adapt and change their **business models** to better respond to market challenges. | 2,20 | 0,842368 | 38,4% |
| 15. | The use of detailed data analytics is crucial for generating consumer **demand** for innovative food products. | 1,89 | 1,073917 | 56,8% |
| ***Category 6: Optimising, control, and monitoring FS activities and processes*** | | | | |
| 16. | The data analytics integrated in food supply chain activities enhances the precision and reliability of production **monitoring** processes, ensuring better quality control and compliance with safety standards. | 2,17 | 0,914532 | 42,1% |
| 17. | Continuous access to up-to-date data is essential for making timely and informed decisions, ensuring responsiveness to **market** changes and emerging trends. | 2,19 | 0,911432 | 41,7% |
| 18. | Extensive use of data for optimisation and control of activities leads to **over-reliance on data and digital technologies** reducing the role of human expertise. | 1,28 | 1,457738 | 113,8% |
| ***Category 7: Changing FS innovation ecosystem through digitalisation, data, AI, research, advisory, and stakeholder collaboration*** | | | | |
| 19. | Data helps to improve agricultural **advisory services.** | 1,90 | 1,189454 | 62,7% |
| 20. | Data is essential for different actors such as universities, producers, investors, regulatory bodies and other to **collaborate** on food issues. | 1,93 | 1,05131 | 54,5% |
| 21. | Reliance on information on food systems provided by **AI** (artificial intelligence) often leads to wrong decisions. | 0,95 | 1,551526 | 162,8% |
| ***Category 8: Quality assurance and control, standardisation in FS*** | | | | |
| 22. | Data analytics helps **quality** control in food production. | 2,06 | 1,092206 | 53,0% |
| 23. | Using data analytics to demonstrate compliance with quality standards and **certification schemes** helps | 1,79 | 1,21443 | 67,9% |

| | | | | |
|---|---|---|---|---|
| | farmers gain trust from buyers and secure market opportunities. | | | |
| ***Category 9: Key challenges, risks and opportunities towards fair and inclusive European FS data spaces*** | | | | |
| 24. | Data is essential for identifying emerging **threats** to food security. | 2,02 | 0,873628 | 43,2% |
| 25. | The EU Common Agricultural and Food **Policies** are primarily data-driven, rather than driven by political or social considerations. | 0,24 | 1,959214 | 809,0% |
| 26. | The free flow of data in the food system creates a major the risk of data misuse (improper) and/or unauthorised access (e.g. by not eligible parties, unethical). | 1,00 | 1,5724 | 157,2% |
| ***Category 10: Data sharing and free flow of data*** | | | | |
| 27. | Unrestricted data sharing is a key enabler for new business models and the implementation of new technologies. | 1,04 | 1,342241 | 129,2% |
| 28. | Data security measures (e.g., encryption and access controls) should be prioritised over the speed and ease of data flows. | 1,18 | 1,44415 | 122,4% |
| 29. | Data sharing should be incentivised through mechanisms that ensure fair compensation for data providers. | 1,29 | 1,292939 | 100,3% |

**We would like to ask you a few questions about yourself.**

1. Which food system stakeholder group do you belong to? Please tick the box that best describes your role.

| | | |
|---|---|---|
| 1. | **Food value chain actors**: input suppliers, farmers, processors, retailers, caterers, consumers, waste management companies | |
| 2. | **Food system enabling actors**: equipment manufacturers, advisors, researchers, policy makers, food control agencies, funding bodies, media | |
| 3. | **Data actors**: providers of data solutions in food systems (e.g., digital platforms, digital technology and service providers, data sharing platforms, cloud service providers, etc. | |
| 4. | **Actors from adjacent sectors**: health, environment, territorial development | |

2. Specify your influence on decisions and actions taken in the company/organization on a scale from 0% (none) to 100% (decisive):

.....%

3. How many years of professional experience in relation to food systems do you have?

.....years

4. How do you characterise your gender?
   - ☐ Male
   - ☐ Female
   - ☐ Other
   - ☐ Prefer not to say

| **Food value chain actors** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Input suppliers | Farmers | Processors | Retailers | HoReCa | Waste management companies | Equipment manufacturers | Other |
| | | | | | | | |

| **Food system enabling actors** | | | | | | |
|---|---|---|---|---|---|---|
| Advisors | Researchers | Policy makers | Food control agencies | Financing institutions | Media | Other |
| | | | | | | |

| **Data actors providers of data solutions in food systems** | | | |
|---|---|---|---|
| Digital technology developer | Digital platform providers | Digital services providers | **Other** |
| | | | |

| **Actors from adjacent sectors** | | | |
|---|---|---|---|
| Health | Environment | Territorial development | Other |
| | | | |

