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

D4.2: Future scenarios and pathways for the DE4FS

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Glossary of terms and abbreviations used

List of Abbreviations and Acronyms	
CAP	Common Agricultural Policy
DA	Data Act
DGA	Data Governance Act
DE4FS	Data Economy for Food Systems
F2F	Farm to Fork
GDPR	General Data Protection Regulation
IoT	Internet of Things
KPI	Key Performance Indicator
SME	Small and medium-sized enterprise
ToC	Theory of Change

Executive summary

To make food systems sustainable and foster a fair, inclusive, and innovative data economy, it is essential to gain insights into the challenges and trade-offs of the data economy for food systems (DE4FS) faced by the various stakeholders involved. In this document, we will answer the main research question of Data4Food2030 T4.2 'Social, ethical and legal backcasting experiment: co-developing future scenarios and pathways to realise them':

What are plausible future scenarios and desirable pathways that support a fair, inclusive, and innovative data economy for sustainable food systems?

To answer this research question, two sets of participatory stakeholder workshops have been organised in six European countries.

- The first set of workshops was held to develop scenarios for a fair, inclusive and innovative data economy for sustainable food systems.
- The second set of workshops was held to develop pathways based on backcasting and Theory of Change (ToC), that support regulators and policymakers to realise desired aspects and impacts of previously developed scenarios.

From trends to scenarios

In first set of workshops, stakeholders prioritized key trends from a provided analysis and used them to craft scenario narratives about the future of DE4FS. These narratives explored technological, legal, economic, environmental, and social dimensions. From 16 national scenarios, four overarching EU-level scenarios were synthesized:

1. Personalised healthy diets
2. Local and transparent value chains
3. Strictly regulated high-tech and innovation
4. Environmental benefits through data-driven decisions.

These scenarios depict explorative futures, which are not mutually exclusive and highlight different perspectives on the future of the DE4FS.

Backcasting to shape pathways

In the second round of workshops, stakeholders reflected on the EU scenarios and identified desirable and undesirable impacts. Using Theory of Change (ToC) templates, they mapped out inputs, activities, outputs, and outcomes needed to achieve the desirable impacts by 2030 and 2050. This process resulted in 17 ToC backcastings, which were consolidated into three

refined scenarios. Table 1 shows pathways that are identified to realise the desirable aspects of these three scenarios.

Table 1: Overview of desirable scenarios and related pathways

Scenario		Pathway
A	Personalised healthy diets	Guaranteeing dietary freedom for consumers
		Building a thriving and healthy society
		Securing sustainable livelihoods for farmers
B	Local and transparent value chains	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
C	Strictly regulated high-tech for reduced environmental impact	Upholding full compliance in the agri-food sector by eradicating harmful products and practices
		Securing sustainable livelihoods for farmers

These pathways have been screened against existing legal frameworks, considering potential risks and legal challenges.

Recommendations for policymakers

Based on stakeholder input, three key recommendations emerged:

- **Ensure access to high-quality data for farmers** to reduce market risks and improve production planning.
- **Support innovative business models across the value chain** to enable sustainable livelihoods, interoperable data systems, and healthy food innovation.
- **Strengthen digital and food literacy** to empower all actors in the food system and improve data-driven decision-making.

Concluding remarks

The results of this research give insights into stakeholders' perceptions of the DE4FS, as well as their priorities to ensure a fair, inclusive and innovative data economy for sustainable food systems. Apart from concrete recommendations for policy, this research provides insights for further defining the concept of DE4FS and highlights stakeholders' understanding of fair, inclusive and innovative aspects and impacts of the data economy. Stakeholders envision a data economy that is transparent and strictly regulated, facilitating innovative business models and securing equal access to the benefits of high-quality data through user-friendly interoperable systems. This way, the data economy can contribute to pathways to sustainable food systems such as dietary freedom, healthy societies, farmer livelihoods, strong local economies, and eradicating environmentally harmful food production methods.

Table of Contents

List of figures

List of tables

1 Introduction

To make food systems sustainable and foster a fair, inclusive, and innovative data economy, it is essential to gain insights into the known and unknown challenges and trade-offs of the data economy for food systems (DE4FS) faced by the various stakeholders involved. Special attention should be given to the 'soft' impacts: the ways in which the DE4FS influences and is influenced by ethical and legal, social aspects (e.g. power relationships, roles and responsibilities of people, and moral norms and values related to that). A key challenge for the DE4FS is how to realize that it develops in a fair, inclusive and innovative way. Envisioning trends, discussing how these trends may affect the data economy of food systems and engaging with stakeholders to envision desirable futures can contribute to realizing a fair, inclusive and innovative data economy for sustainable food systems.

This document outlines the results of Task 4.2 'Social, ethical and legal backcasting experiment: co-developing future scenarios and pathways to realise them.' This task is part of Work Package 4 'Towards an inclusive data economy: Stakeholder dialogues and future scenarios' which aligns with the aim of Data4Food2030 to contribute to the development of a fair, inclusive, and innovative DE4FS. The task builds on the stakeholder perceptions developed in T4.1 and the trend analysis of T5.1. Moreover it feeds into T5.2 for data value propositions, T5.3 for impact assessments of the scenarios and T5.4 for policy recommendations.

In this document we will answer the main research question:
What are plausible future scenarios and desirable pathways that support a fair, inclusive, and innovative data economy for sustainable food systems?

This will be supported by two sub-research questions:

- *What are plausible scenarios of the DE4FS in 2050?*
- *What pathways can support regulators and policymakers in the realisation of desired aspects and impacts of scenarios while avoiding the undesired ones?*

To answer these research questions, two sets of participatory stakeholder workshops have been organised in six EU countries. The set of first workshops was held to answer the first sub research question based on scenario development. The second set of workshops was held to answer the second sub research question based on backcasting and Theory of Change (ToC).

This report will continue as follows: Chapter 2 describes the conceptual framework of the research, including explanations of the DE4FS, scenario development and backcasting. Chapter 3 narrates the methodology of the task. This includes the overall methodology of the task, the selection of workshop participants, the methodology and analysis of the scenario workshops, the methodology and analysis of the backcasting workshops and the methodology of the legal screening. Chapter 4 describes the EU scenario narratives and the synthesis of these narratives. In Chapter 5, the results of the backcasting workshops are reported, including the scenario discussions and the pathways. Chapter 5 also includes a legal screening of the pathways. Chapter 6 reports on the stakeholder recommendations for policymakers. Finally, the discussion and conclusion of the study will be discussed in Chapter 7.

2 Conceptual framework

To contribute to the development of a fair, inclusive, and innovative DE4FS, the purpose of this research was to co-create future scenarios for the DE4FS and effective pathways to realise desirable (aspects and impacts of) scenarios while avoiding undesirable (aspects and impacts of) scenarios. This chapter presents a conceptual framework on the DE4FS, scenario development, backcasting and Theory of Change which are the concepts underlying the workshops in this study.

2.1 Defining the DE4FS

Central to this research are the concepts of “data economy” and “food system” that are interlinked in the “data economy for food systems". The Data4Food2030 project aims to develop a definition of the DE4FS to clarify what is entails to. Therefore, in the Data4Food2030 project, WP1 has been assigned with the creation of a working definition of the DE4FS, while also developing a state-of-the-art knowledge base to gain insight into the evolution, structure, functioning and improvement of the DE4FS. Defining the DE4FS in the Data4Food2030 project is a work-in-progress. A preliminary definition of the DE4FS is given in D1.1 of the Data4Food2030 project:

> “*The DE4FS is a spatial and temporal dynamic ecosystem, composed of numerous sub-ecosystems with loosed 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 through resources, institutions, technologies, data and relationships, connecting data ecosystems and food systems, as well as broader economic, societal, digital, technological, and natural environments in which they are embedded in and connected to.”* (Piot-Lepetit, 2024)

This definition of the DE4FS will be improved and updated throughout the duration of the Data4Food2030 project. In the context of WP4, the authors aimed for a simplified and practical explanation of the DE4FS to be used as input and point of reference for the stakeholder workshops. Therefore, in all workshops, the DE4FS was introduced based on the following explanations of the data economy and food systems.

Concerning the data economy, there is an evolution of the use of IT in agrifood systems (Wolfert et al., 2021). Firstly, the IT integration level has increased from stand-alone technology application to systems of systems. Secondly, the number of stakeholders involved in IT also increased, from single process operators to complex business ecosystems where many actors

interact. Where these systems of systems and business ecosystems come together lies a role for the data economy to conceptualise this interaction (Wolfert et al., 2021).

Food systems are defined as: all the drivers and activities related to the production, processing, distribution, preparation and consumption of food, the market and institutional networks for their governance, and the socio-economic and environmental outcomes of these activities (HLPE, 2017). Here, three components are distinguished with linkages and feedbacks: (1) food system drivers (external factors), like urbanisation, technology development, climate change and economic growth, (2) food system activities, like food production, distribution (food value chains) and allocation (consumption) and the (public and private) food environment, and (3) food system outcomes, such as food security, healthy and/or sustainable diets, and other economic, political and environmental outcomes (HLPE, 2017). In this approach, food system drivers cause certain activities and outcomes. Simultaneously, food system activities lead to certain outcomes as well. However, food system activities and outcomes also produce environmental and socio-economic feedback loops that contribute to global environmental drivers and socio-economic drivers (Ericksen, 2008; Ingram, 2011).

The working definition of the DE4FS in this research therefore is: *The DE4FS encompasses a process of co-creating value by human and non-human actors, linked to digital technologies and food-related activities, supported by data sharing and exchange of knowledge, competences, and skills, to provide agrifood products and services.*

Central in the Data4Food2030 project is the aim to shape pathways for a fair, inclusive, and innovative data economy for sustainable food systems. This adds a normative perspective to the concept of DE4FS, but also raises questions to what a fair, inclusive, and innovative data economy for sustainable food systems may entail.

In T4.1 of this work package, the concepts of fairness, inclusion and innovation have been described in the context of the DE4FS. In D4.1, fairness and inclusion are seen as indicators of the data economy in the social and ethical domain. Based on both literature review and stakeholder interviews, fairness is described as the equality of possibilities and opportunities and distribution of benefits. Characteristics of a fair data economy include clarity in terms and conditions, users' control over data and data sharing, transparency, security, and reliability (Šūmane et al., 2023a). Moreover, inclusion is about access to the data economy. This means that data availability, affordability, agency, awareness, and ability of involved stakeholders must be considered in the data economy (Šūmane et al., 2023a). In an inclusive DE4FS, the "data economy should be beneficial for the entire food system and all the stakeholders within

it" (Šūmane et al., 2023b). Finally, an innovative DE4FS indicates that "data-based tailored, customised, personalised solutions stimulate food system stakeholders to adopt novel sustainable food-related decisions and practices" (Šūmane et al., 2023b).

2.2 Scenario development

The development of scenarios is part of a wider approach of foresight studies, which involves the act of thinking about the future to guide decisions made today. Scenarios are representations of the future and can be used to explore effects of potential developments and to inform planning and decision-making (Wiebe et al., 2018).

In general, scenarios can be predictive, explorative, or normative (Börjeson et al., 2006; Wiebe et al., 2018). Predictive scenarios are based on what is probable to happen in the future, using knowledge about the past to derive estimations of alternative futures. Moreover, explorative scenarios start from the present and explore how trends, drivers, and/or interactions from today can impact the future. Finally, normative scenarios are based on a desired vision of the future and work their way back to identify pathways to realise this desired future (Wiebe et al., 2018).

In this study, both explorative and normative scenarios are developed. The goal of this study is to envision scenarios for a fair, inclusive, innovative data economy for sustainable food systems, which is a rather normative point of view about the desired state of the DE4FS. Furthermore, given the relative 'novelty' of the data economy concept, the use of current trends to inform the desired state is more appropriate than using a predictive perspective based on past developments. Explorative and normative scenario development can be combined, following the approach by Kok et al. (2011). Here, explorative scenarios are developed with the aim of creating diverging plausible futures. Moreover, a backcasting exercise is used to translate explorative scenarios into normative scenarios, from where pathways can be created that support the realisation of desirable aspects and impacts of the scenario. This backcasting exercise functions to converge, bringing the scenarios back to concrete pathways for the current situation.

Figure 1, as developed by Kok et al. (2011) summarises the process of diverging towards multiple explorative scenarios and then converging through a backcasting exercise.

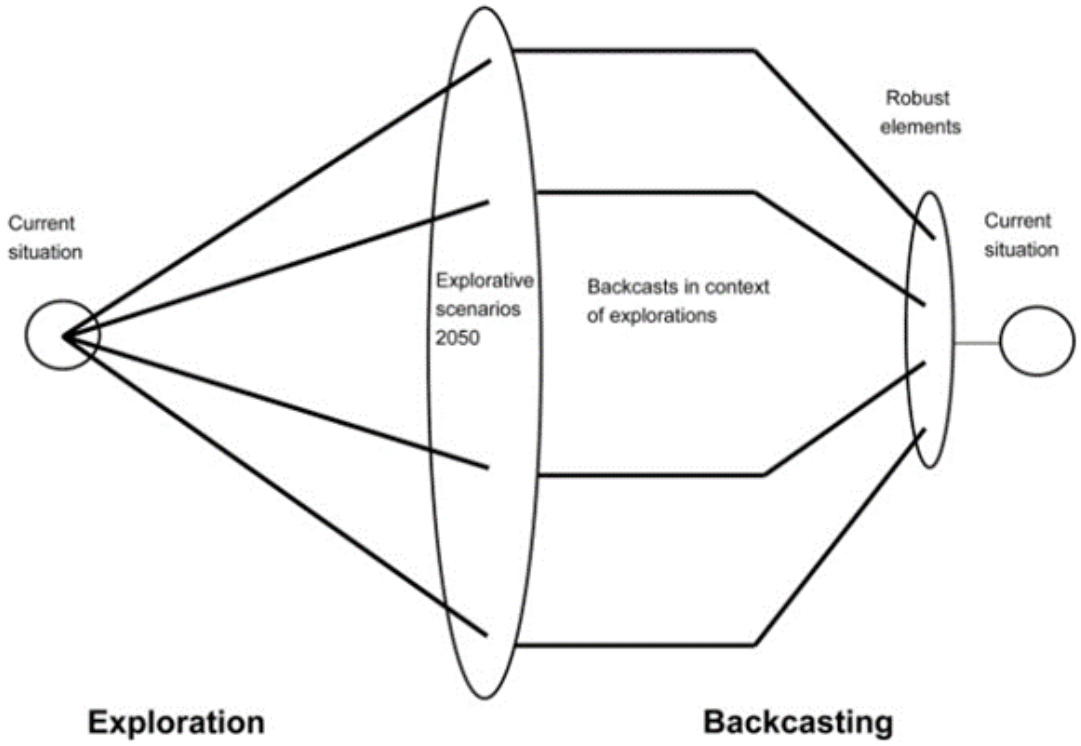

Figure 1: Diverging towards explorative scenarios and converging through backcasting (Kok et al., 2011)

2.3 Backcasting through Theory of Change

Backcasting is a recognised approach to deliver pathways and policy recommendations to reach certain impacts (Nikolakis, 2020). It can be defined as a process of imagining desirable possible futures and working back to the present to consider interventions that might build towards their achievement (Davies, 2014). As emphasised by Vergragt & van der Wel in Quist & Vergragt (2006), "*backcasting implies an operational plan for the present that is designed to move toward anticipated future states. Backcasting is not based on the extrapolation of the present into the future—rather, it involves the extrapolation of desired or inevitable futures back into the present*" (Vergragt & van der Wel in Quist & Vergragt, 2006, p.1032).

In this research the backcasting methodology is combined with the approach of Theory of Change. Both Theory of Change (ToC) and backcasting methodologies are based on future-oriented thinking, starting with envisioning a desired future state or long-term goal and working backwards from that goal to identify necessary preconditions and steps. ToC explains how a given intervention or set of interventions may lead to change, drawing on causal analysis and common-sense logic (Cieslik & Leeuwis, 2021; Deutsch et al., 2021). In general, ToC is a process in which possible sequences of steps from interventions to a desired set of outcomes

are set out (Koleros et al., 2024). This creates a visual model illustrating the main elements of a change process (Deutsch et al., 2021). Although ToCs exist in different forms, a common ToC framework includes input, activities, outputs, outcomes and impacts, inspired by a logical framework (Cieslik & Leeuwis, 2021). This way, ToC provides a structured approach for mapping out the path from the present to the desired future, identifying inputs, activities, outputs and outcomes to realise desirable impacts. Creating a ToC framework in practice however means that you fill in the visual model by starting with the impacts and then work backwards towards the activities and input (see section 3.5). In this research the desirable impacts were created based on the plausible scenarios.

3 Methodology

3.1 Overall methodology

Task 4.2 includes a two-step process:

- Six national participatory workshops to develop plausible scenarios for the DE4FS in 2050 (see Figure 2)
- Six national participatory workshops to shape pathways towards the desired aspects of these scenarios, using a backcasting method (see Figure 3).

In the scenario development workshops, participants were encouraged to envision scenarios based on social, legal, technological, economic, and environmental trends for the DE4FS. For this workshop, the focus was on what futures were plausible and what could happen considering the trends presented. The six national participatory workshops resulted in 16 national plausible scenarios. These 16 scenarios were analysed and shaped into four EU scenarios by the authors (see section 3.4 and Figure 2).

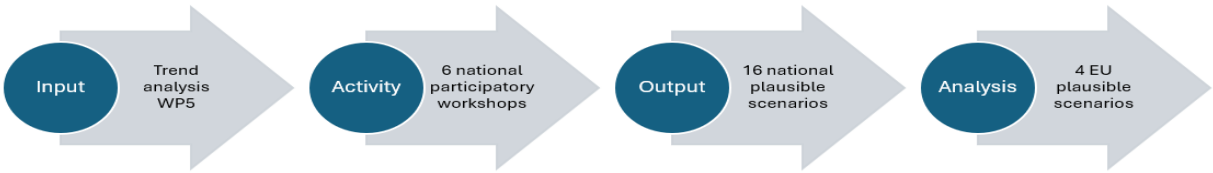

Figure 2: Step 1 towards plausible EU scenarios

To be able to develop pathways for a fair, inclusive, and innovative DE4FS, the second workshop consisted of an exercise in which workshop participants could identify the desirable and undesirable aspects and impacts of the scenarios. This way, the four plausible scenarios were translated into four desirable scenarios. These were used to identify pathways to realise a fair, inclusive, and innovative DE4FS (see Figure 3). Combining plausible and desirable scenarios allowed the researchers to include both long-term explorations, as well as short-term actions through backcasting.

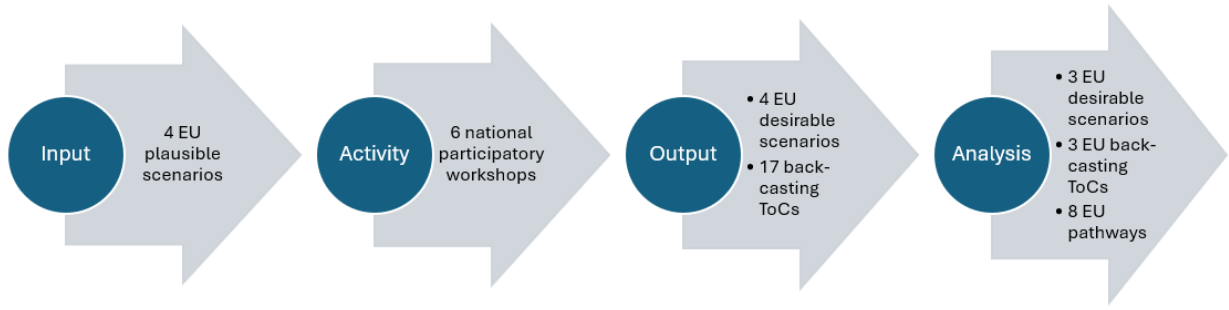

Figure 3: Step 2 towards EU pathways

In this research, diverging and converging is not only apparent through the process of exploration and backcasting, but also within these processes. Both the exploration and backcasting process involved divergence by collecting data in national workshops. These workshops created national level outputs in terms of scenarios and pathways. After the national workshops, the lead authors converged the national scenarios and pathways to EU scenarios and pathways. See Figure 4 for the divergence and convergence processes in this research.

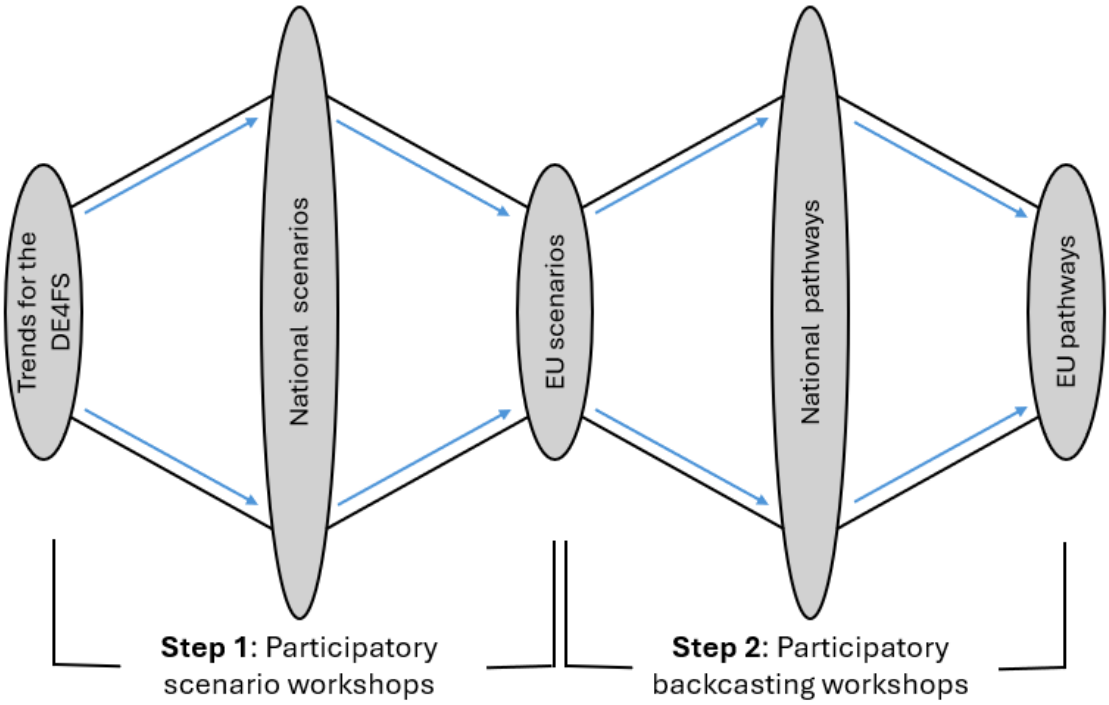

Figure 4: Divergence and convergence of scenario and backcasting workshops for national and EU level

Following the backcasting workshops, consultations with legal researchers took place to assess the pathways against current EU law and policies. These consultations had the aim of identifying aspects of pathways that are supported by EU policies and regulations, potential legal risks of the pathways and impacts of the pathways on legal values, such as fundamental

rights or constitutional values. The consultations took place in September-October 2024 between the authors of this deliverable and two researchers with extensive legal expertise in the agri-food context.

3.2 Workshop participants

To gain a deeper understanding of stakeholder perceptions and foster meaningful interactions, participatory multi-stakeholder workshops were arranged at a national level in six different EU countries: Belgium, Latvia, the Netherlands, Poland, Slovenia and Spain. In these countries the Data4Food2030 project has partners, allowing for better access to relevant local stakeholders, while at the same time creating a geographical spread across Europe for more balanced input. To allow for better quality input and interaction during the workshops, each partner organised and hosted the workshop in their own national language (except in Belgium). Having national workshops also had as an advantage that stakeholders could be actively present on location, rather than in an online setting.

Furthermore, this task builds on results of an earlier task of WP4: T4.1 Stakeholder mapping (see Appendix I) on the understanding and perceptions of stakeholders of the DE4FS. For this task stakeholders were categorised as following:

- **Food value chain actors:** input suppliers, farmers, processors, retailers, caterers, consumers, waste management companies
- **Food system support actors:** actors that provide a range of resources (rules, knowledge and advice, funding, publicity etc.) to food-value chain actors (e.g. 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:** actors from other sectors (e.g. health, environment, territorial development, energy) that are interlinked with food systems.

The participants invited to workshops for both rounds were categorised using the above defined groups to ensure a variety of roles and positions in the DE4FS. The partners were to determine which stakeholder groups were most pertinent in their respective countries to invite for the workshop. Therefore there were two guidelines for partners to use when inviting possible workshop participants: (1) workshop participants have knowledge off or experience with data-related processes within food systems, regardless of their role in the data-chain (data

holder, data user, data service provider, etc.); (2) they work within one of the food system stakeholder groups identified.

Table 2 and 3 show the amount and type of participants that have been attending both the scenario and backcasting workshop. A total of 71 participants have attended the scenario workshops, while a total of 60 stakeholders participated in the backcasting workshops. The same participants were invited for both scenario and backcasting workshops, however, as not everyone who attended the scenario workshop were available for the backcasting workshops, additional 'new' participants were invited for the backcasting workshops to secure enough workshop participants.

The scenario workshops took place in February and March of 2024. Each project partner succeeded to have between 10-15 participants present, as was recommended (see Table 2). At the same time, the national reports highlighted some common challenges that the organisers encountered with the workshop planning. For example, project partners struggled finding participants (Belgium, the Netherlands), had to reschedule the workshop due to farmers protests (Slovenia), coped with last minute withdrawal of participants (Latvia, Netherlands), or had smaller/larger subgroups than initially aimed for (Latvia, Slovenia). In addition, the workshop programme appeared to be more time-consuming than what was planned for. Therefore, some countries decided to either extend the recommended time schedule (Belgium), or to skip a less critical part of the programme (e.g. the prioritisation of trends) due to time constraints (Netherlands). The time constrains were often related to the depth and quality of the discussions.

Table 2: Amount and type of participants for scenario workshops

	Belgium	**Latvia**	**Nether-lands**	**Poland**	**Slovenia**	**Spain**	**Total**
Workshop date	07-03-2024	21-02-2024	29-02-2024	29-02-2024	22-03-2024	15-03-2024	
Food value chain actors	2	6	3	4	4	5	24
Food system support actors	4	4	5	4	3	3	23
Data actors	2	0	3	5	3	2	15

Actors from adjacent sectors	3	3	0	0	1	2	9
Total	11	13	11	13	11	12	71

The backcasting workshops took place in the period May - June 2024. Although the recommended number of participants for the workshops was approximately 15 persons, only one project partner succeeded in achieving this threshold (see Table 3). Some countries decided to limit the number of scenarios discussed and backcasting templates created so that they could spent enough time on specific scenarios instead of having limited time to go into all scenarios (Belgium, Latvia, Slovenia, Spain).

Table 3: Amount and type of participants for backcasting workshops

	Belgium	**Latvia**	**Nether-lands**	**Poland**	**Slovenia**	**Spain**	**Total**
Workshop date	18-06-2024	29-05-2024	06-06-2024	14-06-2024	31-05-2024	26-06-2024	
Food value chain actors	1	4	2	10	5	5	27
Food system support actors	3	3	4	1	3	2	16
Data actors	4	1	0	5	2	1	13
Actors from adjacent sectors	3	0	0	1	0	0	4
Total	11	8	6	17	10	8	60

In the sections 3.3 and 3.5, more details are given about the workshop methodologies, while sections 3.4 and 3.6 outline the process of data analysis for each set of workshops.

3.3 Scenario workshop methodology

The main aim of the scenario workshop was to develop plausible scenarios for the DE4FS in 2050. The year 2050 functions as a more distant point on the horizon for the development of scenarios. This way, workshop participants are stimulated to think outside of current possibilities with regards to envisioning the future of the DE4FS.

For each of the six national workshops, the aim was to have 10 to 15 participants in each workshop. The reason for this was for each national workshop to have three subgroups during the workshop to develop national scenarios. This would ideally produce three national scenarios per national workshop.

The scenarios were qualitatively developed and shaped into scenario narratives. The methodology for plausible scenario development in the workshop involved the following steps (a detailed version of the workshop methodology can be found in Appendix III):

Step 1: Introducing the project, workshop purpose and key concepts

This step in the workshop methodology involved the introduction of the project, task and purpose of this workshop. Basic definitions of key concepts such as the data economy, food systems, and data economy for food systems were shared with workshop participants. From earlier work done (Deliverable T4.1 – see Appendix 1) the authors had learned that people struggled to define the data economy for example, so sharing definitions gave the workshop participants an equal point of departure for the joint development of the scenarios and the pathways. In addition, it also provided consistency across the six countries, supporting the analysis of the workshop results.

Following this, trends for the DE4FS were presented. These trends were identified in WP5 of the Data4Food2030 project and are distinguished by clear categories (i.e. social, legal, technological, economic and environmental) (see Appendix II for the trends presented).

Step 2: Discussing trends for the DE4FS

The presented trends were discussed in small groups (three to four workshop participants) allowing them to validate and add to the trends from their own perspective and experiences. They used a set of guiding questions, which served as a conversation starter supported by a facilitator. Not all questions needed to be asked nor answered, as the aim of the discussion was to unravel stakeholder perceptions of the trends presented. The guiding questions can be found in Appendix III.

Step 3: Prioritising trends for the DE4FS

After the subgroup discussions, each group gave a quick plenary summary of their findings. This was followed by a joint prioritisation of the key trends that will likely have an impact on the DE4FS in 2050, either in positive or negative sense. Each workshop participant was asked to define their individual top 3 priorities of key trends by indicating their preferences with stickers

on a large sheet with the trends written on it. This led to a ranking of prioritised trends, of which each subgroup could choose two trends to base their scenario on.

Step 4: Plausible scenario development

Back into the same subgroups, a scenario was developed for the DE4FS using two trends the subgroup had chosen. The definition of a scenario that was given to the participants was: a fictional story about the future. It is not meant to be a prediction, rather the scenarios are explorative in nature. It is a way for thinking about the future. The story is evocative and gives words to developments.

To support workshop participants to develop plausible scenarios, a template was provided (see Figure 5). Guiding questions (see Appendix III) helped the workshop participants to fill in the template. These guiding questions supported workshop participants to give a description of what the DE4FS would look like if their chosen trends became a reality. This formed the scenario narrative. To further develop the scenario, workshop participants were asked to reflect on technological, legal, economic, environmental and social aspects of the scenario, and to identify the key stakeholders in the scenario.

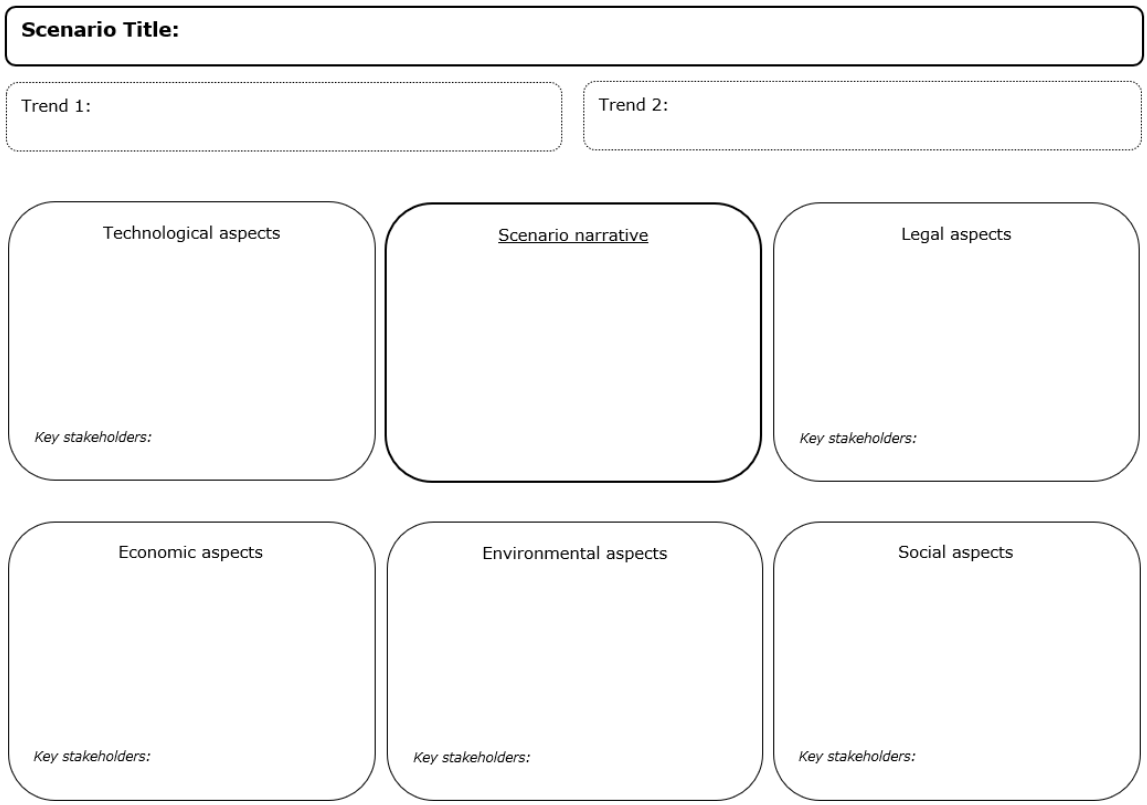

Figure 5: Template for scenario development

Step 5: Plenary reflection

The final step of the workshop involved a presentation of each developed scenario to the whole workshop group, followed by a discussion on the implications of these scenarios. There was a set of guiding questions for the discussion. These guiding questions build on the results of Data4Food2030 T4.1, where stakeholder interviews and focus groups identified the perceptions and experiences of the data economy of food system stakeholders. (see Appendix III).

3.4 Scenario workshop analysis

After the workshops each project partner wrote a report with the results of the workshop in their national language. This report was sent back to the workshop participants for feedback or additional input. The feedback and input were processed into the report which was later translated into English and shared with the authors of this report for further analysis.

The six national workshops produced 16 scenarios for the DE4FS in 2050. In the Slovenian and Latvian workshop, workshop participants expressed that they preferred two subgroups instead of three, because they believed discussions could be more fruitful in groups with 5/6 participants, rather than 3/4 participants. This is why they developed two instead of three scenarios (see Table 4).

Table 4: Number of scenarios developed per national workshop

	Belgium	**Latvia**	**Netherlands**	**Poland**	**Slovenia**	**Spain**
Scenarios developed	3	2	3	3	2	3

The next step and main aim of the scenario analysis was to identify commonalities between the 16 national scenarios, bringing together overlapping national scenarios into EU scenarios. This included an inductive process of identifying shared aspects of the scenarios and merging them into EU scenarios with shared narratives.

A first attempt to bring together the national scenarios into EU scenarios was by analysis of the key trends that were used to develop national scenarios. As described in section 3.3, subgroups in the national scenario workshops based their scenarios on two trends for the DE4FS. The authors therefore firstly created an overview of all scenario titles and trends used to develop the scenario. Hereafter, commonalities were sought between the national scenarios that used similar trends to build their scenario.

The classification of national scenarios based on the trends led to six categories of scenarios with specific topics. The topics in these six categories included: (i) strict regulation, (ii) environmental sustainability, (iii) food safety, (iv) labour conditions, (v) healthy diets, and (vi) power dynamics. For each of these topics, two or more national scenarios from two or more different countries were included.

Based on this initial classification, the authors conducted an in-depth review of all scenarios. Upon this detailed analysis, a new classification was developed which grouped the national scenarios based on their focus on specific dimensions of food systems. For example, three national scenarios focussed solely on food consumption and healthy diets. Moreover, four national scenarios took a value-chain approach, focussing on transparency and localisation. As these narratives overlapped greatly, the authors inductively created four EU scenarios with similar narratives focussing on alike dimensions of agrifood systems and common values (e.g. environmental sustainability, societal health, transparency).

Consequently, each EU scenario consisted of three or more national scenarios from different countries (see Table 5). Based on the categorisation above, a scenario narrative was developed by the authors for each of the EU scenarios. These narratives were created by combining the scenario narratives of the national scenarios into one shared EU scenario narratives, and adding and combining the technological, economic, environmental, legal and social aspects. I.e. all workshop results and the text of each national scenario were carefully grouped on similarities, with the aim of including as much as was possibly relevant from each national scenario into the EU scenario. Contradicting views were limitedly found, but not shied away from and shown in the narrative that there are different views on a topic. In addition, the EU scenario narratives were visualised through illustrations (see Chapter 4).

Table 5: National scenarios divided over EU scenario groups

EU Scenario 1: Personalised healthy diets	**EU Scenario 2: Local and transparent supply chains**	**EU Scenario 3: Strictly regulated high-tech and innovation**	**EU Scenario 4: Environmental benefits through data-driven decisions**
Belgium scenario 1	Slovenia scenario 1	Netherlands scenario 2	Netherlands scenario 1
Poland scenario 2	Spain scenario 1	Belgium scenario 3	Poland scenario 1
Latvia scenario 2	Spain scenario 2	Belgium scenario 2	Slovenia scenario 2
	Latvia scenario 1	Poland scenario 3	
		Netherlands scenario 3	
		Spain scenario 3	

3.5 Backcasting workshop methodology

The methodology for the backcasting workshop builds on the plausible EU scenarios for the DE4FS in 2050. The aim of the backcasting workshops was to move from the plausible EU scenarios of the DE4FS in 2050 into pathways towards 2030 that help to *achieve desirable* aspects and *avoid undesirable* aspects of the EU scenarios in 2050. Whereby workshop participants are the ones who jointly decide what they think is desirable or undesirable. Focussing on 2030 supports workshop participants in making it more tangible, with the pathways becoming a starting point for reaching desired impacts in 2050. In other words, what actions can be taken in the short term until 2030, to support the realisation of long-term desirable aspects of scenarios in 2050. In these pathways, a variety of stakeholders can play a role, but the focus is on shaping policy recommendations for regulators and policy makers.

In preparation for the backcasting workshop the results from the scenario workshop (i.e. both the narratives and the visualisations) were shared with the workshop participants in advance. The following subsections present step-by-step the methodology used during the workshops (see also Appendix IV for a detailed explanation of the backcasting methodology).

Step 1: Introducing the project, workshop purpose and key concepts

This step involved introducing the project, task and purpose of this workshop. Therefore, we have defined the concepts of data economy, food systems, and data economy for food systems, and we showed the results of T4.1 stakeholder dialogues (see Appendix I).

Step 2: Presenting the scenarios

Following this introduction, the EU plausible scenarios were presented, based on the national results from the scenario workshops in February/March 2024. These scenarios are:

- Scenario 1: Personalised healthy diets
- Scenario 2: Local and transparent value chains
- Scenario 3: Strictly regulated high-tech and innovation
- Scenario 4: Environmental benefits through data-driven decisions

The scenarios were presented using the visualisations and scenario narratives. In the invitation to the workshop, the scenario narratives were already shared with the workshop participants. Moreover, the scenario narratives and visualisations were printed and given as handout to the workshop participants.

Step 3: Reflecting on the scenarios

The scenarios have been reflected upon using a carrousel setting. This means that the four scenarios have been displayed on posters (the visualisations printed on A1 format) in a workshop space. For each scenario, a facilitator summarized the scenario narratives, supported the reflection with guiding questions and took notes of the discussion. The workshop participants, in subgroups, went around all the different scenarios (like a carrousel), and answered the following main questions:

- What aspects of this scenario are undesirable? Why?
- What aspects of this scenario are desirable? Why?

The participants answered these questions by writing down the undesirable aspects on red sticky notes and the desirable aspects on green sticky notes. These sticky notes were attached to the scenario posters on the elements they applied to. To foster discussions, the facilitators had a set of guiding questions (see Appendix IV).

The output of this step has been a concrete division of aspects into desirable and undesirable ones for each specific scenario, which has been used as input for the backcasting exercise.

Step 4: Backcasting

For the backcasting exercise, the aim was to imagine concrete actions or interventions, and to shape them into pathways for different stakeholders to achieve a fair, inclusive and innovative data economy for sustainable food systems. Although the pathways aimed to focus on the roles for a variety of stakeholders, the role for policy makers and regulators was key for this exercise.

The backcasting exercise consisted of working with a Theory of Change framework which needed to be completed for every EU scenario (see Figure 6). In the workshops, the participants were divided into four subgroups, each to do backcasting of one of the scenarios.

Figure 6: Template for backcasting

The backcasting template should be approached from the right side to the left side of the template, hereby shaping pathways from the desirable impacts of 2050 to the inputs and activities needed now (2024-2030) to reach these impacts. The aim of the exercise is to work backwards to concrete inputs for activities that will lead to desirable outcomes in 2030 and avoid the undesirable outcomes.

For the impacts of 2050, the workshop participants selected the discussed desirable aspects of each scenario that contribute to the creation of a fair, inclusive and innovative data economy for sustainable food systems. Because the impacts need to be formulated positively, the workshop participants could also choose to reverse the undesirable aspects identified into desirable aspects. However, the pathways have the aim to formulate steps for a more nearby future, namely 2030 (i.e. Data4Food2030). Hence to reach the *2050 impacts,* participants were encouraged to imagine *outcomes for 2030*. These outcomes are an 'in-between' step to assess if we are heading in the direction of reaching the 2050 impacts. That also means that multiple 2030 outcomes can contribute to one 2050 impact.

The 2030 outcomes result from *activities*, and their *outputs* that are performed before 2030 (hence activities in the template are suggested for 2024-2030). And of course, the activities and related outputs require *inputs.* Participants were asked to connect the different steps of the backcasting template using arrows, to show, for example, what outcomes lead to what impacts or what activities lead to what outputs. Here, it is important to have every step connected to at least one other step, but possibly more steps.

3.6 Backcasting workshop analysis

After the workshops each project partner wrote a report with the results of the workshop in their national language (except Belgium). This report was shared with workshop participants for feedback or additional input. After the feedback and input were processed into the report, the report was translated into English and shared with the authors of this report for further analysis.

For the analysis of the scenario reflections, the authors collected all desirable and undesirable aspects of the scenarios that were mentioned in the national reports. After some back-and-forth correspondence with the project partners to clarify any unclear aspects and explanations mentioned, lists of desirable and undesirable aspects for each scenario were created. These lists were supplemented with tags in which national workshop the aspects were mentioned (country) and whether the aspects could be categorised in technological, legal, economic, environmental and/or social aspects. These lists formed the basis for the scenario discussions (for scenario discussions, see section 5.1.1, 5.2.1 and 5.3.1). Consecutively, the scenario discussions were also used to update the scenario visualisations for a final-coloured version.

For the analysis of the backcasting exercise, the templates created in the national workshops were collected per scenario. As most national workshops could not find enough participants to make four subgroups for each scenario, they did not complete all the scenario backcasting templates. Table 6 presents the scenario backcasting templates delivered by each country.

Table 6: Backcasting templates provided per scenario per country

	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**
Belgium	x	x		x
Latvia		x		x
Netherlands	x	x	x	x
Poland	x	x	x	x
Slovenia		x		x
Spain	x		x	
Total	4	5	3	5

The analysis of the backcasting templates relied on an inductive process. For each scenario, the national backcasting templates were compared and synergies in pathways were explored. Overlapping impacts, outcomes, outputs, activities and inputs between the different national templates were identified en merged into EU pathways. These EU Pathways thus consisted of combined and shared impacts, outcomes, outputs, activities and inputs from the related national pathways. However, not all national backcasting templates and related pathways were completed during the workshops. In these cases, following logical inference, the authors needed to add one or more elements in a pathway to make it complete (e.g. based on several national outcomes an EU outcome was created, however a suitable output was missing and therefore created by the authors).

While analysing the pathways created for each scenario, the authors identified many similarities between the pathways proposed for scenario 3 and scenario 4. The overlap experienced led to the decision to combine the two scenarios (3 and 4) into a single one. To avoid confusion, the new scenario combining scenario 3 and 4 was rephrased as scenario C, while scenario 1 was rephrased to scenario A and scenario 2 was rephrased to scenario B. The scenario discussions of scenarios 3 and 4 were also rewritten into one scenario discussion for scenario C, accompanied by one backcasting template for scenario C.

The sections 5.1.1, 5.2.1 and 5.3.1 present the scenario discussion based on the identified desirable and undesirable aspects of the scenarios and accompanying backcasting results, including the pathways found for the three scenarios.

3.7 Legal Screening

During the backcasting workshop, participants were not considering if their suggestions aligned with current legal frameworks, as the focus was on desirable or undesirable aspects regardless of them fitting within existing legal frameworks. Following the analysis of the pathways, the researchers identified the need to assess the pathways based on existing policies and regulations to support the making of relevant policy recommendations. Thus, a legal screening was added to the analysis of the pathways. This legal screening aims to explain the relationship between existing EU law and policies and the elements described in the pathways. It considers potential risks and legal challenges that should be considered in the context of proposed pathways. To address the aim of legal screening, the analysis follows three main questions:

- What aspects of the presented pathways are already supported by existing EU policies and regulations?
- What are the potential legal risks of the pathways?
- What is the impact of the pathways on legal values, such as fundamental rights or constitutional values?

The methodology of this legal screening contained two steps. Firstly, consultations took place with legal researchers working on food systems and digital regulations. This step allowed for identifying risks, legal concerns, legal frameworks and policies related to the pathways. Secondly, we uploaded the policies and regulations identified in the first step into the qualitative data analysis software (MaxQDA) and prepared a coding structure that included all elements of the pathways. Then, we identified and deductively coded each phrase in the uploaded documents that related to the pathways. It enables us systematically to link relevant legal provisions with specific elements of the scenarios.

Following the legal screening of the pathways for scenario A (see Appendix V, section 2.1), the proposed pathways align closely with existing EU policies, such as the CAP Strategic Plan Regulation (2021/2115) and the Farm to Fork (F2F) Strategy, which emphasise improving farmers' livelihood security, resilience, and sustainability within the agricultural value chain. These frameworks also address societal demands for healthier food systems, providing a solid foundation for realising the vision of healthier societies and greater dietary freedom for consumers. However, specific policy gaps persist, particularly in ensuring demand-driven data availability to support farmers in mitigating market risks and optimising production planning.

Moreover, the concept of "personal data ownership" is inconsistent with EU data protection principles, which regard personal data as a fundamental right rather than a tradable commodity. The General Data Protection Regulation (GDPR) emphasises safeguarding individuals' rights over their data rather than promoting ownership-based models. In business to business (B2B) data exchanges this is complemented by protections of trade secrecy. Policymakers should prioritise equitable data governance mechanisms that address ethical concerns, mitigate harms from inferred data, and balance individual rights with public interests. To achieve the broader goals of sustainability and innovation, targeted interventions, such as financial incentives for specialised agricultural practices, are essential to support data-driven decision-making and economic viability.

From the analysis of legal risks and impacts on fundamental rights, concerns are raised regarding data protection, equality, market power concentration, dependence on technology, and cybersecurity (see Appendix V, section 2.2). From a data protection perspective, the collection of a wide range of data, including sensitive categories such as genetic data and consumer behaviour data, should be evaluated through the lens of proportionality. This evaluation should occur on two levels. First, the data minimisation principle (GDPR Art. 5(1)(c)) should be applied, and each data category must be assessed to determine its relevance in providing optimal dietary advice. This principle is strictly enforced, as seen in the CJEU's 2023 Mousse v. SNCF ruling, where even seemingly justified data (e.g., gendered titles for train tickets) was deemed non-essential, highlighting that apps must limit data collection to absolute necessities while allowing users to volunteer additional information voluntarily. Second, in the context of potential public interventions, such as educational campaigns to promote personalised nutrition, the value of data protection must be confronted with the freedom to conduct business and the pursuit of public health objectives. The extensive collection of sensitive data by personalised nutrition companies could exacerbate power imbalances between data subjects and data controllers. The pathways may also contribute to existing power imbalances and inequalities among food producers. For example, only highly skilled producers with sufficient resources for investment may be able to benefit from demand predictions.

4 EU scenarios

This chapter responds to the first sub-research question, namely: “What are the plausible scenarios of the DE4FS in 2050?”. It includes narratives of the plausible EU scenarios and the corresponding visualisations. Each scenario consists of the narratives from a selection of national scenarios from the workshops described above. The narratives include the technological, legal, economic, environmental and social aspects considered by these national scenarios. The differences between the scenarios are highlighted and summarised in Table 7 for all the aspects presented (e.g. technological, legal, economic, environmental and social).

These scenarios reflect the perspectives of workshop participants when asked to explore the future of the DE4FS freely. These scenarios have been critically discussed with the workshop participants of the backcasting workshop (see Chapter 5) and are further assessed against current EU legislative frameworks in a legal screening (see Chapter 5). Thus, the narratives described below should be seen as stakeholder-created explorations of the future, meant to invoke fruitful discussions of the future of the DE4FS. The authors have, at this point, not engaged in critical review of these narratives regarding its feasibility, accuracy, and/or resemblance with for example current EU legislation

4.1 Scenario 1: Personalised healthy diets

In 2050, the DE4FS in Europe has accelerated. The most prominent change in food systems has been a transformation of the diets, which shifted towards personalised healthy diets. These are designed with the support of a large amount of personalised data (see Figure 7).

Data collection on individual consumer level will increase. The data collection is not only based on consumer behaviour and purchasing preference, but more importantly is centred around personal characteristics, such as DNA. This data is primarily used to create specific recommendations for people's diet. Although it is a voluntary and individual choice to follow such a personalised diet, this type of diet has become mainstream for all consumers of all ages. Therefore, food consumption behaviour has been reduced to making healthy choices based on personalised diets. This alters the way people perceive food: eating food becomes a matter of sustenance, rather than a matter of enjoyment or social experience and merely for the act of taking in the “right” food based on personalised dietary recommendations. For example, the entire population has considerably reduced its meat consumption, and food is increasingly processed, including additives such as nutrients, fibres and vitamins. This highlights a large role for food innovation by private food processors. The personalised diets

are created by private companies which have restricted access to the data which is stored on government controlled centralised data bases and platforms.

The data available about food consumption can support and predict what is needed in terms of food production. Food production becomes more efficient, because knowledge about the dietary profile of citizens results in better understanding of market demand. Therefore, the role of farmers in food systems changes, as they mainly provide specialised products that meet consumer personalised dietary demands. Through the transparent use of farm data across the value chain farmers can prove their food has health benefits. The government plays a large role in subsidising farmers and making sure that they are paid fairly and equally. Additionally, digitalisation on farms contributes to maximising outputs while minimising inputs, through precision agriculture and vertical farming. Environmental benefits arise from more efficient production: a precise estimation of food demand significantly reduces the overproduction, hence less resources are used. Overall, this results in a reduction of emissions, and more circularity.

Personalised healthy food will become subsidised for consumers, which will financially incentivise them to buy the healthy options, as it becomes available and affordable for everyone. This means that the groceries bought by consumers will be checked against their personalised diet. As a result, other food types not included in the individual's personalised diet are more expensive, and only available and affordable for people with higher incomes. Thus, individuals have less freedom of choice when it comes to food, and people are more or less required to consume what is considered “right” for them. Moreover, people with higher incomes can afford better quality personalised food as well, adding to their social status and increasing inequalities.

This change in food production, processing and consuming is made possible through the vast amount of personalised data and value chain data shared through highly secured and centralised government regulated databases and platforms. The amount of data requires huge data centres and increased cybersecurity as the processed data is highly sensitive. Therefore, much stricter regulations around the privacy and security of data are needed, in addition to the clear and commonly agreed data standards for food systems.