# Annex III: Assessment results across 29 statements and respondent groups

| Statement | Farmers | Science | IT | Other | Total |
|---|---|---|---|---|---|
| Category **1: Food System Governance** | | | | | |
| Data-based insights are essential for dealing with food crises | 2.07 | 2.20 | 2.27 | 2.06 | 2.14 |
| The use of data gathered in government databases helps ease admin procedures | 1,69 | 1,72 | 2,10 | 1.77 | 1,81 |
| Data serves as a critical input for developping effective government policies | 1,83 | 1,92 | 2,03 | 1.94 | 1,92 |
| **Average for Category 1** | **1,86** | **1,95** | **2,13** | **1,92** | **1,96** |
| **Category 2: Decision-making processes** | | | | | |
| Access to reliable data improves decision-making for individual stakeholders | 2,43 | 2,52 | 2,30 | 2,07 | 2,33 |
| Data sharing and data-based decision-making improves functioning of entire food supply chains | 2,02 | 2,16 | 2,03 | 2,13 | 2,08 |
| Decisions in food systems should be based on data, even if it means disregardding traditional knowledge and experience | 0,88 | 0,48 | 1,33 | 1,16 | 0,98 |
| **Average for Category 2** | **1,78** | **1,72** | **1,89** | **1,79** | **1,80** |
| **Category 3: Managing performance attributes of the food system** | | | | | |
| Data plays role in enhancing food safety by enabling better monitoring and risk management | 2,19 | 1,76 | 2,30 | 2,01 | 2,11 |
| Data helps to establish and/or enhance food traceability from farm to fork | 1,88 | 2,12 | 2,27 | 2,00 | 2,05 |
| The collection and sharing of detailed data on food production and distribution should be mandatory…. | 0,81 | 0,49 | 1,63 | 0,71 | 0,91 |
| **Average for Category 3** | **1,63** | **1,45** | **2,07** | **1,60** | **1,69** |
| **Category 4: Food System Outcomes (środowisko, zdrowie, informacje, dobrostan)** | | | | | |
| The data provides insight into the environmental impacts of the food system | 1,67 | 1,64 | 1,67 | 2,00 | 1,74 |
| Data helps to create new relationships and solidarities between consumers and producers | 1,21 | 1,12 | 1,73 | 1,61 | 1,41 |
| Data on nutritional content, and production methods empowers consumers to make choices which benefit health | 2,14 | 2,16 | 2,30 | 2,42 | 2,25 |
| **Average for Category 4** | **1,67** | **1,64** | **1,90** | **2,01** | **1,80** |

| | | | | | |
|---|---|---|---|---|---|
| **Category 5: Efficiency, value creation and value capture in Food System** | | | | | |
| Data-driven decision-making significantly enhances operational efficiency | 2,21 | 1,84 | 2,10 | 1,68 | 1,98 |
| Data helps companies adapt and change their business models to market challenges | 2,29 | 2,08 | 2,37 | 2,00 | 2,20 |
| The use of detailed data analytics is crucial for generating demand for innovative food products | 2,00 | 1,60 | 2,20 | 1,68 | 1,89 |
| **Average for Category 5** | **2,17** | **1,84** | **2,22** | **1,76** | **2,02** |
| **Category 6: Optimising, control, and monitoring Food System activities and processes** | | | | | |
| Integrating data analytics enhances precision and reliability in production monitoring | 2,07 | 2,36 | 2,13 | 2,19 | 2,17 |
| Continuous access to up-to-date data is essential for timely and informed decisions | 2,01 | 2,20 | 2,33 | 2,16 | 2,19 |
| Extensive use of data for control reduces the role of human expertise | 1,64 | 0,88 | 1,00 | 1,39 | 1,28 |
| **Average for Category 6** | **1,94** | **1,81** | **1,82** | **1,91** | **1,88** |
| **Category 7: Innovation ecosystem – digitalisation, AI, collaboration** | | | | | |
| Data helps to improve agricultural advisory services | 1,93 | 2,00 | 1,70 | 1,97 | 1,90 |
| Data is essential for collaboration among actors (e,g,, universities, producers, regulators, etc,) | 1,95 | 1,72 | 2,23 | 1,77 | 1,93 |
| Reliance on AI in food systems often leads to wrong decisions | 1,50 | 0,48 | 0,97 | 0,58 | 0,95 |
| **Average for Category 7** | **1,79** | **1,40** | **1,63** | **1,44** | **1,59** |
| **Category 8: Quality assurance and control, standardisation in Food System** | | | | | |
| Data analytics helps quality control in food production | 1,95 | 2,08 | 2,17 | 2,10 | 2,06 |
| Using data analytics to demonstrate compliance with standards helps gain market trust | 1,74 | 1,60 | 1,83 | 1,97 | 1,79 |
| **Average for Category 8** | **1,85** | **1,84** | **2,00** | **2,03** | **1,93** |
| **Category 9: Key challenges, risks and opportunities in European Food System Data Spaces** | | | | | |
| Data is essential for identifying emerging threats to food security | 2,07 | 1,92 | 2,07 | 2,00 | 2,02 |
| The EU Common Agricultural and Food Policies are primarily data-driven (not political/social) | 0,79 | -0,36 | 0,27 | -0,03 | 0,24 |

| | | | | | |
|---|---|---|---|---|---|
| The free flow of data in the food system creates a major risk of misuse or unauthorized access | 1,07 | 1,00 | 1,03 | 0,87 | 1,00 |
| **Average for Category 9** | **1,31** | **0,85** | **1,12** | **0,95** | **1,09** |
| **Category 10: Data sharing and free flow of data** | | | | | |
| Unrestricted data sharing is a key enabler for new business models and the implementation of new technology | 1,07 | 0,60 | 1,53 | 0,87 | 1,04 |
| Data security measures (e.g., encryption and access controls) should be prioritized | 0,76 | 1,20 | 1,73 | 1,19 | 1,18 |
| Data sharing should be incentivized through mechanisms that ensure fair compensation for data providers | 1,12 | 0,88 | 1,87 | 1,29 | 1,29 |
| **Average for Category 10** | **0,98** | **0,89** | **1,71** | **1,12** | **1,17** |

# Annex IV: Interview report analysis

| Document ID | Interview number | Stakeholder category | Organisation represented |
|---|---|---|---|
| D1 | 9-1 | Advisor | Latvian Rural and Agricultural Advisory Centre (LRATC); European Forum for agricultural and rural advisory services (EUFRAS) |
| D2 | 5-1 | Consumer | Twinds Foundation |
| D3 | 5-2 | Consumer | Eating City 2030 |
| D4 | 16-5 | Data actors | Wrocław Center for Networking and Supercomputing; Polish Association of Data Processing Centers; Wrocław University of Science and Technology |
| D5 | 16-1 | Data actors | 1001 Lakes; Alto University |
| D6 | 16-2 | Data actors | DIH AGRIFOOD |
| D7 | 16-3 | Data actors | Ynternet, Haute École de Gestion de Genève |
| D8 | 16-4 | Data actors | Institute of Information Science and Technologies; National Research Council (ISTI CNR) |
| D9 | 1-1 | Farmer | COPA COGECA |
| D10 | 11-1 | Food Safety | European Food Safety Authority (EFSA); BIOR: Institute of Food Safety, Animal Health and Environment (Latvia) |
| D11 | 14-1 | Health | European Public Health Alliance |
| D12 | 7-1 | Input | European Agricultural Machinery Industry (CEMA-AGRI) |
| D13 | 8-1 | Policy | DG AGRI |
| D14 | 8-2 | Policy | Department of Agricultural Markets and Energy Transformation of Rural Areas; Ministry of Agriculture and Rural Development |
| D15 | 2-1 | Processor | Unilever |
| D16 | 10-1 | Researcher | James Hutton Institute |
| D17 | 10-2 | Researcher | Université Catholique de Louvain |
| D18 | 10-3 | Researcher | Pisa University |
| D19 | 10-4 | Researcher | EIT Food |
| D20 | 10-5 | Researcher | Bangor University |
| D21 | 3-1 | Retailer | Latvian Association of Food Retailers (LAFR) |
| D22 | 3-2 | Retailer | EuroCommerce; European Retailers and Wholesalers Association |

**Benefits for consumers**

| Document ID / Stakeholder group | Quotes / Qualities and processes |
|---|---|
| D2 / Consumer | *"The benefits are just so obvious. There is a lot of groups that have an interest to be more transparent. Organizations nowadays sense that there is **a selling argument to being more transparent and sharing more of what they do**. I think there are a lot of business models where **consumers are actually willing to even pay a premium for having that bit more of transparency and honesty and trustworthiness. (transparency)** There is a market for this. Not a 100% market, because there are also consumers who really don't care. You will not convince everyone, which is fine. But we need data for this. It does not work without data."*<br><br>*"Data and transparency can help to **show where products are coming from (transparency).** We need to become aware and educated consumers. I think data can **help us to better understand and differentiate between 'good' and 'bad' products**. There is a very **direct connection from data to sustainability (sustainability).**"* |
| D3 / Consumer | *"The respondent made reference to a book where he wrote an article on food data, so for example he referred to the possibility of using QR code to share traceability and data on distance. In this he link the data economy to digital services, where digital technologies can help link data to users. In this sense **data is information for consumer (transparency)**, it doesn't force the consumer to make better choices, but it **gives the information to consumers or buyers to make choices if they wish to do so**."*<br><br>*"The idea is that this **extra data will help consumers make a more informed decision (transparency)**. The idea is that more knowledge promotes awareness and empowerment. So the data is there but is not as easily available for the consumer to make informed decisions."*<br><br>*"Even **profiling for business (knowing what a customer prefers, and catering to that) (enhancement)**, is something that can prove to be more efficient in the air travel catering industry"* |
| D8 / Data actor | *"On the consumer side digital tools and **data are aimed to improve information flow towards consumers**, to **rise consumer awareness about products** and **improve traceability (transparency)**. There is much space yet to improve data use on the consumer side. F.i. – to prove traceability of products by barcodes on packaging."* |
| D18 / Researcher | *"Consumers can benefit, because they **can compare offers** and **quality**. **(transparency)**."* |

**Benefits for policy / food safety / health actors**

| Document ID / Stakeholder group | Quotes / Qualities and processes |
|---|---|
| D13 / Policy | *"The respondent defined first his role, and the role of DG AGRI, as a data collector because they receive data from member states and try to use it for **evidence policy making (governance)**. They try to understand the situation in the sector, understand the main problems, and then propose the best policy mix to address all challenges."* |

| | |
|---|---|
| | *"Another possible benefit is, that many **tasks regarding production monitoring can be done without bothering farmers (enhancement, innovation)**. For example, pictures taken by satellites allowing monitoring the crop production."* |
| D10 / Food safety | *"We receive public funding, be it national or European, and we are performing a public function. We have some data generated that we use and exploit for different purposes [dažādos virzienos] – for instance, for the **development of the national nutritional policy or assessment of food-related risks (governance),** we cannot work without such data."*<br><br>*"For the sake of public health, in a situation of, for example, Salmonella outbreak in Europe, we need to protect consumers. How can we protect them? We have data on producers and their distributed products. Then we have data, for instance, that one type of sequence appears in three or five countries. We can put these data together in one cluster, we can **extract information about a concrete product or a group of products, we can identify the country and the enterprise (governance, interoperability).** In the trace-back system we get till the concrete producer. We, or rather the monitoring institution, kindly demand the enterprise to stop production or to recall the product from the market."* |
| D11 / Health | *"Data driven opportunities: **reduce environmental impact of food waste; shift dietary patterns (sustainability)** to more plant based diets."*<br><br>*"Economic aspects of DE4FS: **each euro spent in prevention saves 20 euros spent in treatment (enhancement)**."* |