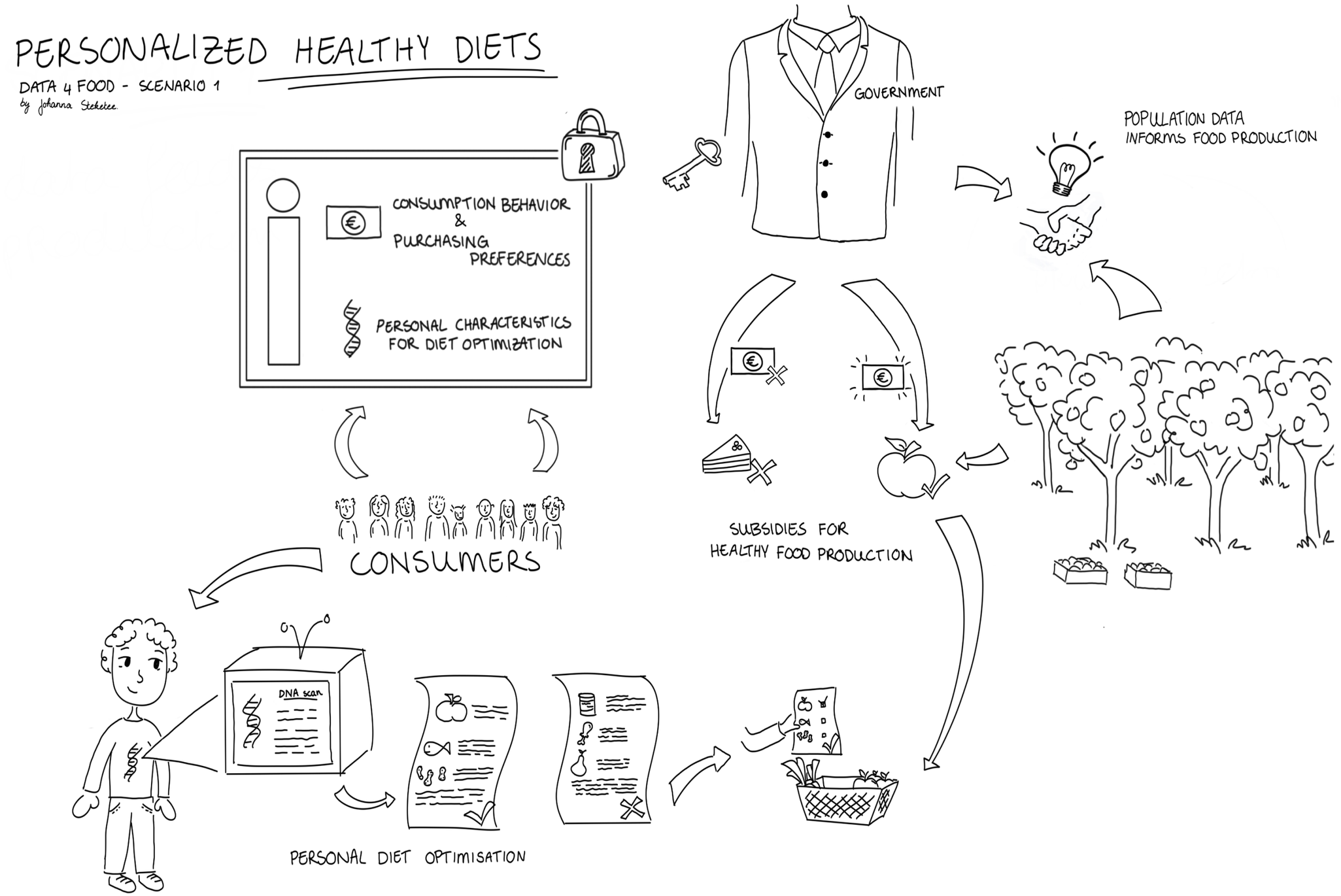

Figure 7: Scenario 1: Personalised healthy diets

4.2 Scenario 2: Local and transparent value chains

In the year 2050, the data economy has revolutionised food systems, fostering a shift towards local and regional food systems that prioritise transparency and sustainability (see Figure 8). Through the widespread adoption of blockchain technology, consumers now have unprecedented access to information regarding the origins of their food, allowing them to make informed choices, while other value chain actors are incentivised to optimise their entire production processes. Data plays a central role in this scenario as it provides information of food production processes and value chain practices. Fostering transparency is not only wanted by consumers but also required by governments. However, the government takes a hands-off approach towards data collection, storage, processing and sharing. Hence the data that supports this demanded and required transparency is owned by different private organisations and thus decentralised.

Basic digital literacy has become widespread, enabling individuals to easily access and interpret data about food production and distribution. Digital literacy also allows for the previously unskilled segment of the agricultural workforce to adopt and use technology effectively, helping to address the sector's high demand for digitally skilled workers.

Stringent regulations mandate that all food producers share comprehensive information through blockchain technology, ensuring accountability and traceability throughout the value chain. This helps the supermarkets to offer clear and accessible product information that can be easily understood by people across all levels of society.

Farmers have embraced transparent business models, recognising that consumer trust and government support are contingent upon open communication regarding their practices. This shift towards transparency is not only driven by market forces (e.g. through consumer demand), but also by a collective desire for a healthier planet. Increased transparency in food chains has facilitated communication about agroecological, environmental, and climate needs. Consumers are more aware of the impact of their food choices and their demand for diversified products from local producers who prioritise sustainability is growing.

The environmental impacts of this regional and transparent approach to food systems are the improved value chain visibility and governance that led to a more efficient inventory management, minimising overproduction and reducing food waste. This scenario also leads to shorter food miles and lower carbon emissions, as food is produced through regional value chains, contributing to a healthier environment.

Overall, this heightened level of information sharing and awareness has cultivated a collective consciousness regarding the value chains and production methods behind our food. With a focus on transparency and sustainability the future of food systems in 2050 promises a healthier planet and people.

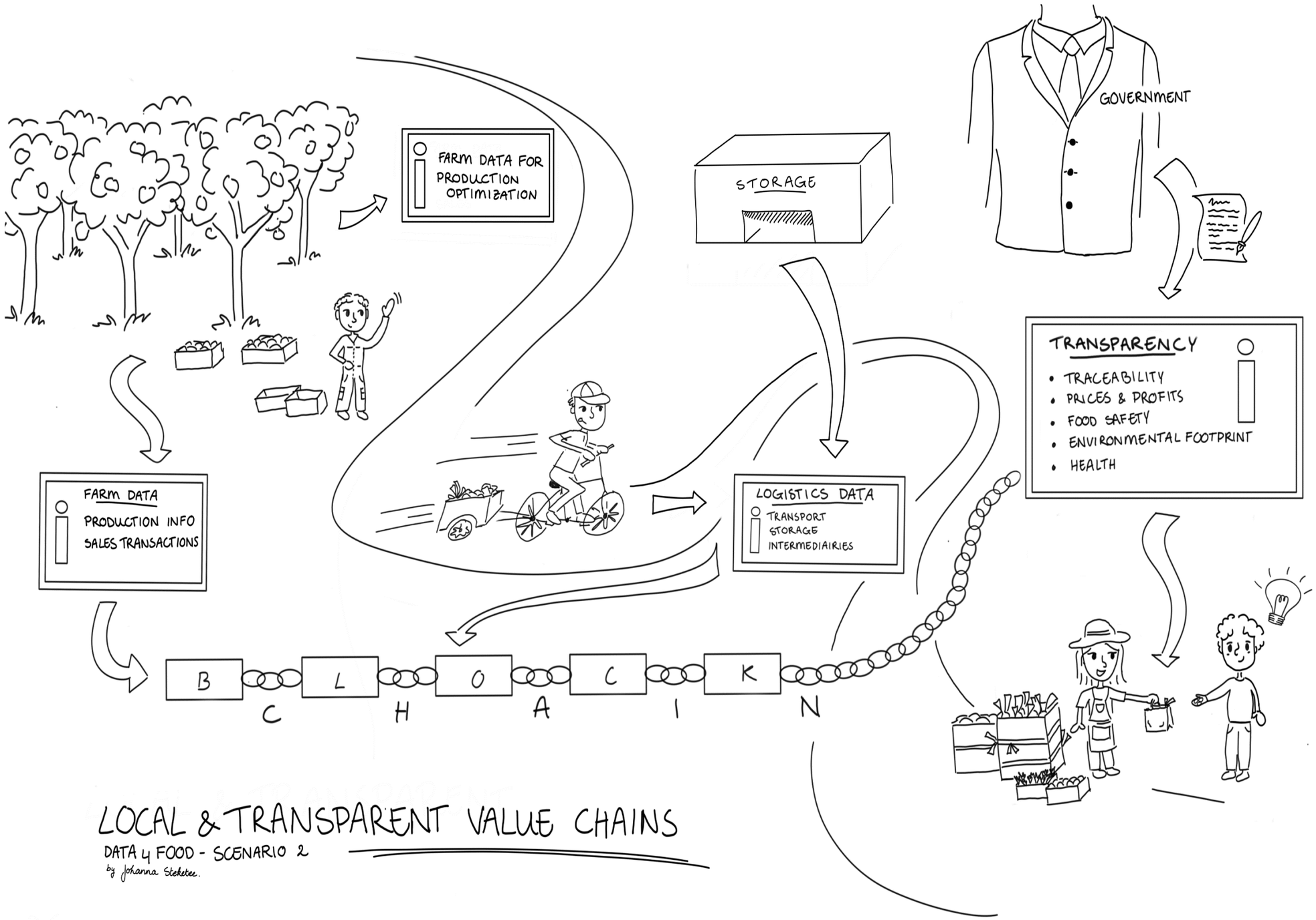

Figure 8: Scenario 2: Local and transparent value chains

4.3 Scenario 3: Strictly regulated high-tech and innovation

In the year 2050, the European Union has undergone a transformative shift in food systems, driven by technological innovation (see Figure 9). Precision farming, automated production technologies, and the widespread use of artificial intelligence and blockchain have transformed the entire food production process. Technological advancements have fuelled innovation and sustainable food production. Data generation, improved access and data sharing fuel innovation in food development, with a focus on plant-based food. Innovation in food systems is supported by improvements in intellectual property rights, clarity around AI regulation and the integration of all value chain actors through data exchange.

Farmers have embraced on-farm technology, with one of the most significant advancements being the use of autonomous robots in food production processes. The widespread use of technology allows farmers to free up time to focus on other topics that are relevant on farm, instead of dealing with administrative activities. Readily available farm data allows for optimised agricultural production processes, reducing inputs and maximising outputs. Traditional farm advisors have been replaced by artificial intelligence tools which make use of the large amounts of integrated value chain data. In farming, the data collection from a multitude of sensors, drones and other technologies offers insights at various levels. This allows the government to monitor farmers' compliance with governmental regulations, especially with regulations regarding sustainability and animal health.

While data is collected and stored by different actors in the DE4FS in a decentralised manner, the government is active in creating policies and regulations for fair data practices. Additionally, ownership of data by big tech companies raises concerns about power dynamics in the data economy, incentivising governments to create policies and regulations. In addition, efforts are made to promote interoperability and democratise data ownership. Governments play a crucial role in regulating the data economy, ensuring data standards and interoperability for efficient sharing. Regulations aim to make data sharing fair and efficient, with automated management of data compliance and consent. While the strict regulation potentially gives room for excessive government control over food production processes, collaboration between stakeholders on data regulation is, however, essential to prevent big tech companies from further gaining excessive control.

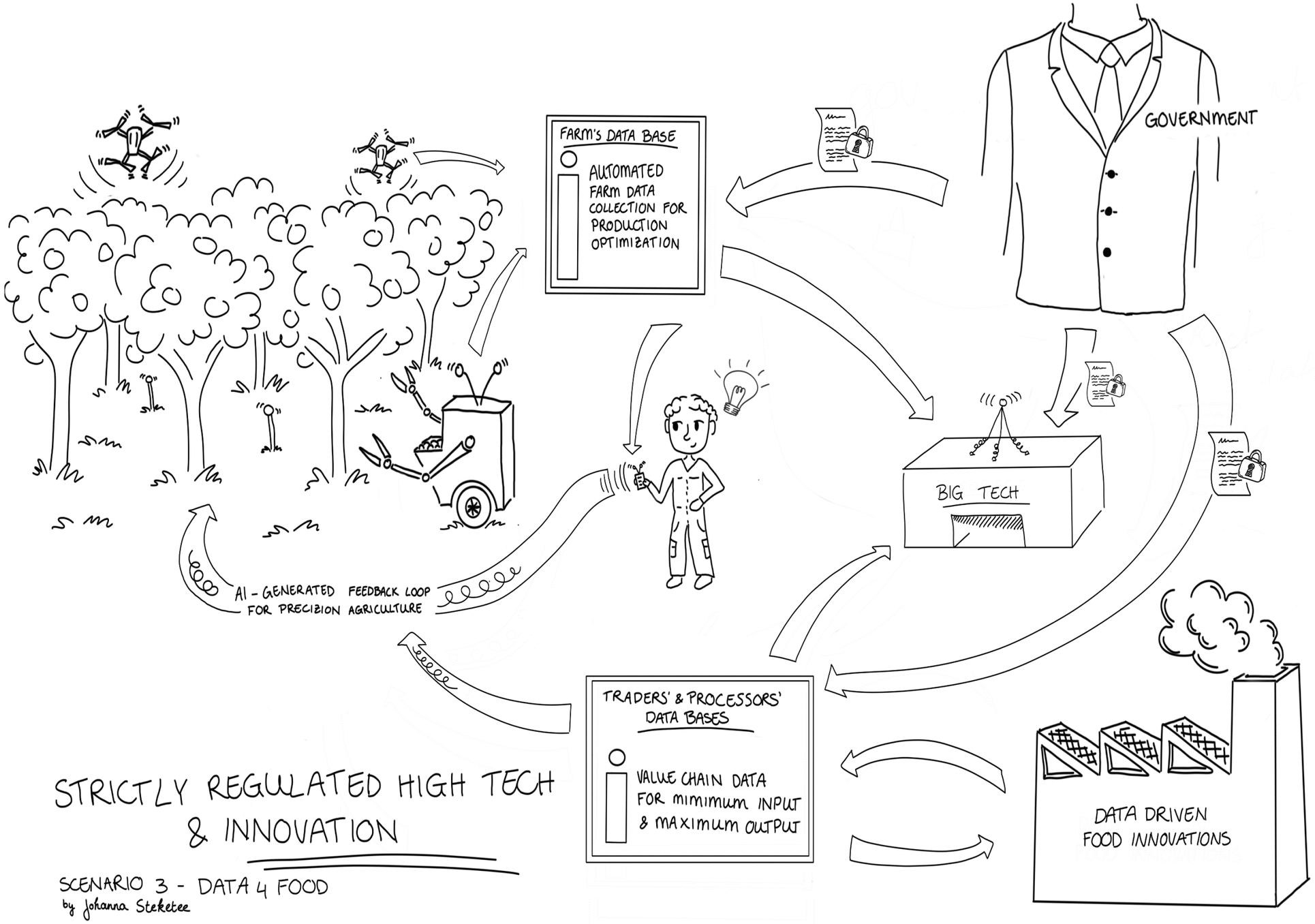

Figure 9: Scenario 3: Strictly regulated high-tech and innovation

4.4 Scenario 4: Environmental benefits through data-driven decisions

The DE4FS in 2050 provides insights into value chain practices through structured, relevant, specific and good quality data. With these insights, decision-making in entire food value chains can be supported with the aim of creating more sustainable food production practices (see Figure 10).

In 2050, data is an essential (if not the most important) part of business models in food systems. Data adds value to food products but is also an important product. Therefore, the farmer identity changes in 2050: farmers are no longer only food producers. Instead, they focus on technology use and, more importantly, on collecting data as additional valuable product, significantly altering their ways of working and daily lives.

In farming business models, this means that farmers can differentiate prices (more data about a product means a better-quality product, hence a better price) and that they have a stable and secured demand from processors and other value chain partners. Data on food production practices can additionally function as a control mechanism, by providing transparency on compliance to rules and agreements. This also enables certification of practices: farmers receive a checkmark from the government when they comply with regulations, which also informs other value chain actors or consumers on this aspect.

In 2050, available data is better structured, relevant, specific and of high quality. Massive, standardised databases are the norm, which reduce data incompatibility because of multiple data collection methodologies that could produce varying data types. Thus, data is more efficiently stored, supporting use and re-use, though with the emphasis of not re-storing the same data in multiple locations (i.e. less data duplication).

Information on the impact of food systems on the environment is widely available. Thus, data has become the key determent for the direction of food systems, contributing to the reduction and elimination of environmentally harmful processes and products. The farm of the future is driven by real-time data collected through technology such as IoT sensors and AI-powered robotics. For example, this data can guide water use and fertiliser applications, leading to more sustainable food production methods. Food production also becomes more efficient by using less input for more output which fuels productivity and profitability.

However, the costs of this data-driven environmentally friendly food and food production are expected to increase – resulting in higher food prices. This could further create disparities and exclusions among consumers when it comes to affordable and accessible good quality food. This exclusion will be more visible among farmers and other value chain partners, as not all can keep up with technological advancements, even when they are provided with support in terms of equipment and knowledge about new technologies.

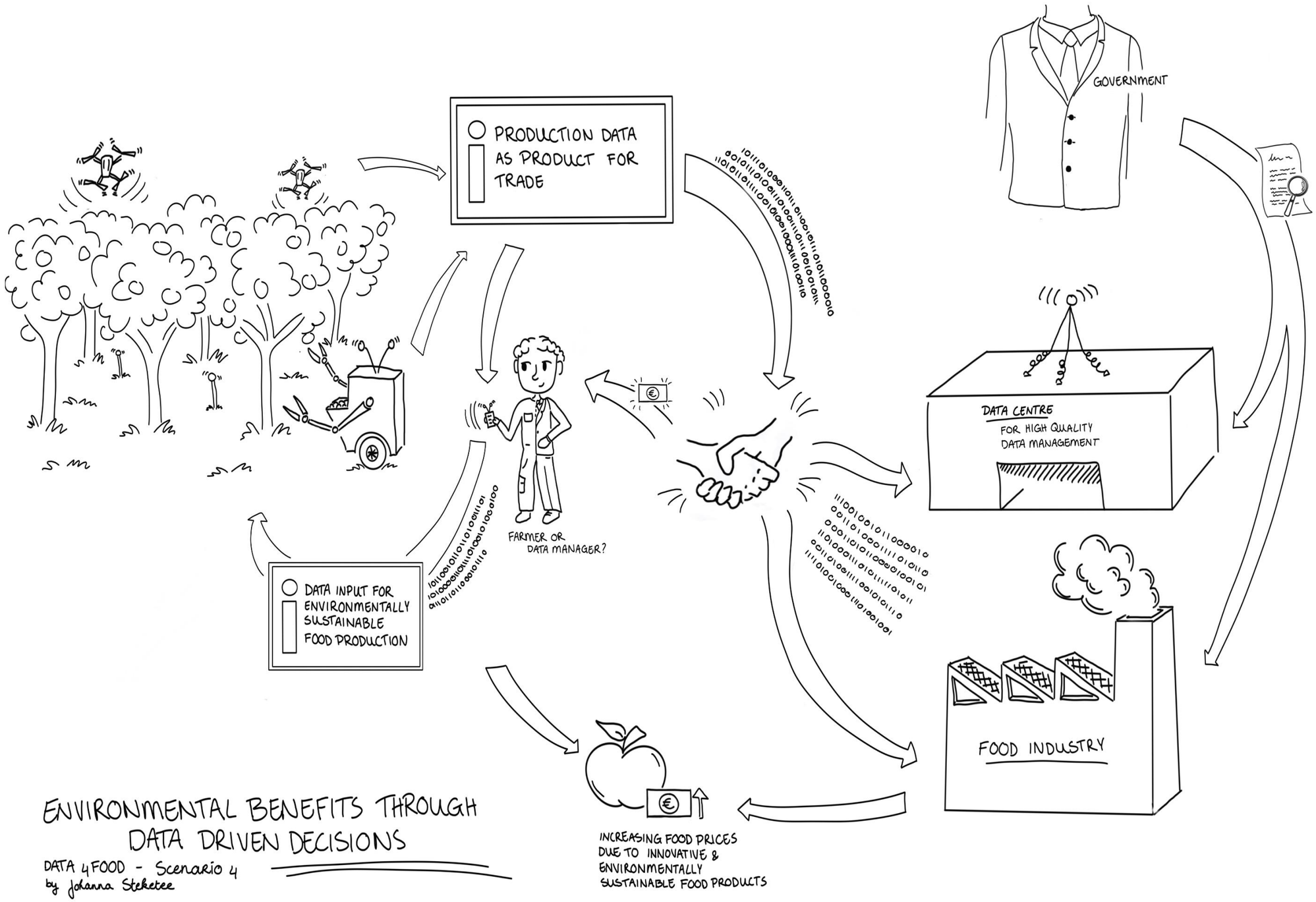

Figure 10: Scenario 4: Environmental benefits through data driven decisions

4.5 Synthesis

A summary of the key points of each scenario described previously is provided in Table 7 below. The findings have been divided into five different dimensions: technological, economic, environmental, legal and social, as these dimensions formed the basis of the scenario narrative exercise in the workshops

Each key point is assessed through the potential relevance for the DE4FS across the different scenarios, by assigning them one or two plus or minus signs. The significance of this evaluation is the following:

- Two pluses (“++”) mean the topic is believed to have a strong positive impact on the DE4FS, while two minuses (“- -") indicates an expected strong negative impact on it;
- A single plus (“+”) means that some positive impact might be expected, while the negative one (“-”) indicates a negative effect;
- The combination “+/-” denotes incertitude on the potential effect on DE4FS from the respective topic (i.e., the stakeholders are not certain if or how the topic might impact the development of DE4FS);
- The “+” or “-” notation means that the topic could have either a positive or a negative impact on DE4FS, depending on the particular context in which the topic is assessed.

It is worth noting that whether the impact of a topic is perceived as positive or negative was linked to particular contexts and workshops stakeholders’ perception on the potential impact of the respective topic.

Table 7: Summary of technological, economic, legal, environmental and social aspects per EU scenario

	1. Personalised healthy diets	**2. Local and transparent value chains**	**3. Strictly regulated high-tech and innovation**	**4. Environmental benefits through data-driven decisions**
Technological	+ Consumer data collection + Centralised data centres	+ Blockchain as driver of transparency	++ Precision agriculture in optima forma ++ Autonomous robots, AI, blockchain across whole value chain	++ High-tech value chain ++ Structured, relevant, specific and good quality data
Economic	+ Clear market demands on food + Food innovation	+ Data owned by private businesses	++ Technological innovation is crucial	++ Data as business model for farmers (added value to food products and a product in itself) - Higher food prices
Legal	++ Government owns the centralised data + Commonly agreed data standards ++ Security + or – Privacy	+/- Government takes hands-off approach: demands transparency, but does not decide how to do that	++ Highly regulation to reduce big tech power ++ Enhanced interoperability + Compliance/control of farmers	+ Compliance of farmers +/- Hands-off approach of government
Environmental	+ Less food waste + Reduced meat consumption	+ Local food production ++ Focus on agroecological, environmental, and climatic needs	+ On-farm focus on sustainability and animal health	+ Reduced energy consumption for data storage + Less external input on farms
Social	++ Healthy people - - Social interaction - Inequality	++ Digital literacy + Collective consciousness + or – High-skilled workforce	+/- Collaboration between stakeholders	+ or - Farmer identity changes - Inequality

Table 7 shows that in the first scenario of ‘personalized healthy diets’ mainly the legal and social aspects stand out. Workshop participants were generally positive about having a centralized database and more strictly organized governance through common standards. About the impact on privacy of consumers, workshop participants were, however, not in agreement. Socially the impact was positive with regards to the health of consumers but at the cost of a large negative impact when it comes to social interactions and inequality due to food prices. The second scenario ‘local and transparent value chains’ is, on the contrary, largely positive when it comes to the social aspects, with increased digital literacy and consciousness about food production. And this scenario positively impacts the environment. The third scenario ‘strictly regulated high-tech and innovation’ is, as expected, very positive about the technological and legal aspects of this scenario, but does not seem to consider social aspects in real depth. Scenario 4 ‘Environmental benefits through data-driven decisions’ is equally positive about the technological aspects and logically in this scenario, about the environmental aspects. There is some ambivalence about the role of the government in this scenario and there has been more consideration of the social aspects that are deemed to be negatively impacted, creating inequality due to higher food prices.

Across these scenarios there is a positive attitude towards the technological aspects of the DE4FS in 2050. Furthermore the legal aspects are deemed crucial, but there is some incongruence about the actual role of the government: hands-on or hands-off. Nevertheless, clear rules and regulation are seen as really important in general. The environmental aspects are in some scenarios more of an afterthought, while in other scenarios they are key. Nonetheless in all scenarios positive impacts on environmental aspects are foreseen. While the social aspects are also a mixed bag of key considerations and afterthoughts, the social impacts of the four scenarios of the DE4FS in 2050 are expected to be far more negative, creating further inequalities due to labour conditions and food prices. Lastly, the economic aspects are considered positive in each scenario, but in none of the scenarios this was the main focus. The impact on economic aspects tend to be seen as advantageous side-effects.

5 Backcasting workshops

This chapter gives an answer to the second sub-question: “What pathways can support regulators and policymakers in the realisation of desired aspects and impacts of scenarios while avoiding the undesired ones?” It includes a discussion of the scenarios, the pathways developed by the workshop participants and the legal screening of the pathways.

During the workshops held in the six countries it became apparent that the participants had very similar thoughts and feedback about scenario 3 and 4. In fact there was a lot of overlap between the two scenarios. Considering this, the authors have decided to combine the feedback of both scenarios and continue them as a single scenario with a new title: Strict regulation to support data-driven decisions for reduced environmental impact. To avoid confusion with the old numbering of the scenarios (1 to 4) henceforth the scenarios will be named: A (former 1), B (former 2) and C (3 and 4 combined).

5.1 Scenario A: Personalised healthy diets

5.1.1 Discussion of scenario A

In this scenario, arguably the most important desirable social aspect is improving the health of all citizens using consumer data to construct and encourage personalised healthy diets (Netherlands, Belgium, Latvia, Poland, Spain, Slovenia). Participants stress the importance of individually tailored nutrition (based on gender, age, health status, etc.), and having specialised products available for people with specific dietary needs (Poland, Latvia). Subsidies should become available for the production and consumption of personalised nutrition, economically incentivising healthy food choices and thus making healthy food the affordable option for everyone. The spread of healthy nutrition habits at individual level and among the population at large fosters healthy lifestyles, improved quality of life and longevity. Collection of personalised data also could diagnose certain conditions early, enabling effective preventive medical interventions (Spain).

Although this scenario has consumers and their (healthy) diets at the forefront, there are wider implications for other food system actors. From an economic perspective, workshop participants stressed opportunities for efficient food production. The availability of good quality consumer data can inform food production about consumer demand to better determine what and how much to produce. It ensures only necessary and suitable foods are produced and consumed according to everyone's specific needs.

Farmers, supported by government-provided data, gain enhanced security in crop planning and determining required inputs (Netherlands, Latvia, Poland, Spain). Other economic benefits for farmers in this scenario relate to additional opportunities for specialisation and differentiation of agricultural production (e.g. for producing “healthy” or “good” food) for which farmers can charge a premium (Netherlands, Belgium). Although some sectors may profit from this scenario (e.g. pharmaceutical and nutraceutical industry), workshop participants are concerned with the threat for production branches and sectors associated with unhealthy foods such as the wine industry or sugar production (Latvia). It is also mentioned that these scenarios enable new market opportunities for fraud, with the trade of certain products on black markets: this way, those who get subsidies for certain products can sell them for higher prices on black markets to those who do not get these subsidies (Slovenia). Another undesirable economic aspect mentioned by participants is the disappearance of the free market due to producing for personalised diets and how this radically changes the role that farmers have in food systems (Poland).

One of the most frequently mentioned aspects in the scenario discussion relates to an undesirable social question of power associated with this large-scale collection of consumer data. Merging consumer data gives extra value and meaning to this existing data but also gives those who have access to this data a lot of power and control (Belgium, Latvia, Netherlands, Spain). This can cause for excessive influence of the food industry over food science and consumer choices. Additionally, workshop participants are not keen on the possibility of governments having unlimited access to highly personal data, such as genetic information, raises concerns about privacy and the security of personal information (Spain, Belgium). Participants agreed that it is undesirable for government and private companies (who develop personalised diet plans) to exert excessive control over individual dietary decisions. This is particularly concerning when these entities have either unlimited (government) or limited (private companies) access to sensitive personal data, which determines the most suitable and economically accessible diet for individuals (Spain).

It is considered desirable that the existence of large databases with consumer data requires and incentivises the creation of stricter data privacy and security regulations, as well as agreed data standards (Poland). However, participants argue that centralisation of data about consumption behaviour, purchasing preferences and personal characteristics is undesirable, due to aforementioned power dynamics (Netherlands). For example, inferring individual and sensitive data to general databases without the knowledge and consent of the citizen is seen

as a threat and considered invasive (Poland). Therefore, participants emphasised the need to ensure voluntary participation in such a system (Netherlands).

Workshop participants raised the issue about whether the data is accurate and reliable enough to base personalised healthy diets on. Genetic data may not be fully representative of the reality (e.g. health status of an individual), or errors in analysis could lead to incorrect or even harmful dietary recommendations for individuals' health (Spain). Also, participants identify difficulty with following the guidelines of individualised diets on the long term. Over time, a consumer ages, changes lifestyle and thus has different nutritional needs that requires constant updating of their individualised diet (Poland).

The limitation on consumers' freedom to choose their personal diets could potentially lead to a loss of identity and a dehumanised relationship with food (Spain). It is considerably undesirable that organoleptic and cultural attributed meanings of food are downplayed, as personalised diets do not provide enjoyment of food and social experiences (Latvia). For example, this scenario could disrupt social dynamics around family meals, reducing the pleasure and spontaneity associated with eating together (Spain). The loss of freedom of choice for consumers is also considered undesirable and it is seen as unnecessary and excessive to punish “bad” eating (Belgium). Additionally, participants are concerned about the social inequality and restriction of personal freedoms that arise in this scenario because of the focus on personalised healthy diets (Poland, Slovenia, Netherlands, Belgium).

Finally, workshop participants stress the desirable environmental aspects of the scenario. The main aspect mentioned here is the reduction of food waste because of availability of consumer demand data and opportunities for planning for production. This does not only reduce food waste but also enhances efficient use of resources and inputs because of targeted food production and food planning (Belgium, Netherlands, Poland, Spain, Slovenia). Undesirable environmental aspects of the scenarios focus namely on the idea that unification and standardisation of food (associated with prescribing diets) may lead to decreased food diversity, where we can end up with a monoculture of food production and associated biodiversity loss (Latvia, Spain). Other aspects involve the high energy use required by the large data centres that are needed to store all consumer data (Netherlands), and participants stress that environmental impact of a diet is not considered in the suggested personalised diets (Belgium). This could be improved to gain desired environmental aspects. Lastly, concerns were raised about the feasibility of local and sustainable food production based on DNA test results. For example, if dietary recommendations indicate the need to consume foods from climatic zones different from where people reside, there would be a heavy dependence on

importing these products, which would not be sustainable due to the long distances these foods would have to travel (Spain).

In Figure 11, the desirable aspects identified from the scenario discussions are translated into an updated visualisation for desirable scenario A. Most importantly, dietary freedom for the consumer is emphasised and the role of the farmer is highlighted in comparison to the visualisation of plausible scenario 1 in Figure 7.

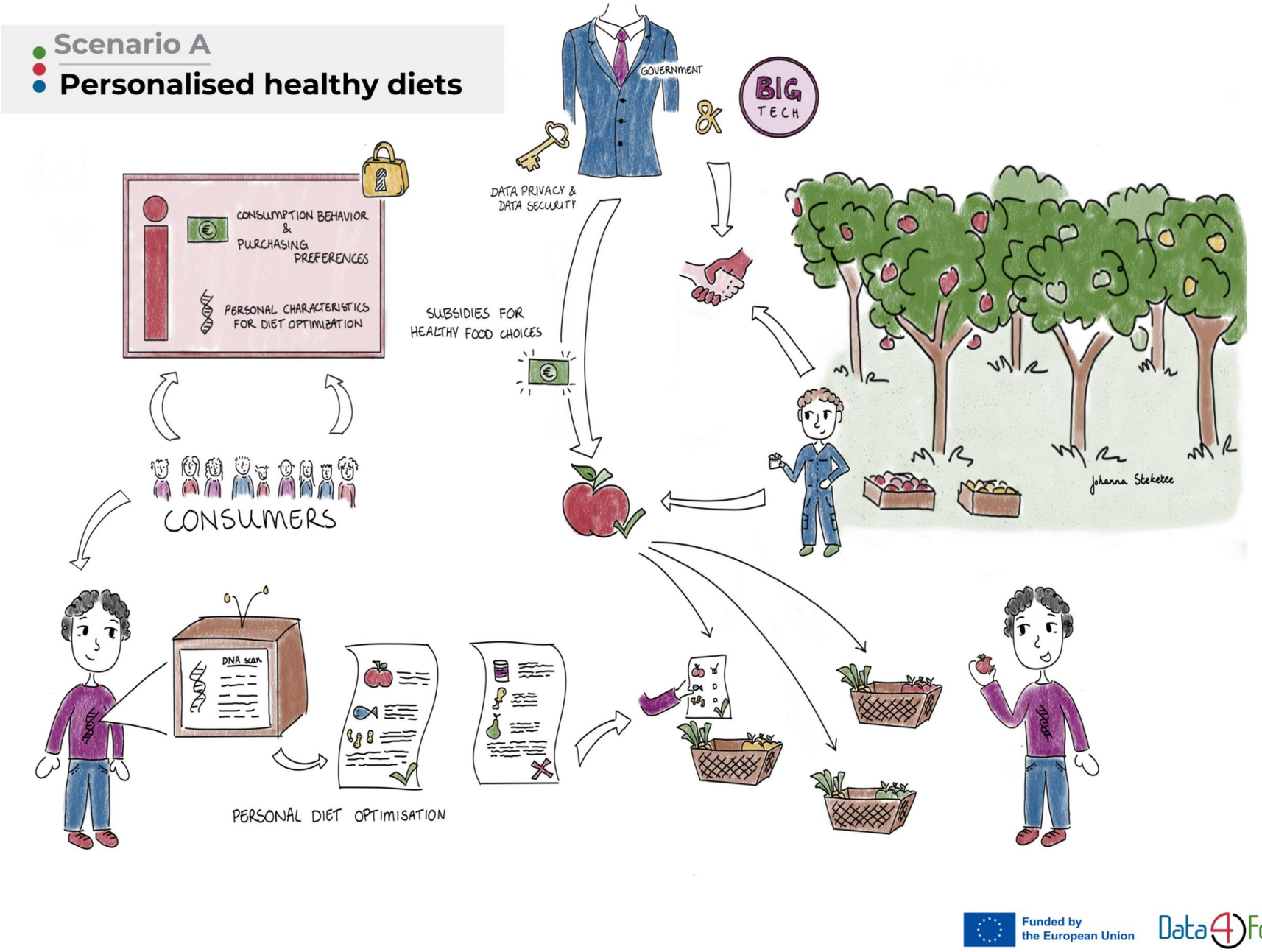

Figure 11: Updated visualisation of scenario A

5.1.2 Pathways for scenario A

The analysis of all the six national backcasting templates and the multitude of pathways described on them, led to the identification of three desirable pathways identified for scenario A – Personalised healthy diets, displayed in Figure 12. This template shows the Theory of Change for this scenario regarding meeting the impact in 2050 and the short-term outcomes in 2030.

Guaranteeing dietary freedom for consumers.

Dietary freedom for consumers is supported by the option for personalised nutritional advice based on DNA and consumer data, stored securely with individualised consent based on personal data ownership. This can be achieved through legislation ensuring secure data systems, enabling consumers to maintain control over their dietary choices and data ownership. Moreover, financially rewarding the production of sustainable and healthy foods for farmers and companies supports the availability of healthy and sustainable food options for consumers, increasing dietary freedom.

This pathway contributes to a **fair** DE4FS, as consumers retain ownership and control over their data while guaranteeing their dietary freedom. Consumers decide if and how their data is used and who can have access, preventing governments or companies from exploiting this data unfairly. The security and privacy of consumers is prioritised, and robust measures are in place to protect sensitive data from misuse or breaches.

Building a thriving and healthy society.

For a thriving and healthy society, healthy food consumption should be the norm. Achieving this requires educational campaigns to raise awareness and business models for food producers and processors to increase availability of specialised healthy food. Moreover, a secured and decentralised database should be in place, in which DNA and consumer data is combined with nutritional knowledge to create personalised nutritional advice for every consumer based on scientific research on nutritional requirements based on DNA.

This pathway contributes to an **inclusive** DE4FS, as efforts are made to build the capacity of consumers to effectively use and understand data-driven dietary requirements. Moreover, the value created from the data in this pathway is used in a way that benefits society. The pathway also contributes to an **innovative** DE4FS, as data is used to innovate how food systems can better meet the needs of consumers, leading to consumer-centric data innovation. Platforms

that provide personalised nutritional advice based on genetic data, dietary preferences or health goals to allow consumers to make better food choices are an important example of this.

Securing sustainable livelihoods for farmers.

Reducing farmers' market risks through high-quality demand data and enabling them to charge premiums for specialised foods will enhance their livelihood security. Achieving this requires developing reward systems for sustainable production and utilising DNA and consumer data to optimise farmers' planning and production. Furthermore, educational campaigns can support consumer awareness for consumption of premium-priced healthy specialised foods.

This pathway contributes to an **innovative** DE4FS, because the availability of high-quality demand data is leveraged in new ways to enhance food systems and support new business models. Through data-driven insights, farmers' challenges of risks and low incomes are confronted (e.g. predictive analysis of food demand). Additionally, the pathway involves data-driven food innovation, where data is used to drive the development of new food products that meet consumer preferences and dietary needs.

Scenario A: Personalized healthy diets

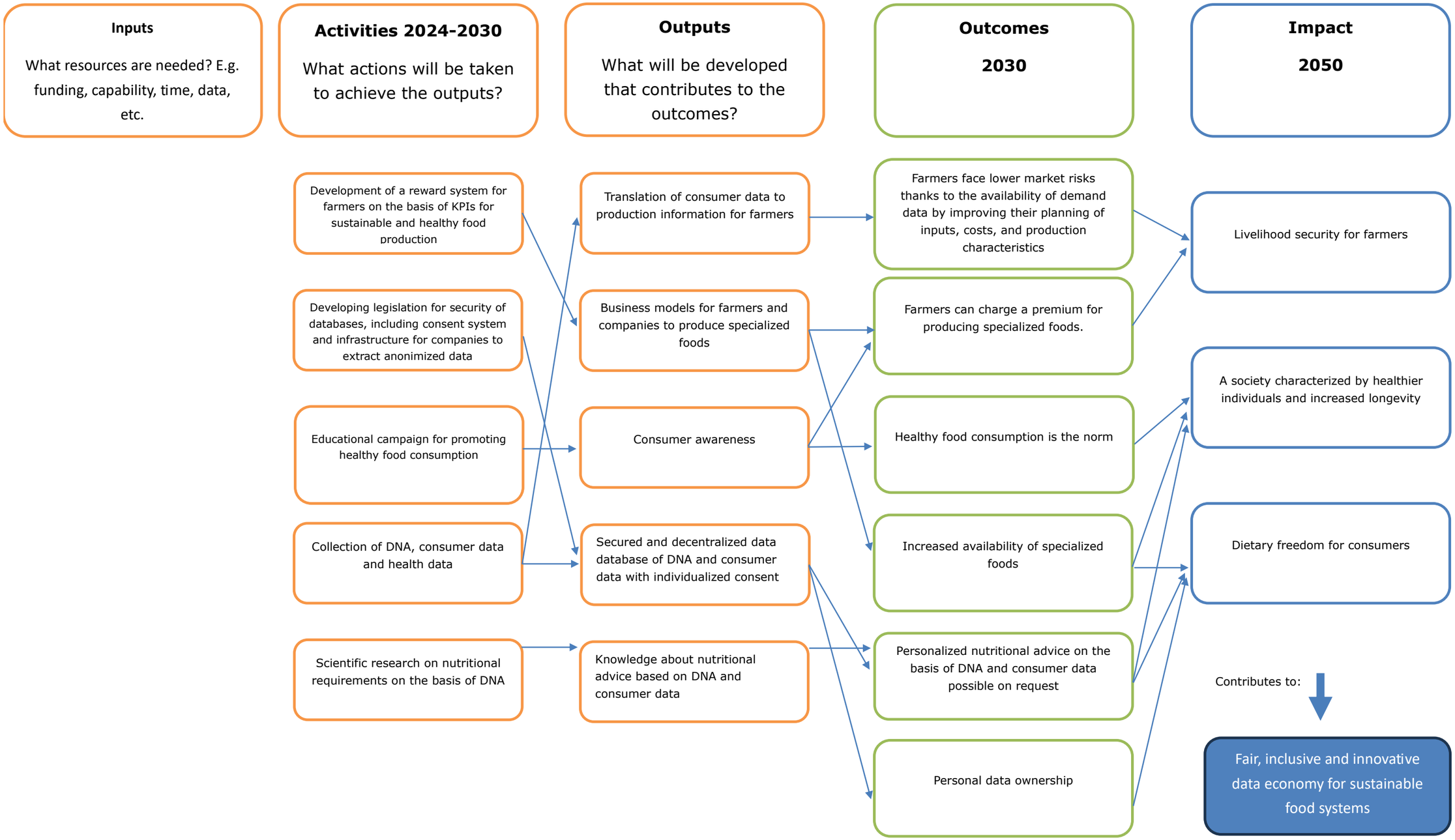

Figure 12: Schematic overview of the pathways linked to scenario A

5.1.3 Legal screening of the pathways for scenario A

Following the legal screening of the pathways for scenario A (see Appendix V, section 2.1), the proposed pathways align closely with existing EU policies, such as the CAP Strategic Plan Regulation (2021/2115) and the Farm to Fork (F2F) Strategy, which emphasise improving farmers' livelihood security, resilience, and sustainability within the agricultural value chain. These frameworks also address societal demands for healthier food systems, providing a solid foundation for realising the vision of healthier societies and greater dietary freedom for consumers. However, specific policy gaps persist, particularly in ensuring demand-driven data availability to support farmers in mitigating market risks and optimising production planning.

Moreover, the concept of "personal data ownership" is inconsistent with EU data protection principles, which regard personal data as a fundamental right rather than a tradable commodity. The General Data Protection Regulation (GDPR) emphasises safeguarding individuals' rights over their data rather than promoting ownership-based models. In business to business (B2B) data exchanges this is complemented by protections of trade secrecy. Policymakers should prioritise equitable data governance mechanisms that address ethical concerns, mitigate harms from inferred data, and balance individual rights with public interests. To achieve the broader goals of sustainability and innovation, targeted interventions, such as financial incentives for specialised agricultural practices, are essential to support data-driven decision-making and economic viability.

From the analysis of legal risks and impacts on fundamental rights, concerns are raised regarding data protection, equality, market power concentration, dependence on technology, and cybersecurity (see Appendix V, section 2.2). From a data protection perspective, the collection of a wide range of data - including sensitive categories such as genetic data and consumer behaviour data - should be evaluated through the lens of proportionality. This evaluation should occur on two levels. First, the data minimisation principle (GDPR Art. 5(1)(c)) should be applied, and each data category must be assessed to determine its relevance in providing optimal dietary advice. This principle is strictly enforced - as seen in the CJEU's 2023 *Mousse v. SNCF* ruling, where even seemingly justified data (e.g., gendered titles for train tickets) was deemed non-essential, highlighting that apps must limit data collection to absolute necessities while allowing users to volunteer additional information voluntarily. Second, in the context of potential public interventions, such as educational campaigns to promote personalised nutrition, the value of data protection must be confronted with the freedom to conduct business and the pursuit of public health objectives. The extensive collection of sensitive data by personalised nutrition companies could exacerbate power imbalances

between data subjects and data controllers. The pathways may also contribute to existing power imbalances and inequalities among food producers. For example, only highly skilled producers with sufficient resources for investment may be able to benefit from demand predictions. While elements of Scenario A could be supported through proportionate policy measures - such as subsidies or incentives for healthier food options - its current reliance on genetic and behavioural data for personalised diets would likely fail the legal tests of necessity and proportionality, risk discriminatory outcomes, and undermine consumer autonomy; any future approach must therefore preserve consumer freedom and limit sensitive data use to what is strictly essential.

The pathways reflect policy practices aimed at encouraging healthy diets at a general level. These can include sugar taxes and lowering taxes on foods considered healthy. These practices fall within the realm of soft law and nudging, and are policies that can be linked to positive health outcomes. In terms of regulation, there is a need to uphold human rights, which include the right to health and the right to non-discrimination. Additionally, there is a need to allow citizens to have some autonomy, thereby being free from automated decisions. There are several risks associated with rights in the pathways. Even if the basis is in the best interests of citizens, there remain overarching risks which need to be critically assessed in a human rights framework, and data protection. This leaves the viability of the pathways questionable regarding its compliance.

5.2 Scenario B: Local and transparent value chains

5.2.1 Discussion of scenario B

Most of the workshop participants appreciated this scenario for the idea that locally sourced food could reduce the environmental impact (Slovenia, Belgium) and support sustainable food systems (Belgium) or at least have reduced transportation (costs) (Slovenia, Latvia). An updated visualisation of this scenario is provided in Figure 13.

At the same time workshop participants said that there are some misconceptions incorporated in this scenario. For example, that local is not necessarily more sustainable as the (most) carbon emissions do not come from transport (Poland, Belgium). Looking only at the environmental data might not show the full picture regarding sustainable food systems (Belgium), and the scenario does not clearly include the processing part of the value chain, with its side and waste streams, and the potential for circularity (Belgium). Thus, it would be

desirable to introduce circular solutions, to minimise overproduction (Poland) and aim for waste avoidance and waste reduction (Latvia and Poland).

The scenario might thus be a bit 'romanticised' and probably can only exists alongside or in conjunction with one or more of the other scenarios (e.g., scenario 4 on data-driven decisions (Spain, Slovenia). According to some participants it is unrealistic to feed the EU´s population only with locally produced food. Concerns were raised about food sovereignty and potential shortages of certain foods, especially in contexts of natural disasters or adverse climate phenomena if there is too much reliance on local production (Spain). Furthermore, there were questions about the definition and scale of local (Netherlands, Spain). For example, it was unclear what local entails in terms of geographical scale, what would qualify as a local value chain and whether this means that data also must be stored locally (Netherlands). Moreover, as there is no clear definition of local, this may create confusion and may affect coherence in policy and practice implementation (Spain).

Participants did, however, value the establishment of a sustainable local market (Spain, Latvia, Slovenia), which mitigates the necessity to import products that are subjected to more expensive regulations and emissions than those within the local community (Spain). It would boost the local economy, making room for new food producers and creative incentives for local producers (Slovenia). This creates resilience of local food systems and enhances food diversity (Latvia).

Above all, the participants appreciated the transparency that is key to this scenario. It allows for accountability and traceability (Belgium, Poland) through clear product information on labels (Belgium). Increased transparency also creates closer links between different stakeholders in the value chain (Latvia, Netherlands, Spain). They play a key role in this scenario as transparency through data and information creates more environmental awareness and consciousness (Belgium, Latvia, Spain) and consumer trust (Latvia, Slovenia, Spain, Belgium). Additionally, consumers also become more aware of how costs and benefits are divided across value chain actors, resulting in a more evenly division of costs and benefits across the value chain (Netherlands). The government plays a role in raising awareness through the promotion of local food and informing consumers about a transparent choice (Slovenia), which in turn also enhances consumer trust and more responsible consumption practices (Spain).

The use of blockchain (or a similar technology or central data platform) facilitates transparency as it gives insights about who is involved, in what way, and what their position is in a data flow, under the premises that the different stakeholders all share their data (Netherlands).

Workshop participants had concerns about being able to compete with global markets (Netherlands) and the pricing of local food. They foresaw that in this scenario the food prices would go up, which would harm people with a lower income as it becomes more difficult for them to consume (Slovenia, Belgium). In addition, the accessibility and affordability of the technology for (small) farmers will likely be a challenge (Belgium, Slovenia) and related to that workshop participants wondered about the return on investment for these farmers (Belgium).

At the same time participants did see that digitalisation of local supply chains can save time for retailers and other food chain participants (Latvia). This brings us to the role of the retailer, which is rather absent in this scenario (Netherlands), as is the role of the (farm) advisor (Belgium).

Moreover, workshop participants questioned the emphasis on blockchain in the scenario. They wondered whether it was the right technology for facilitating transparency as it also captures a lot of data and information for a long time. According to the participants, some data will be kept for much longer than needed and/or than the data is of value. In addition, too much detailed data might be being shared (Poland). The abundance of data stored on such platforms brings additional environmental costs due to energy consumption of data sharing and data storage (Belgium). There are likely other data sharing platforms or technologies available that achieve the same outcomes of transparency, awareness, reduced impact on the environment, etc. that are more suitable than blockchain.

In addition, it was mentioned that the data governance of this scenario is challenging. There are concerns about data privacy and data ownership (and who benefits) (Belgium), as it may result in unauthorised access to data (Poland). Furthermore, the level of transparency required remains unclear (Netherlands), as well as the quality of the data being shared (Spain). This also requires a bigger role from the government to create regulations (Latvia) or exert control over such a centralised (Spain) data sharing platform (but not too stringent (Poland)). This may be a challenging exercise to get agreement amongst all stakeholders (Latvia) but ensures that everyone is following the same approach towards transparency (no one can hide relevant data for safe and local food production) (Slovenia).

In Figure 13, the desirable aspects identified from the scenario discussions are translated into an updated visualisation for desirable scenario B. Most importantly, a data exchange platform (e.g. data space) replaces blockchain and the role of retail is highlighted in relation to the visualisation of plausible scenario 2 in Figure 8.

Scenario B

Local and transparent value chains

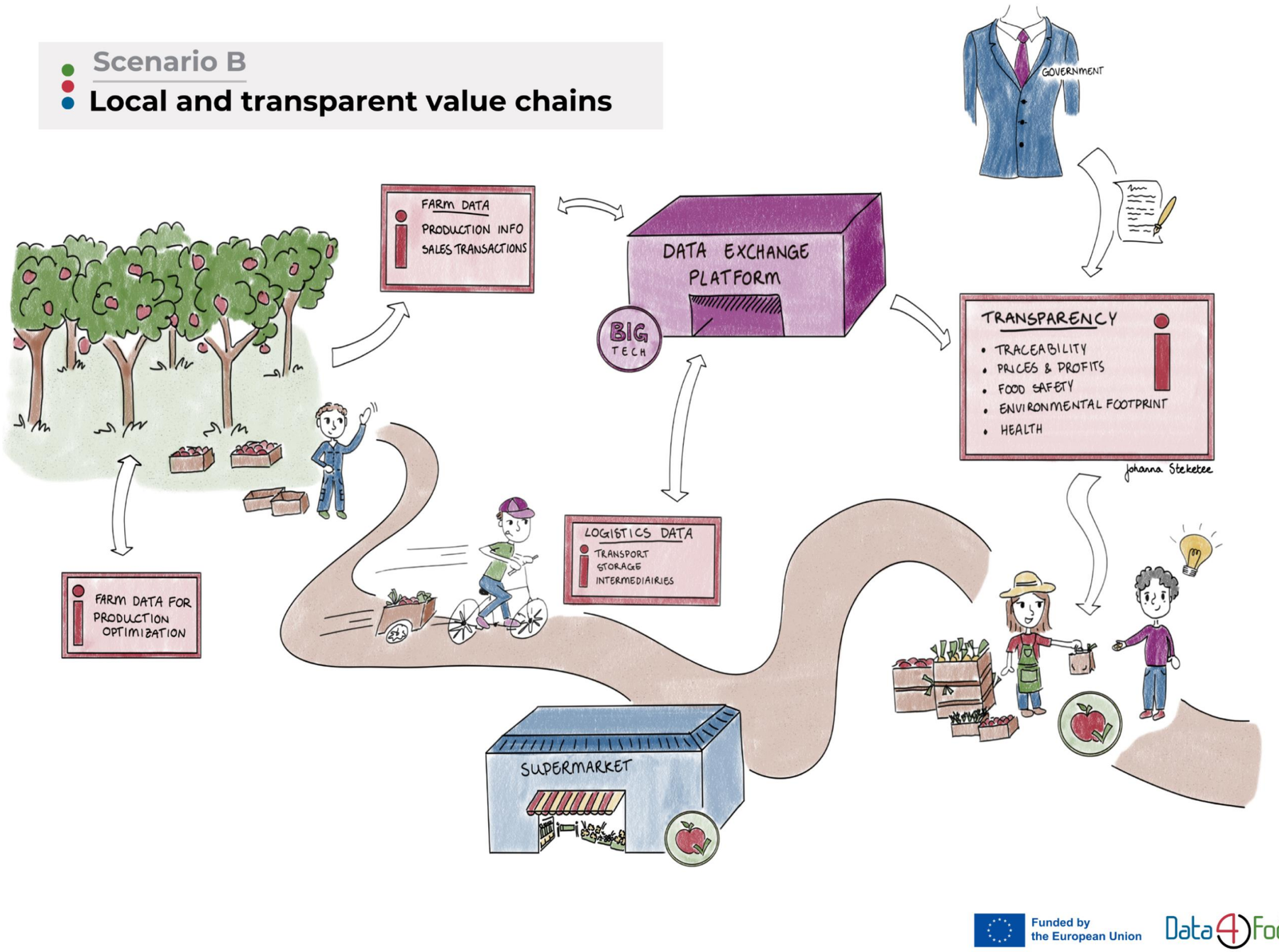

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Figure 13: Updated visualisation of scenario B

5.2.2 Pathways for scenario B

In the analysis of the backcasting exercise, three desirable pathways were identified for scenario B – Local and transparent value chains, shown in Figure 14.

Ensuring local food is accessible, available and affordable for all.

Local value chains and alternative food networks should provide accessible, affordable, and healthy food, driven by consumer demand. Achieving this requires extensive food and digital education to enhance consumer awareness of food production processes, fostering preference for locally sourced options.

This pathway contributes to an **inclusive** DE4FS, as efforts are made to build the capacity of consumers to effectively use and understand data, i.e. helping consumers access transparent food information to make informed choices for food consumption.

Driving strong and resilient local economies

Local economies can thrive through increased local value chains, alternative food networks, and enhanced cooperation among value chain actors, facilitated by data sharing on digital platforms. This requires digitally literate stakeholders, achieved through digital education, along with secure, privacy-compliant data collection and storage on data exchange platforms. For these data exchange platforms to work, they must be further developed in alignment with legislation concerning privacy and security mechanisms.

This pathway contributes to an **inclusive** DE4FS, as collaborative data sharing is one of the building blocks to drive strong and resilient local economies. This collaborative data sharing is based on using open standards and interoperable systems (allowing for better coordination), and results in access to insights and value created for all value chain actors involved. Additionally, a **fair** DE4FS is realised by the prioritisation of data security and privacy mechanisms, hereby protecting sensitive data and preventing exploitation.

Uniting value chains to actively reduce the environmental impacts of food production.