**Benefits for processors/distributors**

| Document ID / Stakeholder group | Quotes / Qualities and processes |
|---|---|
| D9 / Farmer | *"Data are crucial in food processing facilities and slaughterhouses, where **constant monitoring (governance)** at certain places will be mandatory."* |
| D15 / Processor | *"Data is definitely at the core of what they are doing. The respondent mentions many different ways in which data is used at Unilever. This ranges from **predicting consumer trends, to cost optimalization, to attractive and functional packaging (enhancement, governance), and to guiding their production processes, for example to be energy efficient (sustainability)**. Unilever relies on using data and they measure a lot in order to find optimal ways of working."*<br><br>*"They involve the use of data, for example, in **achieving zero waste and using energy more sustainably (sustainability)**."* |
| D8 / Data actor | *"In the middle segments of food chain (logistics, transportation, retail) data is used to **optimise operational processes (enhancement)**. Logistics take the advantage of manipulating data."* |

**Benefits for data / input / advisor actors**

| ID / Stakeholder group | Quotes / Qualities and processes |
|---|---|
| D4 / (Data actor) | *"Another example of their activity is using a sensory system – for inquisition,* ***collecting data and training AI, e.g. AI learning to detect plant or animal diseases (enhancement, innovation)****."* |
| D1 (Advisors) | *"****Speed in the access to information (enhancement)****. Albeit it depends a lot on advisors' individual capacities, whether they are able to perceive, understand, transform data and use this advantage of access and speed."* |
| D12 (Input) | *"The big opportunity is an* ***aggregated value of all data streams (interoperability)****. If the data from different machines and devices are combined – about crops, fertilisation, energy use, etc. this presents a value.* ***If you combine these data properly you may generate great value (enhancement****)."* |

**Benefits for producers**

| Document ID / Stakeholder group | Quotes / Qualities and processes |
|---|---|
| D16 / Researcher | *"And if the data economy can be a wide enough definition of using platform, so* ***embracing certain platforms to reach new customers, create new collaborations with other farmers (innovation)****, so there is this farming system in Wales and Scotland called crofting. So, this allows some diversification."*<br><br>*"There are many ways to harness the benefits of digital, so not focusing on precision farming but to use it to* ***support gaps in the industry so rural farmers, small scale farmers can find new channels to grow their business and reach their customers (inclusivity, innovation).*** *Networking has potential and it is not always linked to smart or precision farming practices."* |
| D3 / Consumer | *"Economic aspects can* ***help producers determine which products they should develop (governance).*** *The economic aspects are best apparent with regards to the market."* |
| D4 / Data actor | *"The respondent, who is involved in research activities related to the agricultural sector, stated that a* ***benefit of the data economy in FS is an implementation of precision agriculture, e.g. possibility of measuring soil parameters and their variability and evaluating how soil parameters influenced the final result, i.e. the yield (enhancement).*** *Data economy uses BigData like digital field map. Another example is GPS trackers, which give precise information about a tractor's location and work performance using satellite guidance systems. Therefore, it allows for increasing the precision of sowing and application of fertilisers and plant protection products and reducing the number of trips.* ***Farmers use fewer resources, less fertilisers, and other chemical products (sustainability)****."* |
| D8 / Data actor | *"On the primary production side, taking the farmers in first place, digitalisation and data use are mainly aimed at* ***improving efficiency of production (enhancement)****. The use of various data and metrics can* ***optimise*** |

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| | ***production processes**, f.i. **reduce the resource use** (fertilisers, fuel, pesticides), **minimise negative impact on the environment (enhancement, sustainability).**"* |
| D9 / Farmer | *"Transparency and proper control are beneficial in food production because all food entities are exposed to multiple hazards (e.g., biological or chemical), resulting in a high likelihood of contamination. That is why instantaneous information about operations at all food production stages **reduces companies' and consumers' risks (governance).**"*<br><br>*"Another positive aspect of the data economy in FS was its incredible **potential to reduce wastage and improve the efficiency of operations in the multi-stakeholder chain (enhancement).**"*<br><br>*"Another opportunity underlined by a respondent was possibly **combining data with other relevant data (innovation)**, it would be essential to know how farmers use the machinery around the year – the data is helpful for John DEER and a farmer as part of farm management. **The same data can be used differently by farmers and suppliers or combined with other relevant data bringing new quality and new information (interoperability)**."* |
| D13 / Policy | *"On the other hand, the respondent appreciated the **opportunities to make good decisions (governance)**, e.g., when to plant, slaughter a cow, and similar things. He sees the potential which can be easily grabbed."* |
| D12 / Input | *"Farmers will have to work on decreased conditions (eventually less subsidies, less use of pesticides, higher production costs), therefore the value of precise data will increase**. Precision farming will be key to ensure yields, support decision making, to choose right crops (governance).***<br>*Access to data and use of data will be increasingly important for farms strategic management."* |
| D14 / Policy | *"The respondent stated that the data economy is an opportunity for those farmers who operate in specific environmental conditions. Farmers using data about production conditions (clean air, clean water, soil quality etc.) can **establish higher standards for their production** - which potentially will **allow them to get higher prices for their products and create additional value for consumers (enhancement)**.*<br><br>*The data economy affects every part of the food chain. It will result in **better use of resources and optimise production processes (enhancement)**. Farmers may use digital tools for **more successful product promotion (enhancement).** I also expect optimization of the flow of components and raw materials in the supply chain, reduction of losses and food waste (environmental and economic benefits)."* |
| D1 / Advisor | *"Data can help **to improve farms' environmental performance, like farm runoff, wind analysis to decide on the timing for field fertilization, or to solve other problems (governance)**. If data is turned into knowledge, organic farms can learn about the **application of environmentally friendly methods (sustainability).** In general, farmers aim to be environmentally friendly [and they use data for this purpose]."* |