Local value chains, alternative food networks, and data sharing among value chain actors will ensure full product traceability and heightened consumer awareness of food's environmental impact. Legislation will need to be developed between 2024-2030 for compulsory transparency and traceability, this will lead to mandatory food labelling for transparency and traceability of food. Compulsory food labelling and legislation for transparency, combined with food

education, will foster collective consciousness amongst all value chain actors, demonstrating awareness of the environmental impacts of food production.

This pathway contributes to an **inclusive** DE4FS, as a wide range of stakeholders are actively involved in the creation, sharing and use of data. Moreover, mechanisms are in place that incentivise data sharing amongst different value chain actors. This results in value chain collaborations that support sustainable food systems. In addition, this pathway contributes to an **innovative** DE4FS as data exchange platforms provide a secure and transparent way to track and verify food products. This can be used to confirm the origins of produce, communicate agricultural production methods, or ensure fair trade practices. Such data exchange platforms support building trust between producers, retailers, and consumers by offering opportunities for transparency.

Scenario B: Local and transparent value chains

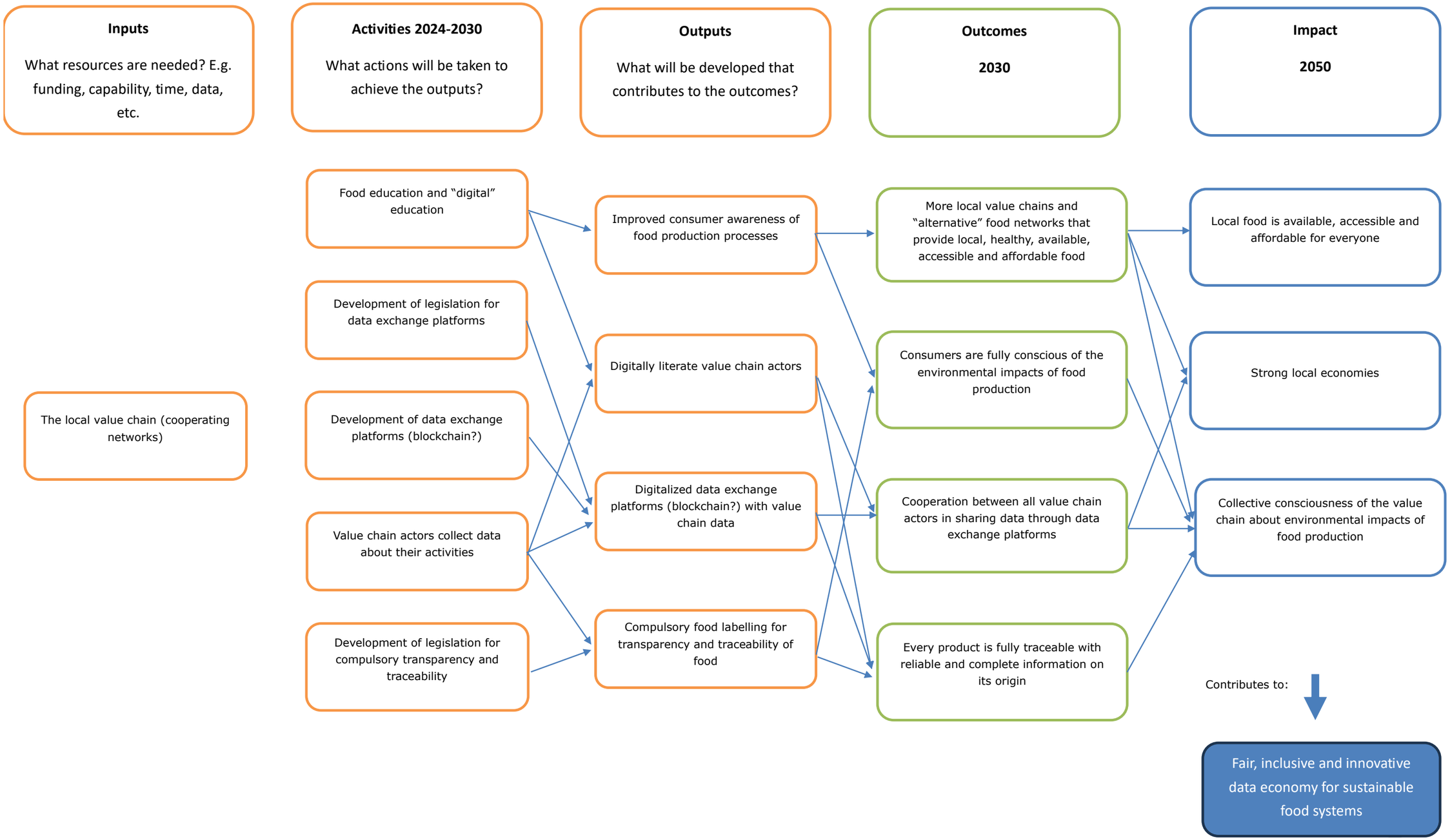

Figure 14: Schematic overview of the pathways linked to scenario B

5.2.3 Legal screening of the pathways for scenario B

Resulting from the legal screening of the pathways for scenario B (see Appendix V, section 3.1), the impacts and outcomes presented in the pathways are aligned with several EU policies and regulations. The Farm to Fork (F2F) Strategy supports the availability of affordable, local food by emphasising shorter supply chains and fairer economic returns. However, F2F stops short of explicitly defining "local" food, prioritising instead “shorter” supply chains. Similarly, strengthening regional innovation ecosystems aligns with the Digital Europe Programme and the European Regional Development Fund, supporting local regional economies and alternative food networks. Enhanced environmental awareness among value chain actors aligns with sustainability objectives in the F2F Strategy, the Regulation on food information to consumers, and the Corporate Sustainability Due Diligence Directive. However, the latter applies only to the largest agri-food actors.

Efforts to improve traceability and transparency of food systems are supported by policies like the F2F Strategy, which proposes harmonised labelling and expanded origin transparency. However, current regulations must be revised to the complete traceability envisioned in the pathways, highlighting the need for further legislative action. The digitalisation of value chain data exchange platforms aligns with the EU’s data strategy and the Common European Agricultural Data Space. Educational initiatives are particularly well-supported, with the F2F Strategy and EU Green Deal promoting digital literacy and advanced skills for value chain actors, complemented by the Skills Agenda. These alignments demonstrate substantial policy support but also underline areas requiring further refinement to realise the pathways' vision fully.

The analysis of legal risks and impacts on fundamental rights shows several issues (see Appendix V, section 3.2 for full analysis). One concern is the decreasing affordability of food, driven by rising production costs associated with stricter compliance requirements and full traceability measures that limit farmers’ choice of seeds and supplies. The need to integrate digital technologies into food production may further exclude small food producers, who often need help with high implementation costs. Additionally, the diversity of food production environments poses a challenge for data models to capture these variations adequately. While the pathways assume that local food systems are more sustainable than importing products from distant locations, this assumption warrants scrutiny. In some cases, the total environmental impact may be lower when food is sourced from regions with more agreeable conditions for crop production. Given the declining affordability of food caused by increasing regulatory demands and efforts to combat the climate crisis, critical questions arise about how

to redistribute the cost of agri-food systems transition related to countering climate change between value chain actors, ensuring everyone can afford food. This implementation of this scenario would require securing affordable food for consumers and appropriate legal changes to introduce specific full traceability requirements.

5.3 Scenario C: Strictly regulated high-tech for reduced environmental impact

5.3.1 Discussion of scenario C

In general, workshop participants acknowledge that this scenario at a high level offers solutions to current problems and needs in food systems, with a focus on sustainable agricultural production (Belgium). Through the widespread use of data, this scenario allows for an effective use of resources (Spain, Latvia), that eliminates harmful products and processes (Poland, Belgium), reduces food waste (Belgium, Spain), and enhances circularity (Spain, Belgium).

There is a strong farmer-centric view amongst the participants. They foresee that digital technologies that enable the use of data generated in real-time (IoT sensors, robots, artificial intelligence) are an opportunity to increase agricultural efficiency and productivity, translating into higher incomes or more profitability for the farmers (Spain, Poland, Belgium, Netherlands, Latvia, Slovenia). This allows farmers to stay focused on the economics, through easier and better decisions making (Slovenia). It will also reduce the administrative burden for farmers (Belgium).

Furthermore, the workshop participants acknowledge that data-driven decisions lead to the prominence of precision agriculture (Latvia), which can contribute to sustainable agricultural production processes on the farm: mainly due to efficiency of precisely determining agricultural input for optimal outputs (Latvia, Spain, Netherlands). This is seen as a win-win for the farmer and the planet: for the farmer because of the reduction of costs associated with optimal input use, and for the planet as limiting the overuse of inputs leads to a reduction of negative environmental impacts (Netherlands). Yet, it is also considered that this type of agricultural production may in fact promote more intensive agriculture when striving to the highest outputs possible (Belgium). And that environmental challenges cannot be solved on a farm parcel level only. There should be cooperation and collective analysis on a landscape level (Belgium).

The wider value chain also has a role to play in the success for farmers in this scenario: there would be better alignment and connections between processors and farmers through data

sharing, which also benefits advisors, who potentially will have access to data to support their farmers (Belgium). Hence, the demand and production needs are clearer (Belgium), allowing farmers to adjust prices based on available data about the demand (Belgium, Spain), which not only gives farmers the opportunity to better manage their income and operations (Spain), but also to rebalance power dynamics (Belgium). And when the agri-food sector is driving the development of new technologies, these technologies are becoming more affordable for small farmers (Slovenia).

Participants also see opportunities for addressing manual labour shortages by replacing this with automated digital technologies: extensive automation and robotisation on the farm can be a solution to labour shortages in agriculture (Netherlands, Belgium, Latvia). Possibly, high-tech and innovation applied to agriculture may even attract the younger generation back to farming (Slovenia). The use of certain on farm-technologies may also reduce or eliminate physically demanding and dangerous tasks for farmers (Spain).

On the other hand, the high level of technology use raises several questions. First, farmers would need to have a high level of digital skills (Slovenia) as they are almost required to become data analysts (Belgium), which also challenges the role of the farm advisor of the future (Belgium). And who bears the costs of such training (Spain, Belgium)? Perhaps more important, what does this mean for the identity of farmers (Belgium): is there still a need for agronomists directly on farms (Slovenia), or is it more important to have digital skills and a tech background as a farmer? Some participants do, however, believe that the farmer will remain a farmer and will not become a data manager (Netherlands).

This scenario may potentially lead to exclusion of farmers (often smallholder ones) and other value chain stakeholders (Poland, Latvia) and inequality in several ways. Firstly, high costs are associated with the adoption of new on-farm technologies (Latvia, Belgium) and its maintenance (Spain, Latvia). Secondly, the costs of data if they are not freely available (Latvia). Finally, the participants believe that there is an increased threat to the market position of small primary producers and processors who will no longer be able to compete due to rising costs. Altogether this raises concerns about who will benefit the most from this reliance on data (Latvia), as it means that there will be technology haves & have nots (Belgium).

While “environmentally” certified farmers will have an opportunity to achieve premium prices (Poland), ultimately this scenario results in higher food prices, on average (Belgium, Poland) which will further exacerbate (social) inequality. For bulk products, the food prices will go up (Netherlands), and these "data-enriched" food products may not be accessible to the whole

population (Spain). Therefore, the technology perhaps should be subsidised (Belgium). At the same time, some participants thought that the sustainability gains of increased digitalisation can outweigh the above-mentioned costs, resulting in net lower price for consumers (Belgium). Beyond the focus on the different stakeholders, this scenario has a strong focus on technology and data, about which the participants are generally positive. Data was seen as a tradeable product that has value of its own and gives added value to a food product (Netherlands). Data thus becomes an essential part of business models from actors all over the value chain (Poland). Furthermore, there is added value is the multipurpose re-use of data, although this data needs to be collected for a clear initial purpose (lean & mean) (Netherlands). Hence there is no need of more data, but better (i.e. qualitative and usable) data (Belgium). This structured, relevant, detailed, and high-quality data provides, as mentioned above as well, insights into value chain practices and processes (Poland, Belgium), supporting aggregated decision-making processes in the development of sustainable food production (Poland, Nederland).

Data also means an opportunity for enhanced transparency, which was a key topic for the workshop participants in Belgium in particular. They said that transparency encompasses traceability of the product by the consumer due to better labelling, hence increasing trust in sustainable purchases. Availability of data also encourages compliance with environmental policies by farmers. Thus, by 2050, non-compliance should no longer be an option, and all food should have traceability, i.e. the whole value chain is transparent. For the benefits of the data economy to appear, actions should be taken to eliminate unnecessary procedures and duplication of data stored in different places. In 2050, therefore, only the essential data will be collected, and the effectiveness of its use will be verified (including the impact on the environment—energy and water consumption, e.g., by data centres and computing centres) (Poland).

At farm level, it means that farmers can collect high-quality data on their own farm about all types of farm or product characteristics. Data collection on the farm using drones and sensors, where data is then stored in one database for the farmer, is seen as desirable, provided the farmer can manage this data themselves (Netherlands). It is an improvement that data about all kinds of processes on the farm can be collected in one database, compared to the current situation where data is collected and stored in different locations. When this can be combined in one system, the ease of use for the farmer improves (Netherlands, Belgium).

On the other hand, there are also threats to this (over)reliance on tech: for example, system failures can freeze the whole farm, and its food production processes, and farms are also more liable to be hacked or hijacked (Belgium). In addition, correct interpretation of data is very

important. It is often assumed that the data will tell us what we need to know, but in most cases trends and patterns require identification and correct interpretation (Latvia). Although the increased collection of data on farms may provide opportunities for governments to monitor sustainability (Belgium), workshop participants worry that this may lead to over-control and even intrusive and excessive government monitoring and intervention: over-regulation and excessive centralisation of the data economy should be avoided (Spain, Poland, Latvia, Belgium).

This raises broader concerns about the use of technologies and data. For example, the introduction of AI in all sorts of aspects comes with the risk of being misused (Slovenia). And with databases often containing excessive (not useful) amounts of data (Poland), it shows that there is a lack of clarity about the reduction of data, data storage and data circularity/re-use (Netherlands). And, on top of this, these technologies (robots, data centres, data processing, etc.) consume a lot of energy, so much so that some participants state that the environmental gains from smart farming are countered by CO2 production (Belgium).

Various participants also raised concerns about the role of big-tech companies (in and outside of agriculture) and large data centres. There is a risk that valuable data and information could end up in the hands of big tech companies (Slovenia). So much so that there are also concerns that these big tech companies control farming as tech becomes more complex and harder to set-up and manage (Belgium). Or, at the very least, farmers may not reap (sufficient) benefits, despite generating a lot of valuable data, due to the substantial power wielded by the government and major technology companies (Spain). The farmer sees little value from the totality of data that is collected and combined, but major technology companies certainly do (Netherlands). This shapes possibilities for the abuse of power by these large companies (Belgium, Spain, Poland). Additionally, data centres have the potential to exert control and enforce sanctions. For example, data centres might have the ability to restrict access to data or services. This could extend to enforcing compliance with laws, regulations, or internal policies, which may be seen as an intrusion into autonomy and privacy of both individuals and private companies (Spain). And, although the foundation of the scenario is about strictly regulation of high technology and innovation, even the role of the government is questioned, with participants raising concerns about transparency and increased concentration of power (Spain).

In other words, governance is key in this scenario, as there seems to be a fine line between desirable opportunities for monitoring and undesirable opportunities for over-control (Belgium). So, despite the concerns about over-control and over-regulation, participants do find it

important that the government could play a stronger role (in relation to data control) (Netherlands). Workshop participants see a desirable role for the state to create standards for data formats and interoperability, for efficient and fair data sharing, hereby using automated data confidentiality management and necessary consents. Moreover, with the amounts of data collected, stored and shared in agricultural production and food systems, workshop participants acknowledge the need for regulations to ensure fair data practices and their reinforcement, while, at the same time ensuring data transparency and insights (Belgium, Poland). New legal framework should be developed when there is a gap in current regulations. Otherwise, better enforcement of the regulations in place can be a fair solution.

Governmental access to data would also allow for better assessments of real policy interventions impacts, and data driven policymaking is more likely to bring benefits (Belgium). The Spanish workshop participants even stated that the government needs data to make more informed decisions and legislate for the common good, including the possibility of implementing fair sanctions and more effective control. In addition, various countries indicated the need for financial support, e.g. government incentives for food producers to become more high-tech (Slovenia). Funding is seen as desirable but challenging in a free market economy (Latvia). Furthermore, concerns remain about organising an effective governance structure as data ownership or data control remain difficult topics to handle right (Netherlands), although ideally ownership of data by farmers is perceived as crucial to ensuring more efficient work with fewer resources.

In Figure 15, the desirable aspects identified from the scenario discussions are translated into an updated visualisation for desirable scenario C, which combines both scenario 3 and 4. Most importantly, the visualisation of scenario 4 (Figure 10) is taken as the basis for the visualisation of desirable scenario C. In comparison to Figure 9 and 10, the prominence of food industry and food innovations is diminished. In addition, the role of the government is clarified by showing the trade-offs between monitoring and overcontrol.

Scenario C

Strictly regulated high-tech for reduced environmental impact

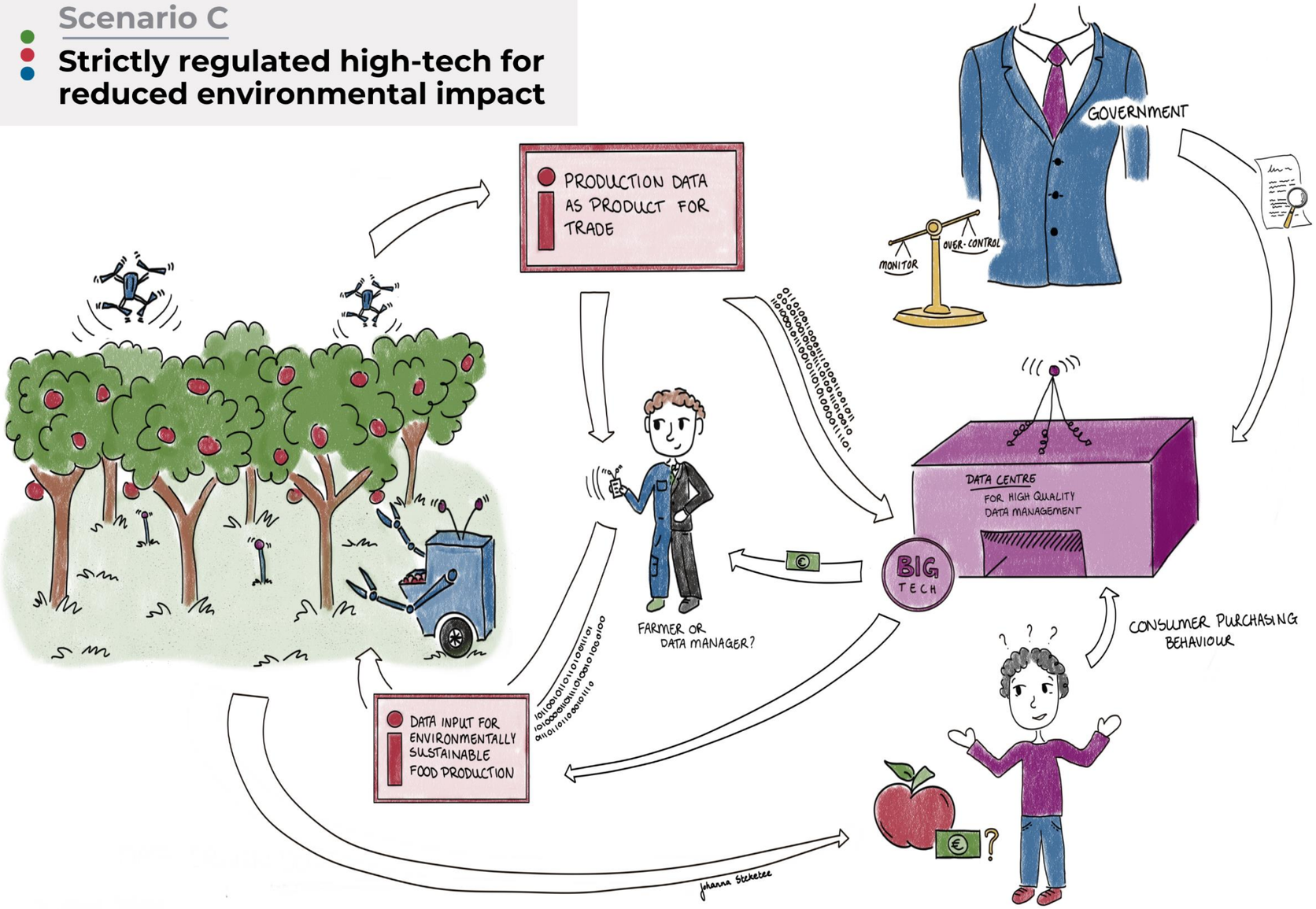

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Figure 15: Combined and updated visualisation of scenario C

5.3.2 Pathways for scenario C

Based on the workshop data two main pathways for scenario C are identified (see Figure 16).

Upholding full compliance in the agri-food sector by eradicating harmful products and practices.

It is essential to enhance farm efficiency and productivity through data-driven decision-making and precision agriculture, while ensuring certification for environmental aspects and food quality across the value chain. This requires improved digital skills, a data-sharing platform for farmers with improved data sharing standards and interoperability, affordable decision support tools, and structured, high-quality data, and a data governance intermediary to streamline data roles and capture environmental aspects.

This pathway contributes to an **innovative** DE4FS as the efficiency, sustainability and resilience of food systems is enhanced by transformative ways of using data. Here, technologies support the creation of data-driven insights and optimised decision-making in the value chain. This can be used for improving transparency and circularity of food production methods, and the eradication of harmful products and practices.

Securing sustainable livelihoods for farmers.

Enhanced efficiency through data-driven decisions and certification for environmental and food quality are essential, alongside improved labour conditions in farming, with reduced administrative burdens and labour shortages while preserving farmer expertise. Additionally, fairer prices and improved business models for farmers, supported by collaboration between technology providers and value chain actors, along with improved digital skills and data governance, will ensure balanced power dynamics in the agri-food sector.

This involves business model development for farmers to incentivise the use of data for sustainable production processes, as well as business model development for technology provides to create combined and interoperable systems. The agri-food sector will also get more involved in technology development. This also requires digital tech awareness building for all value chain actors (producer to consumer). Furthermore, legislation and governance need to be improved and become more effective and supportive of data control for farmers and environmentally friendly food production. The specific inputs that were mentioned for both pathways are lean and mean data (e.g. no excessive data collection and storage), financial support for technology investments of farmers, and data-driven policy making. In other words, it is essential to only collect the data once and store it in such a way that it allows for re-use.

This pathway contributes to a **fair** DE4FS, by striving for data sharing platforms for farmers with improved data standards and interoperability standards and ensuring equal participation. Additionally, the pathway contributes to an **innovative** DE4FS, because the availability of high-quality data is used to support new business models. Finally, the pathway contributes to an **inclusive** DE4FS, addressing power imbalances in food systems with enhanced value chain cooperation for the use of data.

Scenario C: Strictly regulated high-tech for reduced environmental impact

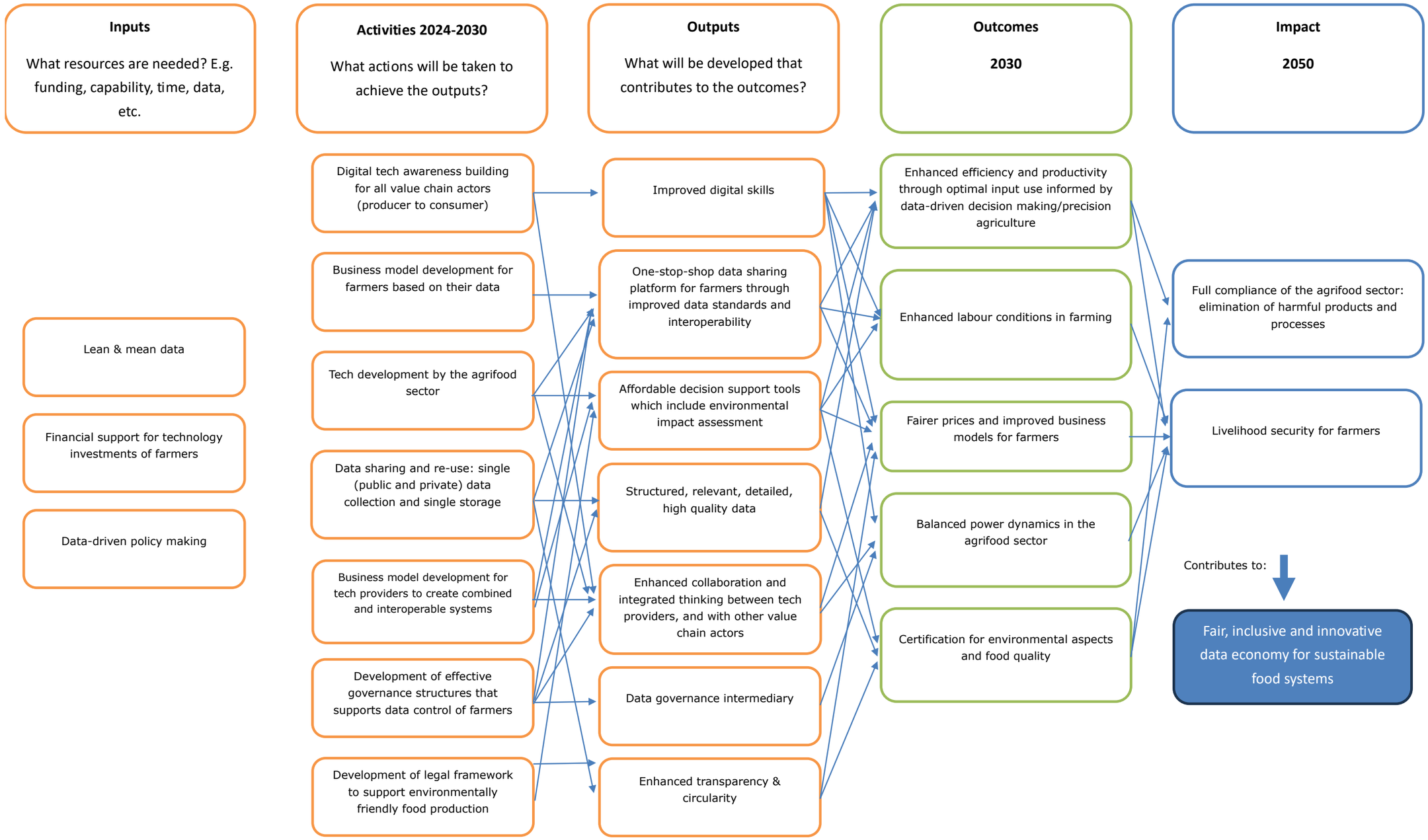

Figure 16: Schematic overview of the pathways linked to scenario C

5.3.3 Legal screening of the pathways for scenario C

Resulting from the legal screening of the pathways for scenario C (see Appendix V, section 4.1), existing EU policies and regulations, particularly in areas like labour conditions, fair pricing, and digital innovation, show significant alignment with the pathways related to this scenario. For instance, the Common Agricultural Policy (CAP) regulation on strategic plans fosters social inclusion, improved labour conditions in rural areas, and a stronger position for farmers in the value chain for fairer economic returns. The Farm to Fork Strategy supports tailored solutions for small and medium-sized enterprises (SMEs), sustainability-focused advisory services, and better business models, aligning with the pathways' goals. However, the pathways' emphasis on "full compliance" with environmental and food quality standards highlights gaps, as current EU initiatives—such as anti-food fraud measures—fall short of this target, revealing a need for more enforcement mechanisms.