**Benefits for retailers**

| Document ID / Stakeholder group | Quotes / Qualities and processes |
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| D21 / Retailer | *"The biggest retailers use everything available. Data bring up many opportunities. Data flow* ***ensures that very fast reactions are possible at every chain element (governance)****, starting from procurement to the situation in shelves. Data flow is used to make all the orders, to* ***forecast procurement****, to* ***get information about customers****...* ***It reduces costs (enhancement)****. Initial investments are needed, but they pay off very quickly. Data solutions substitute human work force which can be employed elsewhere."*<br><br>*Another opportunity is linked to* ***control and risk management of financial flows, traceability of goods, logistics, supplies (governance)*** *etc. IT solutions allow to perform this at a very advanced level, they* ***speed up the process (enhancement)*** *and allow to* ***forecast risks****,* ***follow changes in all the chain from field to customer's basket (governance),*** *and plan and adapt accordingly. They allow also* ***adjustments of workforce (governance)****, which means also to control the costs of workforce, etc."* |
| D22 / Retailer | *"Transition to a more sustainable food system as such. For a business operator, such as retailers, it* ***helps for climate strategy (sustainability)****, decarbonisation of supply chain (for this, data also from suppliers are needed), and also to* ***provide better services for costumers (enhancement).****"*<br><br>*"****Improved visibility across the end-to-end supply chain (transparency)****: By having access to accurate and trustworthy data from every tier along the food supply chain (no matter how complex), we can gain* ***improved visibility and traceability into the quality and safety of food products (governance, transparency)****. This is an enabler for better inventory management, food waste management and thus improved customer loyalty.*<br><br>*"****Tailored marketing campaigns and customer engagement (enhancement):*** *Analysing data on customer preferences, purchasing behaviour, and other relevant factors gives the opportunity to segment the customer base and personalise marketing and customer engagement efforts. With these insights we get to tailor promotions, product offerings, and loyalty programs custom to the needs and preferences of their customers"* |
| D8 / Data actor | *"In the middle segments of food chain (logistics, transportation, retail)* ***data is used to optimise operational processes (enhancement, governance)****. Logistics take the advantage of manipulating data."* |
| D12 / Input | "*The big opportunity is an* ***aggregated value of all data streams (innovation).*** *If the data from different machines and devices are combined – about crops, fertilisation, energy use, etc. this presents a value. If you combine these data properly you may generate great value.*" |

**Benefits for researchers**

| Document ID / Stakeholder group | Quotes / Qualities and processes |
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| D18 / Researcher | *"****Research can be much more accurate and timely.*** *The* ***value of research can be much higher (enhancement)****."*<br><br>*"In terms of education, you can* ***teach about a much broader perspective****. It allows students to* ***teach from direct data from the field (enhancement).****"*<br><br>*"****More fluid social relations (enhancement)*** *in the research and education field."* |

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| D20 / Researcher | *"**Combining and integrating research data with other users can generate additional value and knowledge (enhancement, innovation)**. In the food sector, it can increase traceability, improve control etc."* |
| D10 / Food Safety | *"Nowadays **laboratories are permanently working online (enhancement, interoperability)**, they collaborate, test, share data etc. By definition, we must collaborate, share sequences. "* |

**Conditions for multiple stakeholder benefit**

| Themes | Document ID / Stakeholder group / Quotes |
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| Industry self-regulation | D16 (data actor):<br>***"Use cases can demonstrate, sharing data and using data in new ways, businesses' motivation and reason and willingness to provide and use data** – to understand this from the business model point of view is really important. There is no one solution**. The complexity of different settings needs to be taken into account and figured out between the parties**."*<br><br>D2 (consumer):<br>*"**We're trying to influence not only the vocabulary, but also the protocols and the standards**, which I think should be added here. We are not only providing vocabulary, but we **are also translating from data to food and from food to data and from company to consumer**, etc. That should be the core role in any data economy going forward: you need a spider in the web."*<br><br>D12 (input):<br>*"My organisation protects the companies. Our member companies are data holders. We work to protect the interests of our companies. **We play an intermediary role but not on data, rather on the rights of different parties and the data sets for exchange. We have contributed to the code of conduct on data sharing** (adopted among the industry partners)."*<br><br>D1 (advisor):<br>*"As data providers – **advisors are often intermediaries who transform data in language appropriate for other systems**. App providers – many advisory organisations develop their own advisory programmes for farmers and entrepreneurs. Also LRATC, its programming team has developed several applications. Brokering – there are advisory organisations who collect and analyse data to generate knowledge that is then transferred to other users.*<br><br>*"There are **ready-made solutions for advisors to support them in their work**. **We have experimented with ready software developed in other countries**, but it always demand huge adaptation to local situations."*<br><br>D5 (data actor):<br>*"They are one of the middlemen, intermediary or service provider that **makes sure that the exchange between data providers and consumers is happening in a way that it was intended.**"*<br><br>D6 (data actor):<br>*"The first challenge is that **all applications must be helpful for users; if they can see benefits from using them, they will gather and share data.** The second challenge is cooperation of people in the chain."* |