Several outputs, such as data-driven decision-making and enhanced collaboration among value chain actors, are well-supported by existing frameworks. The Common European Agricultural Data Space is a promising initiative aligned with the pathways' goal of creating one-stop-shop data platforms. The Farm Sustainability Data Network and Digital Europe Programme provide critical tools for fostering high-quality data collection and digital skills development across the agri-food sector. Additionally, interoperability requirements under the Data Act (DA) and support for innovation ecosystems like European Digital Innovation Hubs further enhance the pathways' alignment with current EU objectives. Nevertheless, gaps remain, particularly in establishing robust governance structures for data control by farmers and achieving fully integrated and interoperable systems.

From the analysis of legal risks and impacts on fundamental rights certain concerns are raised. One issue regards a possible lack of inclusivity of alternative production methods in on data and digital solutions for farmers. The increasing demand for highly digitally skilled workers may in parallel be linked to a decline for the need for less qualified employees, potentially leading to issues such as job displacement. Furthermore, while higher food production costs and fairer prices for actors within the agri-food value chain may promote equity, they could also result in reduced affordability for consumers (see Appendix V, section 4.2). While fairer prices for farmers and sustainable production methods may initially raise food costs, affordability can be safeguarded through policy design—for example, by redirecting subsidies to support low-income consumers, incentivising cost-efficient agroecological practices, or using taxation reforms to offset price increases. This balances equity across the value chain with accessible food, turning a

potential trade-off into mutual progress. Implementation of such scenario would require appropriate policy and regulatory intervention which secure the affordable food for consumers .

5.4 Synthesis

5.4.1 Leverage points

In total, eight pathways have been developed that aim to realise three desirable scenarios for a fair, inclusive and innovative data economy for sustainable food systems. These pathways are:

- 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

It is important to note that these scenarios and pathways are not mutually exclusive and can exist alongside each other, especially considering the overlapping aspects that can be found in the scenario discussions and pathways.

In terms of overlap between pathways firstly, both scenario A and scenario C include a pathway for securing sustainable livelihoods for farmers. Thereby, it emphasises the importance of this topic and creates an opportunity for synergies in policy recommendations (see Chapter 6). However, although both pathways aim for securing sustainable livelihoods for farmers, they come from different viewpoints. In scenario A, the focus is on reducing farmers' market risks through enhanced knowledge and availability of data about the demand of food. This can help farmers to improve the planning of inputs, costs and production characteristics. In scenario C, the pathway presumes farmers' livelihood security, because of enhanced efficiency and productivity through optimal input use based on data-driven decision making. Moreover, it is emphasised that underlying power dynamics in food systems need to be balanced for farmers to secure sustainable livelihoods. The two pathways from scenario A and scenario C sympathise about the importance of certification and charging premium prices for complying with certain standards of food production. For scenario A, this is about standards for (processed and specialised) healthy and

sustainable food, whereas for scenario C, the emphasis is more on environmental aspects of food production. All in all, the role of **available high-quality data** (be it demand data to lower market risks or production data to enhance input efficiency) is deemed crucial for securing sustainable livelihoods for farmers.

Secondly, and related to securing sustainable livelihoods for farmers, is the importance of new and improved business models. This does not apply only to farmers, but to actors in the entire value chain. In scenario A, the development of new business models is considered important for both farmers and companies in the production of specialised healthy food products. This is believed to result in guaranteeing dietary freedom for consumers, building a thriving and healthy society and securing sustainable livelihoods for farmers. In the context of scenario C, new business models (of which data as tradeable product becomes an essential part) lead to securing farmers' sustainable livelihoods as well. In addition, business model development for technology providers is believed to be crucial for creating combined and interoperable systems for data exchange, such as one-stop-shop data sharing platforms for farmers with improved data standards and interoperability. **New and improved business models based on data** for all value chain actors are thus considered essential preconditions for realising the desirable impacts of the scenarios for a fair, inclusive and innovative data economy for sustainable food systems.

Thirdly, pathways for achieving desirable impacts of the scenarios overlap in their recommendations related to education. This is considered an important topic in all scenarios and multiple pathways. For scenario A, the topic of education primarily relates to educating consumers for promoting healthy food consumption with the main aim of building a thriving and healthy society. In scenario B, the aim of education is mostly related to creating improved consumer awareness of food production processes. This creates demand for food coming from local value chains and "alternative" food networks, ensuring local food is accessible, available and affordable for all and uniting value chains to actively reduce the environmental impacts of food production. Moreover, scenario B also highlights the importance of digital education to stimulate more digitally literate value chain actors to drive strong and resilient local economies. Finally, scenario C emphasises the need for improved digital skills of all value chain actors. **Improved digital skills** lead to better data-driven decision-making, resulting in upholding full compliance in the agri-food sector by eradicating harmful products and practices. Furthermore, digital skills can support enhanced labour conditions in farming and lead to new business models. This contributes to securing sustainable livelihoods of farmers. Education about digital technologies, data usage, or even food production and consumption, for a variety of value chain actors is thus seen as important in realising the desired impacts of the scenarios.

Finally, all scenarios involve certain pathways that mention the **importance of legislation** in relation to the data economy. In scenario A, legislation is deemed important by stakeholders in the context of security of databases with storage of DNA and consumer data. This includes developing consent systems and infrastructures for companies to extract data while still protecting sensitive data from misuse, manipulation and exploitation. These are considered prerequisites to use such databases to create nutritional advice based on DNA and consumer data, ultimately leading to building a thriving and healthy society while guaranteeing dietary freedom. Furthermore, according to stakeholders, legislation also has a place in the pathways for scenario B. Here, it is emphasised that digitalised data exchange platforms with value chain data need to be aligned with legislation concerning privacy and security mechanisms of said value chain data. A final legislative measure that is brought up by stakeholders in the pathways is the development of effective governance structures that support data control for farmers. This is meant to uphold full compliance in the agri-food sector by the eradication harmful products and practices, while also contributing to securing sustainable livelihoods for farmers. The need for legislation of the data economy to ensure it is fair, inclusive and innovative is thus evident.

5.4.2 Contradictions

Although there are many overlapping aspects that prove the scenarios and pathways are not mutually exclusive and are able to coexist, 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.

A first point of difference can be seen between scenario A and B in how they frame the **type of food** that needs to be produced and consumed. Scenario A focusses on healthy food to build a thriving and healthy society. Here, healthy food may involve processed food. In fact, if food can be ‘upgraded’ using added vitamins, there is no harm in that if it matches the personalised healthy diet demand of consumers. Scenario B focusses on local food, which has the underlying assumption that this is automatically healthy and sustainable, as the scenario also aims to reduce the environmental impact of food production. However, it is not made explicit in this scenario what the quality of the produced local food is and whether this indeed is healthier for the consumers than food that is not produced locally. Moreover, striving to more local food production with short supply chains also implicitly assumes a smaller role for processing in said supply chains: as short supply chains are associated with fresh produce rather than highly processed foods, this clashes with the role of processing in scenario A.

A second point of debate is identified when considering **food prices**. Throughout the three scenarios, there is no agreement about the height or direction of food prices. In scenario A, it is

mentioned that farmers ask premium prices for specialised foods. Therefore, the prices of "healthy" food may go up. Yet, the scenario also involves a large role for subsidies. Among others, these subsidies are meant to lower the prices of healthy food for the consumer, to make healthy food more affordable and accessible. In scenario B, workshop participants foresee that the food prices will go up as well, which would harm people with lower incomes. In scenario C, both the options of food prices to go up and down are mentioned. On the one hand, "environmentally" certified farmers will have an opportunity to ask premium prices for their products. Thus, this scenario results in higher food prices, exacerbating (social) inequality. At the same time, some participants thought that the sustainability gains of increased digitalisation can outweigh the above-mentioned costs, resulting in net lower price for consumers.

In addition, there has been much of discussion in the workshops about whether **centralised or decentralised databases** are more desirable. In scenario A, it is mentioned that participants argue that centralisation of data about consumption behaviour, purchasing preferences and personal characteristics is undesirable, due to power dynamics. This is why the pathway includes the creation (by the government) of a secured and decentralised data storage of DNA and consumer data with individualised consent. Similar for scenario C, where excessive centralisation of data should be avoided, to reduce power imbalances and enhance autonomy and privacy of individual value chain actors. In scenario B, however, a central data exchange platform is key. The use of blockchain (or a similar technology or central data platform) facilitates transparency as it gives insights into who are involved, in what way, what their position is in a data flow. Yet, in all these scenarios there is still a key role for the government regarding the monitoring of the process.

Finally, inherent to scenario A is a discussion on whether **data collection should be voluntary or involuntary**. The data collection in scenario A encompasses personal and sensitive data, such as consumption behaviour and DNA. Although the scenario states that people are not obliged to get a personalised healthy diet, it remains ambiguous about the voluntary aspect of the data collection. This ambiguity is there because during the national workshops different participants had different perspectives about this, and those were not resolved at that point in time. Mandatory data collection raises various concerns about privacy, safety autonomy, power imbalances, and some workshop participants were worried about the controlling role of the government in this scenario. Mandatory data collection and perhaps other aspects of the three scenarios can thus be in contradiction with various existing EU laws and regulations.

5.4.3 Synthesis of legal screening

The analysis of the pathways, legal acts, and policy documents leads to the conclusion that most elements of the pathways are **reflected in existing legislation and policies**. These include

efforts to improve the livelihoods of farmers, promote digital and dietary education, establish networks connecting agri-food actors with digital technologies, provide advice to agri-food actors for developing new business models incorporating digital tools, and address issues of compensation and affordability. Frameworks such as the Farm to Fork Strategy and the CAP Strategic Plan Regulation (2021/2115) lay the groundwork for visions of healthier societies and greater dietary freedom for consumers. Additionally, the strengthening of regional innovation ecosystems aligns with initiatives like the Digital Europe Programme and the European Regional Development Fund, which support local economies and alternative food networks.

Across pathways of all scenarios, several potential risks have been identified that should be considered. The **inclusivity of agri-food systems** must be addressed at the level of food producers by facilitating the adoption of digital technologies for small-scale producers, while also ensuring space for those who wish to produce food using more traditional methods. The increasing number of compliance obligations, the costs associated with technology implementation, and the push for fairer value distribution within the food value chain may disrupt the current economics of food systems. It means that the current model inadequately compensates farmers, but the costs to consumers may increase in new food systems models. Moreover, the pathways do not adequately address the **concentration of market power**. Another critical concern is the **ineffective enforcement of data regulations** to ensure regulatory compliance and enforce consumer protection, particularly in the context of more specialised food services, such as personalised nutrition.

From the perspective of the pathways, existing legislation contains gaps that need to be addressed. While the Data Act and Data Governance Act provide a framework for data sharing, there is a pressing **need for robust governance structures** that empower farmers to control their data and ensure fully integrated, interoperable systems. In terms of traceability, current legislation must be revised to require comprehensive information on the entire value chain, including environmental impact data for products. Furthermore, the call for compliance with environmental, data protection, and food quality standards emphasises the importance of an effective enforcement system. The focus on combating food fraud is insufficient to guarantee data protection, consumer safety, or safeguard vulnerable actors within the value chain. A discussion on legal enforcement in the data economy in food systems is needed.

While these pathways align broadly with EU policies, they do not reflect the entirety of the judicial process and the diverging results that arise when balancing the interests of various food system stakeholders and interest for the common/public benefit. Policies are the result of compromise of many interests; the strategic plans and regulations of the CAP reflect this, aiming to balance

necessary sustainable outcomes while striving to ensure an adequate level of protection and skills development for food system actors like farmers. The policy may be well-worded to achieve balance, but the implementation and focus of the policy in real life may vary based on political and societal interests. Frictions arise when implementing these policies, which may fail to adequately and fairly support outcomes in food systems.

Regulations and policies are static words, but their implementation reveals they are very much a living instrument. Like actors and stakeholders in food systems, none of these regulations are islands but deeply interrelated policies representing key areas of focus. Already, a few cases are being pleaded in national courts for CAP strategic plans that are not doing enough to protect the environment. Such cases highlight the discrepancy and friction between regulatory intentions and societal needs. As the symbol of justice stands, courts aim to balance this.

6 Stakeholder recommendations

Through the input of stakeholders, three leverage points have been identified that are key in the realisation of the desirable impacts of the scenarios. According to the stakeholders, targeting and addressing these leverage points by policymakers and regulators would lead to a fair, inclusive and innovative data economy for sustainable food systems.

Although the research questions target the role of policymakers and regulators, the authors acknowledge the important role that all stakeholders of the DE4FS have in contributing to a fair, inclusive and innovative data economy for sustainable food systems. These recommendations are therefore not only for the responsibility of policymakers and regulators, but require the involvement of various stakeholders of the DE4FS to realise the desirable impacts of the scenarios through the pathways.

Moreover, it becomes apparent from the legal screening that even the desirable pathways may still have legal risks and/or conflicting legal values. Examples are concerning data protection (and related enforcement issues), possible inequalities market concentration, cybersecurity, dependence on technology, misuse of data, and the costs of food. These risks must be weighed against the evolving regulatory landscape, where strategies like Farm to Fork may lapse but their legal foundations (e.g., CAP 2021/2115) endure, demanding scrutiny of both policy shifts and their downstream legal implications. It is beyond the scope of this report to include this in the stakeholder recommendations.

6.1 Securing sustainable livelihoods for farmers by ensuring the availability of high-quality data.

A first recommendation includes ensuring the availability of high-quality data for farmers, both regarding food demand, as well as regarding food production. According to the stakeholders this will aid farmers in mitigating market risks and optimising production planning, therefore securing sustainable livelihoods for farmers.

Following from the pathways for scenario A and C, securing sustainable livelihoods for farmers is deemed crucial for achieving a fair, inclusive and innovative data economy for sustainable food systems. The availability of high-quality data plays an important role in this. On the one hand, farmers' market risks can be reduced through enhanced knowledge and availability of data about

the demand of food. On the other hand, farmers' livelihood security can be realised through enhanced efficiency and productivity by optimal input use based on data-driven decision making.

From the legal screening, it appears that livelihood security for farmers is already described as one of the key goals in several major policies (e.g. CAP Strategic Plan Regulation (2021/2115) and F2F). The objectives of such regulations cover the aspect of the farm income, improvement of the farmers' position in the value chains, and generation of fairer economic returns in the supply chain: all important aspects mentioned in scenario development, scenario discussions and/or pathway development. Yet, the role that high-quality data can play in securing these sustainable livelihoods for farmers is not highlighted in EU policies and regulations. Particularly, policies and regulations fall short in ensuring the availability of high-quality data to aid farmers in mitigating market risks and optimising production planning.

6.2 Developing new and innovative business models for all value chain actors

A second recommendation involves the development new and innovative business models for all value chain actors, e.g. for farmers to secure sustainable livelihoods; for technology providers to create combined and interoperable systems for data exchange; and for food processors to produce specialised healthy food products. It is thereby important to consider and include non-monetary perspectives of value into the business model. Especially if we let requirements of fair and inclusive lead the way to a future DE4FS.

To realise a fair, inclusive and innovative data economy for sustainable food systems, business models for all value chain actors are key. For farmers, this contributes to ensuring sustainable livelihoods. Additionally, for technology providers, business models are crucial for creating combined and interoperable systems for data exchange, such as one-stop-shop data sharing platforms for farmers with improved data standards and interoperability. Finally, for food companies, business models for producing specialised healthy food products contributes to building a thriving and healthy society.

Business models for both SME food producers and processors are mentioned in the policy documents analysed in the legal screening. In the F2F strategy, it is highlighted that ensuring tailored solutions to help SME food processors and small retail and food service operators to develop new skills and business models, while avoiding additional administrative and cost burdens. It will provide guidance to retailers, food processors and food service providers on best

practices on sustainability. In addition, the Enterprise Europe Network provides advisory services and tailored solutions to help SME food producers develop new skills and business models. Yet, this neglects the need for data-driven business models, and the role of technology providers to be able to develop combined and interoperable systems for data exchange, such as one-stop-shop data sharing platforms for farmers with improved data standards and interoperability.

6.3 Strengthening digital and food literacy of all value chain actors

A third recommendation is to strengthen digital and food literacy of all value chain actors. This stimulates consumer awareness for sustainable and healthy food consumption, and the improvement of digital skills which leads to better data-driven decision-making in value chains.

In all scenarios, pathways include a role for education to realise desirable impacts. For scenario A, this concerns food literacy, i.e. educating consumers for promoting healthy food consumption with the main aim of building a thriving and healthy society. This relates to scenario B, where the aim of education is mostly related to creating improved consumer awareness and demand for food coming from local value chains and “alternative” food networks. These forms of education are more consumer focussed. On the other hand, pathways for scenario B and C include digital literacy. Firstly, to stimulate more digitally literate value chain actors to drive strong and resilient local economies. Secondly, to improve digital skills of all value chain actors which leads to better data-driven decision-making, which in the opinion of stakeholders would uphold full compliance in the agri-food sector to eradicating harmful products and practices.

Food literacy becomes apparent in policies and regulations through labelling policies (e.g. F2F) that aim to empower consumers to make informed, healthy and sustainable food choices. This also includes a proposal for harmonised mandatory front-of-pack nutrition labelling. Yet, the proportionality of a possible educational campaign (funded publicly) that aims to promote food consumption based on a personalised diet (dependent on the collection of sensitive personal data) should be assessed due to potential conflicting legal values, such as data protection, public health and freedom to conduct business.

Regarding digital education, this is also supported by existing EU policies. For example, the EU Green Deal aims to promote basic digital literacy of value chain actors and adapt skills of people who are or will be affected by the digital transformation and transition to climate neutrality. These alignments demonstrate substantial policy support but also underline areas requiring further refinement to realise the pathways' vision fully.

7 Discussion & conclusion

The aim of this study was to identify plausible future scenarios for a fair, inclusive and innovative data economy for sustainable food systems and desirable pathways that can support regulators and policymakers in realising desired aspects of future scenarios while avoiding undesirable ones.

Four plausible scenarios for the DE4FS in 2050 have been developed in participatory stakeholder workshops in six European countries. These scenarios are not mutually exclusive but differ in the ways in which they emphasise certain technological, economic, legal, environmental and social aspects of the DE4FS. In backcasting workshops, stakeholders reflected on these plausible scenarios and identified the desirable and undesirable aspects and impacts. This ultimately led to the creation of three desirable scenarios. To realise the desirable impacts of these scenarios, eight pathways are developed. (see Table 8). In these pathways, inputs, activities, outputs and outcomes for 2030 are described that may contribute to a fair, inclusive and innovative DE4FS in 2050.

Table 8: Overview of desirable scenarios and related pathways

Scenario		Pathway
A	Personalised healthy diets	Guaranteeing dietary freedom for consumers
		Building a thriving and healthy society
		Securing sustainable livelihoods for farmers
B	Local and transparent value chains	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
C	Strictly regulated high-tech for reduced environmental impact	Upholding full compliance in the agri-food sector by eradicating harmful products and practices
		Securing sustainable livelihoods for farmers

During the development of the pathways it became clear that there were several overlapping aspects of these pathways between multiple scenarios (see section 5.4.1 for more detail). These overlaps have led to a set of recommendations based on workshop participant's normative input.

7.1 Discussion

7.1.1 Methodology discussion

The DE4FS is a relatively new concept. While it is an integral part of the Data4Food2030 project to understand and further develop this concept, the lack of a shared clear and short definition of the DE4FS complicated the execution of stakeholder workshops. Whilst the researchers had generated a simple working definition, they identified a limited understanding of the data economy, let alone the DE4FS, by the workshop participants. This is in line with the conclusion of deliverable 4.1. (see Appendix I). Thus, it was easier or more tangible for the participants to give input from the perspective of food systems than from the perspective of the data economy, which therefore reduced the incorporation of the data economy perspective in the scenarios compared to a food systems perspective. It shows that (integrated) systems thinking is a challenging and sometimes difficult exercise for most workshop participants. To give more attention to stakeholders' perspectives of the data economy, the researchers of WP4 aim to include this in T4.3 Stakeholder feedback and monitoring.

In line with the previous limitation, during the scenario workshops, workshop participants were asked to develop plausible scenarios for the year 2050. The year 2050 was chosen to function as distant point on the horizon. This way, participants were stimulated to think outside of current possibilities and imagine a future that is not limited by today's structures with regards to envisioning the future of the DE4FS. In practice, however, imagining this distant point on the horizon appeared to be quite difficult to grasp for workshop participants. This may have been due to the necessary methodology step of the introduction of trends, which were relevant to participants in the present as well. Therefore, today's structures were still on the forefront of scenario development. During the backcasting workshops it was noticed that working backwards from impacts of 2050 to pathways for outcomes in 2030, i.e. imagining the nearer future was more manageable for the participants. It is also an indication that, although systems thinking was challenging, the workshop participants did feel comfortable with the normative questions they were asked to engage with.

Moreover, finding workshop participants has been quite a challenge in multiple countries. This meant that for the backcasting workshops few countries had less participants present than recommended based on the chosen methodology, as the workshops were designed with a certain amount of workshop participants in mind. Furthermore, having less participants also affected the diversity of views and variety of stakeholder groups. Therefore, in some countries, the workshop

programme was on the spot adapted to suit the number of participants whilst achieving similar intended outcomes.

Additionally, when legislation was discussed during the workshops and in the pathways, it often focussed on security and data protection. However, people need to be viewed as more than consumers and/or users of data and food. Therefore, there are more rights and protections that need to be realised, for example: considering collective profiling and potential discrimination by DNA, right to adequate food, right to health, rights to adequate work. Although important, this was not raised by workshop participants, and therefore these topics cannot be further addressed in this empirically based report.

Finally, the methodology applied in the legal screening of the pathways pursued to review regulatory intention aligned with these pathways, but it doesn't analyse all potential discrepancies in how these are applied. Future and perhaps deeper longitudinal case law analysis may be needed to reconcile these pathways with the directions and intentions of various courts or enforcement bodies. In essence, policies and regulations are just the starting point, but the enforcement and application will serve as testimony to the potential realisation of these pathways.

7.1.2 Results discussion

The scenarios and pathways for a fair, inclusive and innovative data economy for sustainable food systems show how stakeholders perceive the data economy. Stakeholders have prioritized dietary freedom, healthy societies, farmer livelihoods, strong local economies, and eradicating environmentally harmful food production methods as pathways to sustainable food systems. They see a significant role for the data economy to realise these pathways to sustainable food systems. In doing so, they envision a data economy that is transparent and strictly regulated, facilitating innovative business models and securing equal access to the benefits of high-quality data through user-friendly interoperable systems. In the absence of a clear and simple definition of the DE4FS, it is important that the stakeholder perceptions highlighted in this research are incorporated in further development of a definition for the DE4FS in the Data4Food2030 project, in other future research, and in the creation of policy and legal frameworks for a fair, inclusive and innovative data economy for sustainable food systems.

Nevertheless, the researchers also acknowledge the value of noticing what is currently not mentioned by stakeholders. In essence, the study presented in this deliverable indicates what is currently seen as important to the stakeholders of the DE4FS. Yet, this is merely an indication of stakeholders' priorities at one point in time, showing what is relevant in the contextualisation of

the data economy at this moment. Further research can highlight how priorities may shift because of the evolving contextualisation of the DE4FS.

Finally, the scenarios, pathways and stakeholder recommendations focus on the desirable aspects and impacts that should be achieved to realise a fair, inclusive and innovative data economy for sustainable food systems. Yet, from the perspective of transition studies, it could be interesting to not only focus on what should be encouraged and scaled up or out, but also on what should be prevented, discouraged or "phased out" to realise a fair, inclusive and innovative data economy for sustainable food systems (e.g. de Roo et. al, 2025). While the participatory stakeholder workshops did encourage participants to identify the undesirable aspects and impacts of the plausible scenarios, we focussed on how we could turn these undesirable aspects and impacts into desirable aspects and impacts. Future research could dive deeper into the undesirable aspects and impacts that should be prevented or phased out, not only in future scenarios, but also in current reconfigurations of the DE4FS.

7.2 Conclusion

All in all, the use of scenarios and pathways as part of a foresight exercise supported a variety of DE4FS stakeholders in their thinking about, and perhaps even designing and/or organising of a fair, inclusive and innovative data economy for sustainable food systems. Based on their input this deliverable forms the basis for several avenues for future research, be it seeking the additional perspectives of more diverse stakeholders, further exploring the potential impact of the developed scenarios, or deepening the policy analysis. All these avenues are best undertaken with the support of a commonly understood definition of the DE4FS. Continuous research efforts should thus be focussing on a definition of the DE4FS which carefully considers what it means to be fair, inclusive and innovative, taking current stakeholder perspectives into account.

This is important as this research highlights stakeholder's priorities for further development of a fair, inclusive and innovative DE4FS. What this entails is reflected in stakeholders' perceptions of desirable aspects and impacts of the scenarios developed in this study. These perceptions form the preconditions of a fair, inclusive and innovative DE4FS. Thus giving additional insights for policy and the formation of legal frameworks and allowing for future research to dive into questions such as: what kind of (non-monetary) value does the DE4FS add to different stakeholders?

Moreover, this research has shown that the complexity for stakeholders to grasp the data economy highlights that it cannot be seen separately from the (sub)system(s) in which it is embedded. To reach its full potential in realising desirable impacts, the data economy needs to

be linked to other subsystems, such as the food system. This research has shown the diversity of ways in which the data economy can impact food systems, but that the organization of the data economy in a fair, inclusive and innovative way is important to ensure that these impacts are desirable.

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Appendix I: Infographic

Appendix II: Overview of trends for the DE4FS

Source: Data4Food2030 D5.1: Analysis of Trends: Identifying technological and societal challenges with impact on the DE4FS.

Definition of a trend: a realistic expectation of the future regarding the data economy, the food system or a combination of those two (DE4FS).

Background:
Overall the trends for the Data Economy, Food system or the DE4FS are driven by other global or general trends such as:

- Climate change
- Biodiversity loss
- Globalisation
- Demographic changes
- Geo-political insecurity
- Social inequality
- Post-Pandemic responses
- Slower/stagnant economic growth (greater-than-expected inflation persists/ upward pressure on wages)

Dimension	**Trend**	**Category (data economy/food system/DE4FS)**
Technological	*Overall: Increase in use of ICT for the Green transition*	
1	*Technological advancements* New technological developments (e.g., advanced connectivity, cloud and edge computing, smart sensors, immersive-reality technologies (augmented reality (AR)/virtual reality (VR), quantum technologies, etc.) provide further opportunities for data generation, use and re-use. High costs might remain an important barrier for using the newest technologies.	Data economy, Food systems, DE4FS
2	*Further advancement of AI*	Data economy

	Artificial Intelligence (e.g., automated machine learning, generative AI, ethical AI, natural language processing, AI as a service, etc.) provide opportunities for improving products and processes, due to large availability of data and technology improvements. A technological risk is that there could be a data bias in algorithms' training.	
3	*Continuous increase in data volume from agri-food* The increasing data volume available for the agri-food sectors offer new possibilities for service and product development for the stakeholders (from farmers, through industry, to policy makers). Data re-use also creates new opportunities and increases the value of data.	Data economy, DE4FS
4	*Increasing use of tech devices* This trend accelerated during the pandemic across all economic sectors and continues to remain relevant after the period. Similarly, the agri-food industry has increased its efforts to shift to using more digital tools and other advanced technologies, to innovate and to adopt new solutions to reduce human-to-human and human-to-food contact.	Data economy, Food systems, DE4FS
Policy	*Overall: Increase in regulations*	
1	*Stricter regulations regarding data access, sharing and use* Data regulations such as GDPR, Data Act, Data Governance Act aim to help clarify data ownership, privacy and security concerns. It targets various aspects and provides rules and regulation for collection, processing and use and reuse of data by all stakeholders. Compliance with the regulations increase the administrative burden on stakeholders. Lack of interoperability of different systems might slowdown the uptake of data use and re-use.	Data economy, DE4FS
2	*Stricter regulations regarding food safety and traceability* Food regulations set out the minimum acceptable standards for food and allow monitoring and enforcement against these standards. Thus, more responsibilities for food and feed business operators. Example: Food sustainability labelling aims to help with the transition to a EU sustainable food system and to integrate sustainability into all food-related policies. It uses different categories of data to assess the impact of food on the	Food systems, DE4FS

	environment, increase the transparency of this impact and held shifting towards a more sustainable food system. Data will help identify the source of the food and increase the traceability of the food products.	
Economic	*Overall: Shifting the establishment?*	
1	*Increasing investments in technological developments* Provides support for new digital technologies to be developed and increase the diversity of available options, which could lead to potentially a decrease in the price of these technologies. Lower prices promote more accessibility to devices which equals increased use of the technologies and, potentially, contributes to the generation of more data. Higher volumes of data accessible conduce to new services and products to be developed (across different sectors, include agri-food ones).	Data economy, Food systems, DE4FS
2	*Increased power concentration of market players (including in the agri-food sectors)* In the digital market, big digital platforms are considered a challenge to competition enforcers and the health and dynamism of the economy, due to their increasing power of control over the market. They can influence adjacent markets, discourage competition, and penalise potential challengers. The competition will often emerge in the form of disruptions that reduce dependence on the platform or undermine the network effects that protect the platform's dominant position. While digitalisation makes it easier to enter a market, often the smaller players tend to concentrate to be able to survive on the market. Small farms are often integrated into concentrated agricultural supply chains dominated by a few, large supermarket companies. Intense competition among supermarkets pressures continuously on suppliers to enhance efficiency, reduce costs, and meet stringent quality and safety standards. Due to intensive production and large-scale farms with low margins and bargaining power, small and medium-sized firms need find innovative strategies to remain resilient and adaptive to the market. The increased use of data, encompassing monitoring, analysis, transfer, and application for decision-making purposes, has an increased potential to assist small and medium-sized farms.	Data economy, Food systems, DE4FS

3	*Business model innovation related to new digitalisation and data solutions* Digitalisation offers new opportunities for market players to reach all economic sectors, regardless of their main domain of activity. It also facilitates the entry of new market actors, due to simplified business procedures, and encourage the expansion of businesses activity domain through the development of new product and services using data from multiple sources for clients from different economic sectors. It also comes with an increase in the competition between market players, both new and established ones.	Data economy, Food systems, DE4FS
Environmental	*Overall: A need for sustainable production methods (through innovative technologies)*	
1	*Transition to agro-ecological production methods* Although this is still quite often a more 'low-tech' approach there is an opportunity for digital technologies to develop new ways and processes for the agricultural production in line with the nature. It will contribute to the development of sustainable farming, ensure sustainable and diverse production and reduce biodiversity loss.	Food systems, DE4FS
2	*Increased focus on circularity* By tracking the flow of materials and resources throughout their entire life cycles, areas of improvement and innovation could be identified; at the same time, it helps measure the environmental and economic impacts of the production and consumption patterns and validate the shift toward circularity. Data becomes an agent of change and transformation, not just a tool for monitoring and reporting. However, the quality and accuracy of data capture remains an important aspect of the circularity process.	Food systems, DE4FS
3	*Increased efforts to reduce waste and food loss* Increase of the number of people affected by hunger, and the lost and/or wasted tons of edible food on daily basis are important factors for food systems' transformation. Access to data from different stages of the food chain process could help reduce to time from production to end-consumer, monitor the quality of food and better estimate the freshness of the produce and develop proper actions to reduce and limit the food waste.	Food systems, DE4FS

4	*Increasing need for sustainable/green data centres and supercomputers* The continuous and steady increase of digital technologies in agri-food consumes an increasing amount of energy. Green energy sources could provide a solution.	Data economy, DE4FS
5	*Increase of food innovations* A dietary shift away from conventional animal-based products to other alternative protein sources to help reduce emissions and other environmental pressures. The protein sources include plant-based foods, cultured meat, alternative dairy products and insect-based protein.	Food systems, DE4FS
6	*Increase focus on energy efficiency and transition towards green energy use* Energy efficiency is an important element for environmental sustainability. Energy-efficient technologies, optimisation of processes and encouraging behaviour change of energy consumption can significantly contribute to the reduction of carbon emissions. It will also result in cost savings for both population and businesses and improved business competitiveness overall.	Data economy
Social	*Overall: Pressure on an inclusive agri-food sector*	
1	*The transformation of the work environment* Digitalisation impacts jobs, which are replaced by automation, transformed into different jobs or developed into completely new types of work. Additionally, there is reduced social contact due to frequent technology use, which results in an increase of psychological pressure on the workforce. Job precarities and slow replacement of the older workforce result in longer active work life. Also, the changes in the work environment could also affect the work-life balance of the labour force.	Data economy, Food system, DE4FS
2	*Increased need of skilled and digitally literate workforce* The transformation of the working environment and digitalisation of many low-skilled jobs require a	Data economy

	corresponding skilled workforce. There is an increased need of upskilling and re-skilling of the labour force to match the socio-economic needs. Longer transition periods from unemployment to employment due to training needs.	
3	*Increasing number of you people working into the agri-food sector* Encouraging the young people to work in the agri-food sectors and helping address the shortage of workforce in the sector. Statistics shows slow progress in the engagement of young people (under 35 years old) in the farms' management. For example, in 2020, the number of EU farms with young managers increased only by 2.8% compared to 2016. Moreover, in 2020, 10% of large farms have had a young manager, compared to the overall average of 6.5%.	Food system, DE4FS
4	*Increasing interest into (sustainable and) healthy diets* A shift in consumers behaviour towards food, with focus on sustainability and local consumption, as well as transparency of food sourcing and quality and nutrition of food. Online shopping for food (and delivery) also contributes to increasing access for consumers.	Food system, DE4FS
5	*Persistent lack of trust on ethical use of data between data owners and data users and re-users* Remains an important issue when it comes to access to data. Laws and regulations aim to address the lack of trust to a certain extent and their implementation is an important fact in achieving this goal. Transparency in the use and re-use of data could contribute significantly to the improvement of trust from data owners. Developing new business models that ensure proper benefits for all partners involved in the transactions might be another avenue for dealing with the distrust.	Data economy

Appendix III: Guidelines for the scenario workshop

Outlined in more detail below the methodology for the visioning workshops in which we take trends on the data economy and the food system as central points of discussion in developing scenarios for the future of the data economy for food systems. In particular relevant are the different guiding questions and the workshop planning.

Introduction

This step involves introducing the project, task and purpose of this workshop. Therefore we need to define the concepts of data economy, food systems, and data economy for food systems, and we will show the results of T4.1 stakeholder dialogues. Following these definitions, we will present the trends from WP5 for the data economy for food systems. These trends will be presented using clear categories such as social, legal, technological, economic and environmental.

Discussing trends

The trends that were presented during the introduction will be discussed in small groups (3 to 4 people) using the guiding questions below. The aim of this discussion is to unravel stakeholder perceptions to the trends presented. Make sure the participants are mixed in terms of the stakeholder groups that they are representing. We recommend the workshop facilitators to make groups of stakeholders prior to the workshop where this mix can be established. Each group will need a facilitator that can ask the guiding questions and capture key point on sticky notes on a large sheet.

Guiding questions:

- What trends are likely to continue and have an impact on the DE4FS in 2050?
- What trends are unlikely to continue or have an impact on the DE4FS in 2050?
- Are there any trends or external factors missing? (local/ regional/ …)
- What trends are the most important for the future of the DE4FS, and why?
- *What similarities do you see between data economy trends and food system trends? How will this impact on the DE4FS in 2050?*
- *What differences or even contradictions do we see between data economy trends and food system trends? How will this impact on the De4FS in 2050?*
- *Is it necessary that the trends from both entities align to be relevant for the DE4FS in 2050?*

(Note: the guiding questions function as a conversation starter, not all (*in italics*) need to be asked. The other questions will need to be answered.)

Prioritising trends

After the small group discussion, a quick plenary summary is given by each group, followed by a joint prioritisation of the key trends that will likely have a positive or negative impact on the DE4FS in 2050. Use a large sheet for an overview of all trends from the presentation, and add any additions from the trend discussion. Each participant gets to define their individual top 3 priorities of key trends using 3 stickers (i.e. 1 sticker per trend). This will result in a top 6 of trends that have received the most stickers of the participants. In the following phase, each subgroup can choose 2 of these trends to develop a scenario. It is ok if there is overlap between chosen trends.

Development of scenarios for the data economy for food systems

Back into the same small groups, a scenario is being developed for the DE4FS using 2 trends of the 6 prioritised trends. The group receives a template to develop their scenario.. Use the following guiding questions to fill in the template. The answers can be filled in (annex 3) using sticky notes or writing directly on the A0 template. Here, the trends are the basis, from where a narrative can be constructed, followed by a discussion of aspects and a scenario title.

- Scenario narrative: Give a description of what the DE4FS looks like when trend 1 and trend 2 come together.
- Technological aspects: What do the following aspects look like in this DE4FS scenario?
    - Data collection, data processing, data storage, data analytics, data sharing, interoperability, use of AI/blockchain/robotics/drones, etc.
- Legal aspects: What do the following aspects look like in this DE4FS scenario?
    - Regulations in food: food security, food safety, traceability, transparency, etc.
    - Regulations in data: privacy, ownership, security, governance, etc.
- Economic aspects: What do the following aspects look like in this DE4FS scenario?
    - Market dynamics, supply chain logistics, business models, livelihoods, trade, workforce, financial investments, etc.
- Environmental aspects: What do the following aspects look like in this DE4FS scenario?
    - Biodiversity, energy consumption, water use, land use, climate change mitigation and adaptation, etc.
- Social aspects: What do the following aspects look like in this DE4FS scenario?
    - Participation, trust, equity and access, empowerment, awareness and education, responsible innovation, resilience, gender, etc.
- Key stakeholders: Who plays an important role? Who wins and who loses?

(Note: the guiding questions function as a conversation starter, not all need to be asked.)

A plenary feedback session

The final step of the workshop involves a presentation of each group of the scenario they developed, followed by a discussion on the implications of the scenarios developed. Use the following guiding questions for the discussion based on the results from the stakeholder interviews and dialogues:

- Who are the winners and losers in this scenario, and why?
- Are the technological solutions suggested in this scenario supported by social and legal solutions?
- Are the costs and benefits balanced? For whom are there costs or benefits, in what way?
- Does the DE4FS scenario support or undermine decision-making of various stakeholders? Which ones?
- Is there a focus on environmental and social sustainability in this scenario?
- Does the scenario take transparency into account? Are there sufficient regulations on data sharing and control?
- Does the DE4FS scenario to innovation?
- Is the scenario well governed? Does it promote the data economy, while also protecting those affected?

(Note: the guiding questions function as a conversation starter, not all need to be asked. Choose 1 or 2 questions that point to gaps in the developed scenario)

Workshop plan

The table below demonstrates the workshop plan. Please consider that the times mentioned are our suggestions, but they may be adjusted for each national workshop. However, we do recommend not to make the workshop components shorter, as you will minimally need the amount of time mentioned in the table below.

TIME	WHO	ACTIVITY	DETAILED ACTIONS	MATERIALS
12:00-12:30 (30 mins)	Facilitators and participants	Lunch and getting to know each other	• Check names on participant list • Hand out name tags • Get consent forms signed	• Lunch • Participant list • Name tags • Consent forms

12:30-13:00 (30 mins)	Main facilitator	Plenary: Present workshop introduction	• Introduction to Data4Food2030 • Defining the main concepts: data economy, food system, and data economy for food systems • Present technological, legal, economic, social and environmental trends.	• Workshop presentation
13:00-13:30 (30 mins)	Facilitators and participants (ideally a facilitator in every small group of participants)	In small groups (3-4 people): discussion on trends for the data economy for food systems	Use the following guiding questions • What trends are likely to continue and have an impact on the DE4FS in 2050? • What trends are unlikely to continue or have an impact on the DE4FS in 2050? • Are there any trends or external factors missing? (local/ regional/ …) • What trends are the most important for the future of the DE4FS, and why?	• Small group division to enhance a good mixture of stakeholders • Large sheets • Sticky notes • Pens
13:30-14:00 (30 mins)	Main facilitator and participants	Plenary: Prioritising trends for scenario development	• Summarising all trends on large sheets • Each participants gets 3 stickers to prioritise their personal top 3 “most important trends for the data economy for food systems” • Based on the amount of stickers a joint top 6 priorities of trends is identified.	• Large sheet with overview of trends • Stickers
14:00-14:15 (15 mins)	Facilitators and participants	Break		• Drinks and snacks
14:15-15:15 (60 mins)	Facilitators and participants (ideally a facilitator in every small group of	In small groups (similar groups as trend discussion): Each group will choose 2 trends from the top 6	After choosing 2 trends, fill in the scenario development format: • Scenario narrative: Give a description of what the DE4FS looks like when trend 1 and trend 2 come together. • Technological aspects:	• Small group division • A0 scenario development template (4x)

	participants)	that they use as input for their scenario. Overlap of chosen trends between the groups is ok.	• Discuss: data collection, processing, storage, analytics, sharing, interoperability, use of AI, blockchain, robotics, drones, etc. • Legal aspects: • Discuss: regulations in food: security, safety, traceability, transparency; and regulations in data: privacy ownership, security, governance, etc. • Economic aspects: • Discuss: market dynamics, supply chain logistics, business models, livelihoods, trade, workforce, financial investments, etc. • Environmental aspects: • Discuss: biodiversity, energy consumption, water use, climate change mitigation and adaptation, land use, etc. • Social aspects: • Discuss: participation, trust, equity and access, empowerment, awareness and education, responsible innovation, resilience, gender, etc. • Key stakeholders: Who plays an important role? Who wins and who loses?	• Sticky notes • Pens/markers
15:15-15:45 (30 mins)	Facilitators and participants	Plenary feedback session. Each group will present their scenario followed by a brief	Use the following guiding questions for the discussion: • Who are the winners and losers in this scenario, and why? • Are the technological solutions suggested in this scenario	• Tape to stick the templates on the wall

		discussion of the impacts of the scenarios.	supported by social and legal solutions? • Are the costs and benefits balanced? For whom are there costs or benefits, in what way? • Does the DE4FS scenario support or undermine decision-making of various stakeholders? Which ones? • Is there a focus on environmental and social sustainability in this scenario? • Does the scenario take transparency into account? Are there sufficient regulations on data sharing and control? • Does the DE4FS scenario to innovation? • Is the scenario well governed? Does it promote the data economy, while also protecting those affected?	
15.45–16.00 (15 mins)	Close	Closing remarks:	• Brief summary • Key points/lessons learned: Participants can make some final remarks and share their take home message • Next steps: back casting workshop in May/June. Scenario results will be shared before then and they will be invited for this next workshop. • Thank you to participants, facilitators, note takers and venue.	

Appendix IV: Guidelines for the backcasting workshop

Introduction

This step involves introducing the project, task and purpose of this workshop. Therefore we need to define the concepts of data economy, food systems, and data economy for food systems, and we will show the results of T4.1 stakeholder dialogues. This will generally be a similar story as in the scenario workshops.

Presenting the scenarios

Following the introduction, we will present the EU level plausible scenarios that are constructed based on the national level plausible scenarios from the T4.2 scenario workshops in Feb/March 2024.

Reflecting on the scenarios

In order to reflect on the scenarios presented, a carrousel setting will be organised. Here, all scenarios are displayed on posters throughout the workshop space. With each scenario comes a facilitator that leads the reflection and takes notes of the discussion. The workshop participants go around all the different scenarios (like a carrousel), and answer the following main questions:

- What aspects of this scenario are undesirable? Why?
- What aspects of this scenario are desirable? Why?

The participants answer these questions by writing down the undesirable aspects on red sticky notes and the desirable aspects on green sticky notes.

The supporting questions below can be used to foster the discussion.

- Who are the winners and losers in this scenario? Is this desirable or do we need to change this?
- Is there a level of interoperability? Is there effective use of data and innovation? Is this supported by social and legal solutions?
- Is there a desirable balance between the costs and benefits? E.g technological, socio-economic and environmental costs, and benefits in terms of improved performance, such as optimised food production, research efficiency, policy implementation. For whom are there costs and benefits, and in what ways?
- Is there effective use of data to support decision-making? Or do data abundance and poor-quality data undermined their effective and sound use in decision-making?

- Does the scenario have the potential to equally improve economic, environmental and social sustainability?
- Does the scenario take transparency into account? Are there sufficient regulations on data sharing and control to deal with risks such as data insecurity, reduced competitiveness and economic advantage, overcontrol and repressions in case of non-compliance with formal requirements?
- Does the scenario allow for tailored data-based solutions to encourage food system stakeholders to adopt novel sustainable food-related decisions and practices? Is there sufficient access to data and appropriate digital infrastructure, equipment, tools, skills and data intelligence?
- Does the scenario entail proportional policy interventions that steer fair data economy and shared rules regarding data rights and responsibilities? E.g. is there sufficient coordination without overregulation?

The output of this step is the concrete division of scenario aspects into desirable and undesirable aspects for each specific scenario, which will function as input for the backcasting exercise.

Backcasting

For the backcasting exercise, the aim is to create concrete actions or interventions, and to shape them into a pathway for different stakeholders. Although we aim to focus on a variety of stakeholders, pathways for policy makers and regulators are key. The backcasting exercise consists of working with a logic framework which needs to be completed for every scenario. The participants need to be divided over all the scenarios, and will be working on the backcasting exercise in subgroups.

In the template it shows the impacts in 2050, these are (desirable) aspects of the plausible scenario's as presented and commented on during the workshop (see step 1 below). The pathways, however, will be connected to a more nearby future, namely 2030 (i.e. Data4Food2030). Hence to reach the *2050 impacts*, we need to be aware of the *outcomes in 2030*. These outcomes are an 'in-between' step to assess if we are still heading in the direction of reaching the 2050 impacts (see step 2 below). That also means that multiple 2030 outcomes can contribute to one 2050 impact. The 2030 outcomes result from *activities* (see step 4), and their *outputs*, i.e. tangible results (see step 3). And of course, the activities and related outputs require *inputs* (see step 5).

Instructions for completing the template.

- Impact in 2050: The desirable and undesirable aspects of the scenario that are identified define the impacts in 2050. The aim of the exercise is to work backwards to concrete inputs

for activities that will lead to desirable outcomes in 2030, and avoid the undesirable outcomes.

    - Impacts are positively formulated. Turn aspects red sticky notes into desirable aspects/impacts.
- Outcomes in 2030: Given the impacts desirable in 2050, what are plausible outcomes for 2030? An outcome has directionality, e.g. increased, decreased, enhanced etc.
- Outputs: Given the envisioned outcomes for 2030, what concrete outputs are needed/need to be developed? Who owns these outputs? We define output as tangible result needed to achieve the outcomes.
- Activities: Discuss and describe the concrete actions that will be taken to achieve these outputs. Who needs to be involved in these activities?
- Inputs: Finally, discuss and describe what resources are needed for these activities. Examples of resources are: funding, capability, time, data, etc.

Make sure to connect the steps in the logic framework. E.g. what outcomes lead to what impacts. Each step needs to at least connect to one other step, but possibly to multiple steps.

Plenary feedback

This final step of the workshop aims to share the results and give each other feedback.

Workshop plan

The table below demonstrates the workshop plan. Please consider that the times mentioned are our suggestions, but they may be adjusted for each national workshop. However, we do recommend not to make the workshop components shorter, as you will minimally need the amount of time mentioned in the table below.

Time	Who	Activity	Detailed actions	Materials
12:00-12:30 (30 mins)	Facilitators and participants	Lunch and getting to know each other	• Check names on participant list • Hand out name tags • Get consent forms signed	• Lunch • Participant list • Name tags • Consent forms
12:30-13:00 (30 mins)	Main facilitator	Plenary: Present workshop introduction	• Introduction to Data4Food2030 • Defining the main concepts: data economy, food system, and data economy for food systems	• Workshop presentation

13:30-13:30 (30 mins)	Main facilitator	Plenary: Present EU scenarios	• Present all the scenarios	• Workshop presentation
13:30-14:15 (45 mins)	Facilitators and participants (every scenario needs to be accompanied by a facilitator)	Carrousel: Scenario reflection	• (Everyone can get a drink before starting the carrousel) • Participants rotate between the scenarios • For every scenario, an overview will be made of desirable and undesirable aspects using red sticky notes and green sticky notes • Supporting questions can be used to foster the discussion	• Large A0 printouts of all the scenarios • Red and green sticky notes • Pens
14:15-14:45 (30mins)	Facilitators	Plenary: Discuss carrousel results	• Facilitators summarise the discussions for each scenario using the green and red sticky notes to highlight scenario aspects that need to be promoted or avoided	• Output from the carrousel
14:45-15:00 (15 mins)	Facilitators and participants	Break		• Drinks and snacks
15:00-16:00 (60 mins)	Facilitators and participants (every scenario needs to be accompanied by a facilitator)	In small groups: Backcasting exercise	• Participants can choose over the scenarios • Participants complete the logic template together with the facilitator, focusing on the impact, outcome/output, activities and input needed	• Large A0 printout of the logic framework • Pens
16:00-16:30 (30 mins)	Facilitators and participants	Plenary: summarise backcasting and closing remarks	• Groups present the logic framework • Room for feedback on backcasting	

			• Closing and take aways: lesson learned, next steps, thank you!	

Appendix V: Legal Screening

1. Policies and regulations included in legal screening

The following 16 policies and regulations constituted the corpus guiding the analysis:

- Commission, 'The European Green Deal' COM (2019) 640 final (referred to hereafter as "**EU Green Deal**");
- Commission, 'Annex to The European Green Deal' COM (2019) 640 final (referred to hereafter as "**EU Green Deal - annexe**");
- Commission, 'A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system' COM (2020) 381 final (referred to hereafter as "**Farm2Fork**");
- Commission, 'Annex to the Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system' COM (2020) 381 final (referred to hereafter as "**Farm2Fork - annex**");
- Commission, '2030 Digital Compass: the European way for the Digital Decade' COM (2021) 118 final (referred to hereafter as "**2030 Digital Compass**");
- Commission, 'Annex to the 2030 Digital Compass: the European way for the Digital Decade' COM (2021) 118 final (referred to hereafter as "**2030 Digital Compass - annexe**");
- Commission, 'A European strategy for data' COM (2020) 66 final (referred to hereafter as "**EU strategy for data**");
- Regulation (EU) 2021/694 of 29 April 2021 establishing the Digital Europe Programme and repealing Decision (EU) 2015/2240 [2021] OJ L 166/1 (referred to hereafter as "**Digital Europe Programme**")
- Regulation (EU) 2021/2115 of 2 December 2021 establishing rules on support for strategic plans to be drawn up by Member States under the common agricultural policy (CAP Strategic Plans) and financed by the European Agricultural Guarantee Fund (EAGF) and by the European Agricultural Fund for Rural Development (EAFRD) and repealing Regulations (EU) No 1305/2013 and (EU) No 1307/2013 [2021] OJ L 435/1 (referred to hereafter as "**CAP**")
- Regulation (EU) No 1169/2011 of 25 October 2011 on the provision of food information to consumers, amending Regulations (EC) No 1924/2006 and (EC) No 1925/2006 of the European Parliament and of the Council, and repealing Commission Directive 87/250/EEC, Council Directive 90/496/EEC, Commission Directive 1999/10/EC, Directive 2000/13/EC of the European Parliament and of the Council, Commission Directives 2002/67/EC and

2008/5/EC and Commission Regulation (EC) No 608/2004 [2021] OJ L 304/18 (referred to hereafter as "**Regulation on the food information to consumers**")

- Directive (EU) 2022/2555 of 14 December 2022 on measures for a high common level of cybersecurity across the Union, amending Regulation (EU) No 910/2014 and Directive (EU) 2018/1972, and repealing Directive (EU) 2016/1148 [2022] OJ L 333/80 (referred to hereafter as "**NIS2**")
- Regulation (EU) 2024/1689 of 13 June 2024 laying down harmonised rules on artificial intelligence and amending Regulations (EC) No 300/2008, (EU) No 167/2013, (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1139 and (EU) 2019/2144 and Directives 2014/90/EU, (EU) 2016/797 and (EU) 2020/1828 [2024] OJ L 2024/1689 (referred to hereafter as "**AI Act**")
- Regulation (EU) 2023/2854 of 13 December 2023 on harmonised rules on fair access to and use of data and amending Regulation (EU) 2017/2394 and Directive (EU) 2020/1828 [2023] OJ L 2023/2854 (referred to hereafter as "**Data Act**" or **"DA"**)
- Regulation (EU) 2022/868 of 30 May 2022 on European data governance and amending Regulation (EU) 2018/1724 [2022] OJ L 152/1 (referred to hereafter as "**Data Governance Act**" or "**DGA**")
- Regulation (EU) 2016/679 of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC [2016] (referred to hereafter as "**GDPR**")
- Proposal for a Regulation on the European Health Data Space, COM (2022) 197 final (referred to hereafter as "**European Health Data Space - proposal**")
- Charter of Fundamental Rights of the European Union [2012] OJ C 391 (referred to hereafter as "**EU Charter**")
- Regulation (EU) 2024/1991 of the European Parliament and of the Council of 24 June 2024 on nature restoration and amending Regulation (EU) 2022/869 [2024] OJ L 2024/1991 (referred to hereafter as "**Restoration Regulation**")

2. Legal screening of the pathways of Scenario A

The next two sections provide insights on what policies or regulations are align with the pathways associated with Scenario A, and what are the potential legal risks or legal concerns related to them. Those are concluded in the third subsection.