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| | D9 (farmer):<br>*"Data is generated, but often there is no interpretation—the tools for transferring data (telephone and a charger are only sometimes matching). We have to standardise the data.* ***The respondent believes a market will harmonise that because it is so needed.****"* |
| Open data and common data sharing platforms | D5 (data actor):<br>*"The ideal way, from which we are far, would be that we* ***combine data in one place and data owners provide their conditions what can be done with their data****, and then multiple service providers and users can use those data according to the policies provided."*<br><br>D13 (policy):<br>*"A recommendation is to* ***use data from AJAX and make it available for the greater number of stakeholders****, including researchers."*<br><br>D22 (retailer):<br>***"****In relation to sustainable food systems and labelling, one needs access to data.* ***Such kind of databases as Agri....[??] are helpful for retailers to look up for products and know their average impacts on the environment****. It is really useful to inform consumers. But this database is specific for France. Such kind of databases would really help and could be duplicate."*<br><br>*D10 (food safety): "****Public and private data sharing: regulation needs to be improved, especially for cases when public interests*** *(f.i. public health) are at stake. Linked to data ownership – who can own what data.* ***Public data sharing platforms.*** *Agreements on the harmonisation of data-processes (methodologies of data collection, analysis...)."*<br><br>D11 (health):<br>*"From the data point of view –* ***make good use of data and have more open data."***<br><br>D7 (data actor):<br>*"Ownership comes from the collaborative and cooperative path. It is not about closing data, but* ***keeping it open, so data should be used for science, for research and monetisation, but this should come from a collaborative stand-point."*** |
| Interoperability / data format standards | D5 (data actor):<br>*"Comment on interoperability: semantic interoperability whether the meaning of data is the same or similar enough to make mapping between data sources [...]* ***Perhaps AI can help with the semantic interoperability in cases when there is no completely harmonious descriptions and data models****."*<br><br>D6 (data actor):<br>"*For the respondent, the main issue i****s interoperability and common standards*** *[...]* ***Requirements for mandatory standards and interoperability obligations can reduce interoperability problems,*** *such as adapters or converters.* |

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| | *Example: many different standards of vocabulary created**. There is a problem with connecting them with other vocabularies** – they are many; we **need some harmonization** in the future."*<br><br>D13 (policy):<br>*"Many systems are available on the market, but **there are no common standards** (apart from big machinery companies, there are only a few) [...] . Technology is available, but **more skills and interoperability are needed."***<br><br>D17 (research):<br>*"**The format of data used in food systems should be understandable and useful for all actors** of the food value chain (in the inclusive matter). For example**, using words and practices instead of digital sequence.**"*<br><br>D18 (research):<br>*"**The creation of common data standards for data formats is something like a regulatory utopia.** But it would be **good for meta-rules for data formats**. There is a lot of faith in AI that it helps to find the value of data through connecting currently not interoperable data."*<br><br>*D19 (research):*<br>*"Availability of a **common data model that can enable. Data. Uh collections data interoperability between different stakeholders**, but the fact that I say stakeholders also means **between different applications** that are used by those stakeholders."*<br><br>D5 (data actor):<br>*"Emerging technological challenges in link to **the transition towards distributed data models**. The change that is foreseen is moving towards decentralised ways of managing data. The main idea is that **the exchange of data between different sources and providers of data and data users happen peer-wise, in a distributed manner, instead of having centralised data interactions platforms**."*<br><br>D14 (policy):<br>*"The respondent as most urgent issues listed: discussion about the potential of **blockchain to provide the consumer with complete information to make an informed decision of perfect information**."*<br><br>D8 (data actor):<br>*"**Technical solutions, interoperability, are important to break data silos, to create conditions for data aggregation and synthetic use**. It is important to generate connections between various thematic groups data."* |
| Education and training | D7 (data actor):<br>*"Qualite haut geneve" (a school teaching high end restaurant and hotel staff) is who they are working with on an Erasmus project to work on issues of inclusion. During which, they noted that **data protection and data ethics are a big part of the industry, yet these themes are not including in education and training."***<br><br>D8 (data actor):<br>***"Data related skills are needed for everyone in the food system**, from farmers to consumers. Many actors miss* |

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| | *these skills, are not aware how to use data, how to make benefit of it. It is not easy to understand the value of data, how can one benefit.* ***The skills to access data are also missing for many actors.*** *Application of data-based solutions also requires skills"*<br><br>D13 (policy):<br>*"****The second challenge - is skills****. Decision making processes should evidence-based. This requires extracting and selecting data from the vast amount that the machines can produce.* ***People have to possess at least basic skills to process and use available data****."*<br><br>D1 (advisor):<br>*"So, data availability is one side, and the other side is how you analyse data and what can you get out of them.* ***Some advisors have these skills, while other still need to acquire them****. Until you do not know to turn data into conclusions and decisions, data remain data.*<br><br>*[...] In many countries, including Latvia, there is* ***no specific education in advisory.*** *One obtains education in some field and afterwards an advisory organisation trains him/her to become an advisor."*<br><br>D12 (input):<br>*"Recommendations:* ***Training on data use is needed for farmers and companies****.*<br>*There is a* ***shortage of experts and professionals*** *in data economy."*<br><br>D18 (research):<br>*"He has a feeling that there is a huge quantity of data available, but* ***he does not have the skills****, tools, or resources (tools to aggregate data in a fast and easy way) to use them."*<br><br>D22 (retailer):<br>*"Also* ***skills are needed to digitalise and use data****. And how you communicate with consumers."*<br><br>D1 (advisor):<br>*"Data security – it concerns data that advisors are both receiving and providing. Finnish advisors are very active in this regard, and, for instance,* ***when the war in Ukraine started they got worried about the food data security. Their advisory organisations trained advisors on how to train farmers on safe use of on-farm devices****, like, milking robots, for instance. If a dairy farm's data base gets damaged, the farm stops."* |
| Regulation improvements – balanced gains for different stakeholders | D1 (advisor):<br>*"Data interoperability – negotiations and mutual agreements between the involved parties about data sharing and correct use of data.* ***"A voice from the above", be it the EU or the national government is often the most effective way – if there is a directive that data must be shared, they'll be shared.*** *Otherwise, it depends on organisations, if they see some benefit in data sharing."*<br><br>D3 (consumer):<br>*"The first most important issue is the matter of (1) governance, (2)ethics, (3) there needs to be a* ***serious European agency leading the discussion (with no conflict interest).*** *Companies that benefit from using data should not be* |

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| | *the one leading these discussions.""*<br><br>D18 (researcher)<br>*"The risk is that those who have the biggest capacities to collect data will be the most powerful.* ***There should be regulations and public actors that balance this asymmetry.*** *It needs to be proactive. Actors need a different form of collaboration to share the resources and participate in the data economy at the right level."*<br><br>D13 (policy):<br>"*The respondent believes digitalization should be for everybody, not only the big ones.* ***The EU policy should ensure no division between small and big actors who have the data.*** *The respondent stated that there are different needs in the community, and the EU government only has to complement what the market didn't do - introduce an intervention."*<br>***"In the new regulation, farmers do not own the data they generate, but the machinery company owns it****. Farmers can ask for all data generated with their activity and pass it to someone else (another service provider) under some constraints."*<br><br>D9 (farmer):<br>*"****New data protection regulation is elaborated because current law is insufficient*** *- they are some issues. He said, "It won't be surprising for me if we need to look at legal aspects concerning personal data again". He is not convinced that the law is good enough.* ***Data-related processes must be safe and well-controlled.*****"**<br><br>D12 (input):<br>*"The main concern is linked to the* ***Data Act. The balance is distorted. Companies which collect data, have full access rights to data,*** *regardless IPR.* ***Data sharing across value chain should be negotiated and much better established in terms of norms, rules, procedures, responsibilities."***<br><br>D17 (researcher):<br>***"Redirect Intellectual property law into a more inclusive, pro societal****, approach."*<br><br>D8 (policy):<br>*"Social and legal aspects are* important for data economy. **Positive value, gains are important to parties to encourage them to share data***. […]* ***Data and monitoring should not lead to punishment. We must develop legal system and legal culture which incentivise actor participation in the data economy****."*<br><br>D5 (data actor):<br>*"EU have many new regulations comping in. EU data act come from the recognition that something needs to be done, that there are power imbalances of data. It will have an impact on agriculture.* ***Farming machinery manufacturer and provider might have a dictate what happens with data, and regulation can make it possible for users of machinery, not manufacturers, to have control over data****."* |

# Annex V: Appendix to stakeholder workshop section. List of strategic actions

| Code | Name of the strategic action | Share [%] | Code | Name of the strategic action | Share [%] |
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| **A. Data** | | | | | |
| **A1** | Data-sharing | 4,61 | **A7** | Deploying advanced digital technologies for data analytics | 1,22 |
| **A2** | Integrate structured and unstructured data | 0,70 | **A8** | Use of digital services | 1,48 |
| **A3** | Implementation of integrated data management systems | 1,74 | **A9** | Use of QR codes, RFID tags, chips (to collect and/or access data) | 1,57 |
| **A4** | Using IoT and sensor networks to collect real-time data | 1,57 | **A10** | Database integration | 1,30 |
| **A5** | Implement automation of data collection throughout the supply chain | 0,52 | **A11** | Using blockchain technology to collect and exchange data securely and transparently | 3,13 |
| **A6** | Deploy personalised predictive models | 0,35 | **A12** | Blockchain use to provide supply chain transparency | 0,09 |
| **B. Digital technologies (general)** | | | | | |
| **B1** | Use AI-powered platforms | 1,30 | **B10** | Participation in group initiatives (e.g. Living-labs) to learn and develop digital solutions and standards | 0,52 |
| **B2** | Implementing digital technologies such as artificial intelligence, IoT, and blockchain | 2,09 | **B11** | Integration of multiple digital technologies | 0,26 |
| **B3** | Using AI for decision-making and modelling | 1,57 | **B12** | Using digital technologies to shorten the food supply chain to the "last mile" | 0,17 |
| **B4** | Leveraging AI: NPL and Machine Learning (ML) for Analytics and Automation | 0,78 | **B13** | Application of predictive models for environmental monitoring | 0,35 |
| **B5** | Use of digital platforms | 1,83 | **B14** | Implementing remote sensing technologies | 0,96 |
| **B6** | Applying digital twin technologies to simulate and optimise | 0,87 | **B15** | Implementation of advanced food tracking technologies in the supply chain (barcodes, RFID tags, blockchain technology) | 3,48 |
| **B7** | Cloud-based applications and digital systems for data analysis and decision-making | 1,04 | **B16** | Use simulation models to optimise production processes | 0,87 |
| **B8** | Create your own data centres | 0,26 | **B17** | Use apps to engage consumers (e.g., retail apps) | 0,78 |
| **B9** | Developing new food recipes using artificial intelligence | 0,26 | **B18** | Use of sensors, IoT infrastructure, GPS, other digital tools | 1,13 |
| **C. Digital technologies for agricultural sector** | | | | | |