2.1 Alignment of Pathways with Existing EU Policies and Regulations

Each element of the pathways is enlisted below, and relevant policies and regulations are linked to them. The analysis is presented from impacts to inputs. All the pathways' elements are provided in *italics*.

All the desirable **impacts** are to a certain extent supported by EU policies or existing legislation.

- The *Livelihood security for farmers* is described as one of the key goals in several major policies (Art. 6(a)(c) 2021/2115, Section 2 of Farm2Fork). The objectives cover the aspect of the farm income, improvement of the farmers' position in the value chains, and generation of fairer economic returns in the supply chain.
- *A society characterised by healthier individuals and increased longevity* and *dietary freedom for consumers* overlaps with the CAP 2021/2115 objective of improving the response of Union agriculture to societal demands on food and health (Art. 6(i), 2021/2115)

In the context of **outcomes,** the majority of them have certain overlaps with existing policies.

- *Healthy food consumption is the norm that* overlaps with several goals of the Farm2Fork strategy, such as ensuring **food security, nutrition and public health**, **setting up nutritional profiles** to restrict the consumption (via nutrition or health claims) of foods high in fat, sugars and salt, **promoting sustainable food consumption** and **facilitating the shift to healthy, sustainable diets** (Section 2.4).
- The *increased availability of specialised foods* is aligned with the following Farm2Fork objective **improving the availability and price of sustainable food and promoting healthy and sustainable diets** (Section 2.4). There is a difference, the Farm2Fork strategy is focused on sustainable food broadly, not specifically on specialised food.
- *The personalised nutritional advice on the basis of DNA and consumer data possible on request* has a minimal overlap with the Farm2Fork objective to **set up nutrient profiles to restrict the promotion and consumption (via nutritional or health claims)** of foods high in fat, sugars and salt. However, there is no direct policy that aims to develop personalised nutritional advice based on DNA and consumer data. In that context it is important to remember that such data processing must be compliant with the GDPR requirements, especially has a proper legal basis (Art. 9 GDPR).
- *Personal data ownership* is not reflected in EU data protection law, there are rather rights and responsibilities to data sets depending on the role of the subject vis-à-vis data (subject, controller, processor, holder). For data subjects' data protection is a fundamental right a such there are protections limiting how data can be an object of commodification. This strongly relies on consent as a transfer and pricing mechanism ignores the unequal

bargaining power and fails to address the harms produced by inferred or aggregated data. So, lawmakers should rather think not about data ownership but about processing personal data lawfully in a manner that fulfils the data protection requirements, especially the data subject's rights (Cofone, I. (2021). Beyond data ownership. *Cardozo L. Rev.*, *43*, 501).

- Data in B2B cases can be an object of trade secrecy protection, but it still does not make them an object of ownership. It means that the data controller has an additional layer of protection as a right holder against disclosure and third-party use of such data.

There are two *outcomes* for which no strictly related policies were identified (*Farmers face lower market risks thanks to the availability of demand data by improving their planning of inputs, costs, and production characteristics; Farmers can charge a premium for producing specialised foods*).

In the context of ***outputs,*** most of them have some overlaps with existing policies and regulations:

- *Business models for farmers and companies to produce specialised foods* is aligned with the Farm2Fork aim to **ensure tailored solutions to help SMEs,** especially **with developing new skills** and **business models.** It includes the Enterprise Europe Network which provides advisory **(Section 3.2).** However, such a policy is not directed towards the development of specialised food production.
- *Consumer awareness* (and action *educational campaign for promoting healthy food consumption*) is another output, that is supported by the Farm2Fork strategy. The objective of promoting sustainable food consumption includes a labelling policy that aims to **empower consumers to make informed, healthy and sustainable food choices.** The Commission aim to propose harmonised mandatory front-of-pack nutrition labelling and will consider proposing the extension of mandatory origin or provenance indications to certain products. The Commission declare willingness to **review the EU school scheme** to enhance its contribution to sustainable food consumption and in particular to **strengthen educational messages on the importance of healthy nutrition, sustainable food production** and reducing food waste (Farm2Fork, p. 13).
- *A secured and decentralised data database of DNA and consumer data with individualised consent* is the output that has several overlaps with Farm2Fork, EU Data Strategy, DGA, and GDPR. The **common European agriculture data space** shall be established to facilitate fair data governance in the agri-food sector (EU Data Strategy, Farm2Fork). The law sets the required level of protection in the processing of personal or non-personal data and obliges entities to implement appropriate legal, organisational, and technical measures to ensure secured and compliant data processing (Art. 12(j) DGA, Art. 24, 32, 35 GDPR). The question is whether the participants of the Common European Agriculture

Data Spaces would be qualified as essential or important entities according to the NIS2. If so, then additional cybersecurity requirements would apply.

There were no regulations or policies were identified in the context of two **outputs** *translation of consumer data to production information for farmers* and *knowledge about nutritional advice based on DNA and consumer data.* However, some past Horizon projects on the topic were identified, such as *Personalised nutrition: An integrated analysis of opportunities and challenges - FOOD4ME*[1].

For the following ***actions,*** the relevant policies were identified.

- *Developing legislation for the security of databases, including a consent system and infrastructure for companies to extract anonymised data,* is an action that is already partly regulated. The main framework for processing data is already established (GDPR, DGA, Data Act, NIS2).

  In the main policies, we can identify proposals that contributes to the security of the databases and development of the infrastructures. For example, **development of advanced digital skills**, including cybersecurity (Digital Europe Programme, Objective 3), development of a **cloud rulebook** and coherent with the **common European standards and requirements for the public procurement of data processing services** (EU Strategy for Data, p. 18), or the development of a **climate neutral and highly secured data processing infrastructure** (2030 Digital Compass, p. 8). The call for a consent management system is included in the EU Strategy for Data (p. 29) and there is already an existing example of such system in Proposal for Financial Data Access (Art. 8(1)). However, in order to propose a specific solution for consent management, and infrastructure development, **the proposal for the Common European Agricultural Data Space still has to be developed**.
- *The collection of DNA, consumer data and health data* **and** *scientific research on nutritional requirements on the basis of DNA* are the actions that are addressed by GDPR requirements for processing special categories of data, such as health data (Art. 9 GDPR). In the proposal for European Health Data Spaces (EHDS), recital 38 and Art. 34, medical data can be re-used for research related to health or care sectors. However, those provisions must be an object of pending legislative process. Moreover, it might be the case that EHDS will contribute to research on personalised nutrition, but the impact of using data to support the food production process is questionable.
- A new **Horizon Europe** partnership for “Safe and sustainable food systems for people, planet and climate” will aim to **deliver innovative solutions providing co-benefits for**

nutrition, quality of food, climate, circularity and communities (Farm2Fork strategy, p. 16).

There were no relevant laws or policies were identified to develop *a reward system for farmers based on KPIs for sustainable and healthy food production.*

2.2 Legal risks and impact on fundamental rights

In this subsection some identified legal risks are enumerated, followed by reflections related to the potential influence of the pathways on the legal values. The following risks were identified:

- **Data protection.** Under EU data protection law, actors, such as companies providing dietary advice, may process special categories of personal data, including genetic data, with the consent of data subjects. The data controller must prioritise the principle of data minimisation and assess whether specific data types, such as DNA, are essential for the intended purposes.
- Actions like public educational campaigns to promote personalised healthy diets [pathway 1.2] should be reconsidered and followed by a proportionality assessment of such intervention in the context of different conflicting legal values, such as data protection, public health, and freedom to conduct business.
- **Data protection enforcement issues.** The problem of effective enforcement would verify practices of personal data processing by data controllers in ensuring the fulfilment of data subject's rights. In this model, highly sensitive data would be in the hands of private actors with little oversight. This situation undermines trust between value chain actors (data subjects and data controllers) due to the lack of safeguards protecting data subjects from data misuse by controllers.
- **Growing inequalities - consumers.** Companies offering personalised nutrition services will collect a wide range of sensitive data. Contributing to the existing asymmetry between data subjects and controllers.
- **Strengthen inequalities – food producers.** Only farmers with high digital literacy and willingness to produce highly specialised food can contribute to this monitored system. Potentially, large food producers are capable of joining such a system. However, others, like small, traditional farmers, and indigenous communities could be excluded from the system due to the high cost of entrance.
- **Market concentration**. Growing inequalities among food producers would lead to market power concentrating with the most technologically advanced producers. Concomitantly, access to databases would be limited to a few actors meeting strict legal requirements,

often challenging for SMEs. This would result in data siloing, undermining the DA and DGA's goals of optimising data use for societal benefit. (Recital 2, Data Act).

- **Cybersecurity risk.** Breaches of data confidentiality or integrity can significantly impact data subjects. A loss of confidentiality means they lose control over their sensitive data (special categories under Art. 9 GDPR). Integrity breaches could lead to harmful diet changes, causing health issues. Beyond individuals, such breaches also pose risks to legal entities if trade secret data is compromised.
- **Data and model of agriculture.** There is an assumption that farmers have a sufficient amount of land which can comply with data models. Agroecology, small, organic, farms, can have a level of heterogeneity that may not be well reflected in data models. It is an all-eggs-in-a-basket kind of approach, that can result in systemic discrimination of those alternative producers.
- **Dependence of food producers on technology providers.** Food producers become vulnerable to and dependent on business decisions made by technology providers. It might be challenging from the perspective of effective enforcement of EU law.
- **Strategic autonomy.** If technology providers from third countries overtake a significant portion of the market, then it can undermine the EU's strategic autonomy ambitions.

Proportionality. The proportionality of the educational campaign that aims to promote food consumption based on a personalised diet should be assessed. Such assessment would confront the benefits of personalised diet advice (personalised nutrition, nutritional genomics) with the EU fundamental rights. EU and Member States' public interventions have to be proportional. It means that such intervention has to be suitable, necessary, and balanced with other fundamental rights and constitutional values. First, that view needs to be proven that such personalised nutrition achieves its goals[2]. Next, the necessity to ask the question if there are no other (less intrusive ways) to achieve the same goal, what is the minimal scope of data that would allow to reach the same or good enough result? In the last step, *proportionality sensu stricto* the contribution to the values such as public health or freedom to conduct a business is confronted with the level of inferences data protection. Before deciding on public support for such a dietary regime those question needs to be answered.

From the public health and consumer protection perspective it is important to question the **actions of control around how food will be produced to reflect the claims that will lead to its consumption, but how verified will be these claims?** When so much personal data is used to determine optimal health outcomes, **how will be the food supply chain controlled? Knowing that personalised nutrition can positively affect health outcomes, is there a duty of case to**

availing this to all citizens? It is worth inquiring about current food quality and food labelling principles to see if this can correlate to such outcomes.

The pathway includes the introduction of specific KPIs that aim to encourage food producers to produce more specialised food, but such indicators do not make food production more traceable or better controlled. The focus should be put **on the effective enforcement** of rules set for those activities, such as those related to data protection, cybersecurity and interoperability.

The modern development of **food systems has shifted to a productivist model**. The arguments for this can be based on **food security, ensuring countries have enough food (calories) to prevent their populations from getting hungry**. This process was very necessary for various points in history but has now moved to the point that there needs to be new ways to market and sell foods. **Food has been increasingly commodified**, and the question is: how can the food system be tangibly shifted to meet this new model?

3. Legal screening of the pathways of Scenario B

The next two sections provide insights on what policies or regulations are align with the pathways associated with Scenario B, and what are the potential legal risks or legal concerns related to them. Those are concluded in the third subsection.

3.1 Alignment of Pathways with Existing EU Policies and Regulations

Each element of the pathways is listed below, and relevant policies and regulations are linked to them. The analysis is presented from impacts to inputs.

All *impacts* described in the pathways related to scenario B have overlaps with existing policies and regulatory objectives.

- The impact *that local food is available, accessible and affordable for everyone* is buttressed by the Farm2Fork strategy, which aims to **preserve the affordability of food** while generating **fairer economic returns in the supply chain (p. 4), creating shorter supply chains** that will support reducing dependence on long-haul transportation (p. 12). Whether “shorter supply chains” can be considered as “local” is unclear, however, it is a step towards local food production.
- *The strong local economies* and the outcome *more local value chains and “alternative” food networks that provide local, healthy, available, accessible and affordable food* are considered together because identified policies are the same. There is a synergy between the Digital Europe Programme and the European Regional Development Fund that

contributes to **the development and strengthening of regional and local innovation ecosystems** (Digital Europe Programme, Annex III).

- The impact *of the collective consciousness of the value chain about environmental impacts of food production* and outcome c*onsumers are fully conscious of the environmental impacts of food production* set a high bar for the environmental awareness of all value chain actors. The **Empowerment of consumers to make informed, healthy and sustainable food choices is an objective of Farm2Fork strategy** and Regulation on the food information to consumers (Art. 3(1))**.** Additional requirements to identify and assess environmental and human rights adverse impacts are required by the **directive on corporate sustainability due diligence** (2024/1760).

Two of the *outcomes* are highly connected to the *outputs* and the same policies and regulations were identified.

- *Cooperation between all value chain actors in sharing data through data exchange platforms* is *the outcome* that is partially converged by the concept of the Common European Agriculture data space (EU Strategy for Data, p. 22).
- *Every product is fully traceable with reliable and complete information on its origin* is directly linked with output *compulsory food labelling for transparency and traceability of food* and action *development of legislation for compulsory transparency and traceability.* All three have overlaps with Farm2Fork's strategy and Regulation on the food information to consumers, ensuring a level of health protection and traceability requirements by law. Moreover, the Commission plans to **scale up the fight against food fraud**, which undermines the traceability of the products (Farm2Fork, p.14).

The *outputs* of pathways related to scenario B are aligned with the existing legislation and policy documents. Educational efforts are especially strongly supported by EU policies.

- *Improved consumer awareness of food production processes* has an overlap with the Farm2Fork strategy in which the Commission calls for **strengthening educational messages on the importance of healthy nutrition, sustainable food production and reducing food waste** through **the review of the EU school scheme**.
- The output of *digitally literate value chain actors* refers to educational efforts that aim to promote **basic digital literacy** of value chain actors (EU Green Deal, p. 19), while also developing **advanced digital skills** (Digital Europe Programme, Annexe I), and **adapt skills of people** who are or will be **affected by the digital transformation** and transition to climate neutrality (EU Green Deal). The Commission will **update the Skills Agenda**, to

ensure that the food chain actors have access to sufficient and suitable skilled labour and to ensure employability in the green economy (Farm2Fork, p. 16, EU Green Deal, p. 19).

- Moreover, the **European Digital Innovation Hubs** are tasked with **raising awareness** and providing **access to digital transformation expertise**, know-how and services, and **facilitating this between regions**.
- *Digitalised data exchange platforms with value chain data* and action *Development of data exchange platforms* are related to the same regulations and policies as one of the outputs of pathways related to scenario A (*Secured and decentralised data database of DNA and consumer data with individualised consent).*
- Commission invests in a **High Impact Project on European data spaces** and **federated cloud infrastructures** (EU Strategy for data, p. 16).

In the context of *actions* related to the pathways, there were identified following relations with existing EU policies and regulations.

- *Food education and "digital" education* are strongly related to the output *digitally literate value chain actors*. The Commission propose to review the EU school scheme to contribute to sustainable food consumption (Farm2Fork, p. 13). Moreover, Member States can grant funds to support knowledge exchange and dissemination of information (Art. 78(1) 2021/2115).
- *The value chain actors collect data about their activities* that can be funded within the CAP framework (Art. 114(b), 2021/2115). The modernisation aims to **develop digital technologies in agriculture** in rural areas.

3.2 Legal risks and impact on fundamental rights

In the subsection, first, some identified legal risks are enumerated, followed by reflections related to the potential influence of the pathways on the legal values. The following risks were identified:

- **Small farmers** could experience **challenges in introducing digital technologies** into their production processes. This is in opposition to larger-scale producers, who are already using digital technologies. It strengthens inequalities between food producers.
- The system recommended in the Pathways related to scenario B can result in **higher prices** of food production transferred to consumer.
- **Local not always mean more sustainable**. It might be the case that by buying locally without knowing the actual environmental cost of the specific products consumers can buy food that has a higher environmental cost of production than food produced and transported from elsewhere.

- **Data-determinism.** Data determinism assumes farmers operate within standardised frameworks, but this overlooks the diversity of agroecological, small-scale, and organic farms, which often fall outside these rigid models.
- **Consumers can be overloaded by information.**
- **Misuse of data** by value chain actors. Access to information about the practices of other actors within the value chain could enable stronger actors to exploit the weaker or more vulnerable positions of others.
- **Potential change of interest in data exchange platforms.**
- **Cybersecurity risk.** Breaches of data confidentiality and integrity could have significant impacts on data subjects.

In the context of pathways 2.2 and 2.3, food traceability requirements may restrict farmers' choice of seeds and supplies, limiting traditional and spontaneous food production. The system should accommodate such practices.

In relation to all the pathways, a question is raised on the balance between the sustainability of the agri-food system and consumer freedom. It should be questioned how to redistribute the cost of the agri-food system transition related to countering climate change between value chain actors, ensuring everyone can afford food. This transition can be developed in a way that ensures the right to food, through continuing and expanding the support for social canteens in neighbourhoods, at schools, and in places of work, offering tax breaks on grocery purchases etc.

4. Legal screening of the pathways of Scenario C

The next two sections provide insights on what policies or regulations align with the pathways associated with Scenario C, and the potential legal risks or concerns related to them. Those are concluded in the third subsection.

4.1 Alignment of Pathways with Existing EU Policies and Regulations

Each element of the pathways is listed below, with the relevant policies and regulations are linked to them. The analysis is presented from impacts to inputs.

There are two impacts in the pathways related to scenario C. The first one is *full compliance of the agrifood sector: elimination of harmful products and processes,* which overlaps with the Commission's call to scale up the fight against food fraud (Farm2Fork, p. 14). However, it is essential to mention that the Commission calls for a more intensive fight against fraud not for full

compliance. The second impact, *livelihood security for farmers,* is the same in the pathways discussed in Scenario A, so all relevant policies and regulations related to that impact are discussed there.

For the most of *outcomes,* the relevant policies and regulations were identified.

- *Enhanced labour conditions in farming* are in the scope of the objectives of CAP framework (Art. 6(h)), which promotes employment, growth, and gender equality, social inclusion and local development in rural areas.
- *Fairer prices and improved business models for farmers* are the outcome that falls within the scope of the CAP objective (Art. 6(c) 2021/2115) by improving the position of farmers in the value chain. Moreover, the Commission aims to preserve the affordability of food, while **generating fairer economic returns in the supply chain** (Farm2Fork, p.4) and will ensure **tailored solutions to help SME food processors** and small retail and food service operators **develop new skills and business models. The Enterprise Europe Network will provide advisory services on sustainability for SMEs (Farm2Fork, p. 16).**
- *Balanced power dynamics in the agrifood sector* are related to the *output data governance intermediary,* so most identified legislation and policies are described there. The Commission recognises the challenge of the accumulation of data by Big Tech companies (EU Strategy for Data, p. 14).
- *The certification for environmental aspects and food quality* overlaps with the possibility of Member States implementing traceability and certification systems in their CAP Strategic Plans (Art. 47 2021/2115). The Commission plans to develop a legislative proposal that develop a framework of certifications and labelling on the sustainability of food products (Farm2Fork, p. 5).

For the outcome of *enhanced efficiency and productivity through optimal input use informed by data-driven decision-making/precision agriculture,* **no relevant law or policy was identified.**

The *outputs* of pathways related to scenario C are aligned with the following existing legislation and policy documents.

- *The improved digital skills* and action *digital tech awareness building for all value chain actors (producer to consumer)* overlap with the Output of Scenario B *digitally literate value chain actors*, so all the policies and regulations mentioned are also related to this output. Additionally, the Commission **updated the Digital Education Action Plan to reinforce better access to and use of data** (EU Strategy for Data, p. 21). The EU is investing in digital skills development through initiatives like the **Digital Europe programme**, focusing

on expanding the talent pool for deploying new technologies in businesses. It aims to create a **high-performing digital education ecosystem** (2030 Digital Compass) and provide **tailored support for SME food processors** to acquire new skills and business models (Farm to Fork Strategy).

- *The one-stop-shop data-sharing platform for farmers through improved data standards and interoperability* conceptualised in the promotion of data intermediaries.
- *The affordable decision support tools, including environmental impact assessment,* are covered broadly by the Commission initiative of **Agricultural Knowledge and Innovation Systems, which** aims to strengthen resources to **develop and maintain advisory services needed to achieve the Green Deal objectives.**
- *The DA addresses the structured, relevant, detailed, high-quality data* sets requirements regarding the interoperability of data, data sharing mechanisms and services, as well as common European data spaces (Art. 33). The Commission supports the collection of high-quality data through the **Farm Sustainability Data Network** (Farm2Fork, p. 16)**.** The network will enable the benchmarking of farm performance against regional, national or sectoral averages.
- *Enhanced collaboration and integrated thinking between tech providers, and with other value chain actors* are reflected in the initiative of the **Agricultural Knowledge and Innovation Systems**, which involves all food chain actors and aims to provide advisory services to achieve the Green Deal objectives (Farm2Fork, p. 15). Interdisciplinary networks, such as **the European Network for Rural Development** and **the EIP-AGRI Network** (2021/2115, Recital 115). **The European Digital Innovation Hubs** provide training, and advisory services and facilitate transfers of expertise between regions by matching start-ups and mid-caps (Art. 16, Digital Europe Programme).
- D*ata intermediaries*, introduced in data regulations (DGA, Data Act), are an idea to balance power between the Tech companies and other actors.
- *Enhanced transparency and circularity in the EU's food systems* focus on compulsory food labelling to improve traceability and transparency, while promoting circular business models in food processing and retail. The EU prioritises sustainable investments in energy efficiency within agriculture and food sectors, ensuring these actions do not compromise food security or biodiversity (Farm to Fork, pp. 6, 12). In the context of transparency see Output of pathways related to Scenario B (*Compulsory food labelling for transparency and traceability of food)*.

In the context of *actions* related to the pathways, there were identified following relations with existing EU policies and regulations.

- *The business model development for farmers based on their data* is the action that is supported by EU interventions. First, the Commission, through **the Enterprise Europe Network,** will **provide advisory services and** tailored solutions to help SME food producers **develop new skills and business models. Enterprise Europe Network will provide advisory services on sustainability** (Farm2Fork, p. 16)**. The Horizon Europe** and EU programmes provide **structural and investment funds that** will create opportunities for SMEs in the data economy (EU Strategy for Data, p. 21).
- The EU supports *technological development in the agrifood sector* through various interventions, including mandatory modernisation in CAP Strategic Plans (Art. 107(g)) and farm advisory services offering expertise on digital technologies (Art. 15, 2021/2115). Horizon Europe furthers this effort by advancing technologies in the data economy, while access to fast broadband is prioritised to enable precision farming and AI-driven agricultural practices (Farm to Fork, p. 15).
- *Data sharing and re-use: single (public and private) data collection and single storage* is a regulated aspect in the EU. The GDPR, DGA, and DA regulate the reuse of data by public and private actors. The idea of single storage presents cybersecurity risks (lack of the redundancy). The idea data reuse is important to reduce the environmental impact of data processing, data spaces can reduce the level of data replications. However, users of data spaces may copy data from data spaces reinforcing the current practice of data siloing.
- *The business model development for tech providers to create interoperable systems* is linked to the output *enhanced collaboration and integrated thinking between tech providers, and other value chain actors.* The basic requirements for the interoperability set in the DA(Art. 35) is a key idea for the functioning of data spaces.
- *The development of effective governance structures that support data control for farmers* it is an ongoing in the EU law. The DA introduced the right of data subjects or users of IoTs to have access, sharing and use of their data (e.g., Art. 3 - 7). Moreover, the data intermediaries service providers to balance power relations between actors in the data economy.
- The Farm to Fork strategy, which provides the framework for environmentally friendly food production, aligns with *the development of a legal framework supporting* in this pathway. This alignment is reflected in its key objective of ensuring the food chain has a neutral or positive environmental impact, as outlined in the "Draft Action Plan" annex.

Part of the following *inputs* have some overlaps with the existing policies and regulations.

- *The financial support for farmers' technology investments* is an input targeted by many EU programmes. Modernisation is a key element of the CAP programmes (Art. 107(g), 2021/2115). The synergies identified between the European Regional Development Fund, European Social Fund Plus, the European Agricultural Fund for Rural Development and the European Maritime, Fisheries and Aquaculture Fund **support actions bridging smart specialisations and support to the digital transformation of the European economy and society** (Annexe III, Digital Europe Programme). Moreover, the **Horizon Europe** partnership for **"Safe and sustainable food systems for people, planet and climate"** introduces research and innovation governance to deliver innovative solutions that provide **co-benefits for nutrition, quality of food, climate, circularity, and communities.** Moreover, **the InvestEU Fund will foster investment in the agro-food sector by de-risking investments (Farm2Fork, 15).**
- Policymaking is increasingly data-driven, supported by a growing number of policies and tools that enable evidence-based decision-making and policy design. Key tools include AI Watch, the Knowledge Centre for Bioeconomy, and various Competence Centres focused on areas such as indicators, evaluation, modelling, and technology transfer. Within existing legislation, the concept of data altruism encourages data holders to voluntarily share data with public institutions to enhance the policymaking process (e.g., Recital 45).
- *The lean & mean data* is interesting input for which no related laws or policies were identified.

4.2 Legal risks and impact on fundamental rights

- **Risk of exclusion of more traditional food production practices**. High entry costs of digital technologies and new certification standards may overwhelm traditional producers, risking their exclusion from the future of agri-food system.
- **Job displacement.** The rise of digital technologies in agriculture will increase the demand for skilled specialists and may replace traditional farmworkers. Smaller, less digitally skilled farmers and indigenous communities risk marginalisation.
- **Higher costs of food production** (precision agriculture) and **fairer prices for farmers** may result in **less affordable food for consumers**.
- **Decrease of quality of work conditions for small farmers**.
- **Food producers would be highly dependent on technology providers**.

From the perspective of fairness and non-discrimination, the pathways should include means to promote fairness and non-discrimination for all actors. The pathways should be evaluated in a Rawlsian manner that ensures equity and options for traditional ways of life, those who want to incorporate digital technologies, and those who lack the means to do so.