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| **C1** | The use of digital technologies to enable the implementation of smart farming practices and systems | 1,83 | **C7** | Moving from siloed data islands to integrated solutions | 4 |
| **C2** | Application of weed detection and pesticide selection systems using AI | 0,61 | **C8** | Using neural networks to optimise animal husbandry and nutrition | 0,35 |
| **C3** | Application of autonomous agricultural machinery | 2,00 | **C9** | Using artificial intelligence and robotics to support farm management | 0,35 |
| **C4** | Adoption of machine learning models for disease detection (crops, animals) | 0,61 | **C10** | Implementation of VRT technology – adjustment of input rates (fertilisers, seeds, pesticides) to the conditions at each point in the field in precision farming | 1,65 |
| **C5** | Leveraging IoT sensors and infrastructure, GPS, and other digital tools | 0,96 | **C11** | Leverage *edge computing* | 1,04 |
| **C6** | Implement farm management systems for data integration and decision support | 2,52 | | | |
| **D. Collaboration/Integration** | | | | | |
| **D1** | Share data and resources | 1,48 | **D6** | Supply chain participants use data to optimise supply chain | 1,04 |
| **D2** | Building collaborative digital data platforms | 1,13 | **D7** | Collaborate with a wide range of stakeholders in the use of digital technologies | 1,57 |
| **D3** | Co-creating digital solutions in partnership with technology providers | 1,22 | **D8** | Public-Private Partnerships for the Development of Digital Technologies | 0,61 |
| **D4** | Cooperation with the public and private sectors | 1,65 | **D9** | Participation in collaborative learning forums (e.g. living labs) | 0,17 |
| **D5** | Cooperation with technology companies and research institutions | 1,22 | **D10** | Strategic alliances driving standardization | 0,43 |
| **E. Policy** | | | | | |
| **E1** | Expanding 5G and LPWAN connectivity in rural areas | 0,70 | **E15** | Setting standards for data interoperability | 0,35 |
| **E2** | Creating standards for privacy and data governance | 0,17 | **E16** | Encourage public-private partnerships for innovation and digital deployment | 0,70 |
| **E3** | Government policies supporting the adoption of digital technologies (e.g. mobile applications, digital finance) | 2,43 | **E17** | Supporting the development of AgTech startups | 0,52 |
| **E4** | Government investment in digital infrastructure and integration | 1,83 | **E18** | Increasing the availability of high-speed Internet in rural areas | 1,13 |
| **E5** | Harmonisation of data on food ingredients in the European Union | 0,43 | **E19** | Investing in digital skills | 0,78 |
| **E6** | Supporting financing mechanisms for the deployment of digital technologies | 0,78 | **E20** | Investing in R&D to develop new data-driven innovations | 0,17 |
| **E7** | Applying a 'quadruple helix' approach involving civil society, industry, academia and government. | 0,26 | **E21** | Promoting data-sharing and collaboration | 0,78 |

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| **E8** | Putting in place approaches to ensure transparent and ethical data management practices, data protection and | 0,00 | **E22** | Promoting digital ecosystems (digital villages, collaborative data platforms) | 0,00 |
| **E9** | Providing incentives to promote digital farming goals | 0,78 | **E23** | Promoting digital skills training programmes | 0,96 |
| **E10** | Creation of digital application quality control bodies | 0,17 | **E24** | Supporting the development of open-source agricultural databases | 0,61 |
| **E11** | Establish intermediate standards for data integration using Natural Language Processing (NLP) | 0,00 | **E25** | Establishing rules for ensuring data quality and security | 2,26 |
| **E12** | Developing a centralised, reliable platform for the European Union to aggregate primary data | 0,00 | **E26** | Enforcing ethical AI solutions | 1,30 |
| **E13** | Developing a legal framework to ensure fair access to data | 1,13 | **E27** | Creating and participating in European networks | 0,43 |
| **E14** | Develop robust data security and privacy policies | 1,48 | | | |
| **F. Science** | | | | | |
| **F1** | Active use of ML in scientific research | 1,13 | **F5** | Development of a methodology for virtual supply chains (with the "twins" approach) | 0,70 |
| **F2** | Collaborate on open data systems | 1,65 | **F6** | Using machine learning to predict yields | 0,35 |
| **F3** | Conducting research on the unintended effects of digitalisation | 1,22 | **F7** | Improve data availability | 1,48 |
| **F4** | Exploring the economic, social and environmental dimensions of AI deployment, not just technical performance | 1,65 | | | |
| **G. Developers of Digital Technologies** | | | | | |
| **G1** | Adaptation of models to specific needs and conditions (natural, climatic, economic, etc.) | 1,13 | **G8** | Data standardization for data consistency and interoperability | 2,26 |
| **G2** | Tailor-made solutions for farms of all sizes | 1,13 | **G9** | Create trustworthy data sharing models to drive adoption | 0,61 |
| **G3** | Development of interoperable, scalable tools for agri-tech companies | 0,35 | **G10** | The development of virtual supply chains (twin approach) | 0,26 |
| **G4** | Applying the 'quadruple helix' approach to creating innovative digital technologies | 0,00 | **G11** | Improving data availability (data collection methods) | 1,74 |
| **G5** | Development of mobile applications for real-time monitoring | 0,96 | **G12** | Investing in interoperable and scalable digital platforms | 0,17 |
| **G6** | Open source development | 1,22 | **G13** | Establishment of local service centres to maintain the technology | 1,30 |
| **G7** | Acting as knowledge brokers between data producers (technology) and users (farmers) | 0,43 | | | |