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DIGITAL TRANSITION: LONG-TERM IMPLICATIONS FOR EU FARMERS AND RURAL COMMUNITIES

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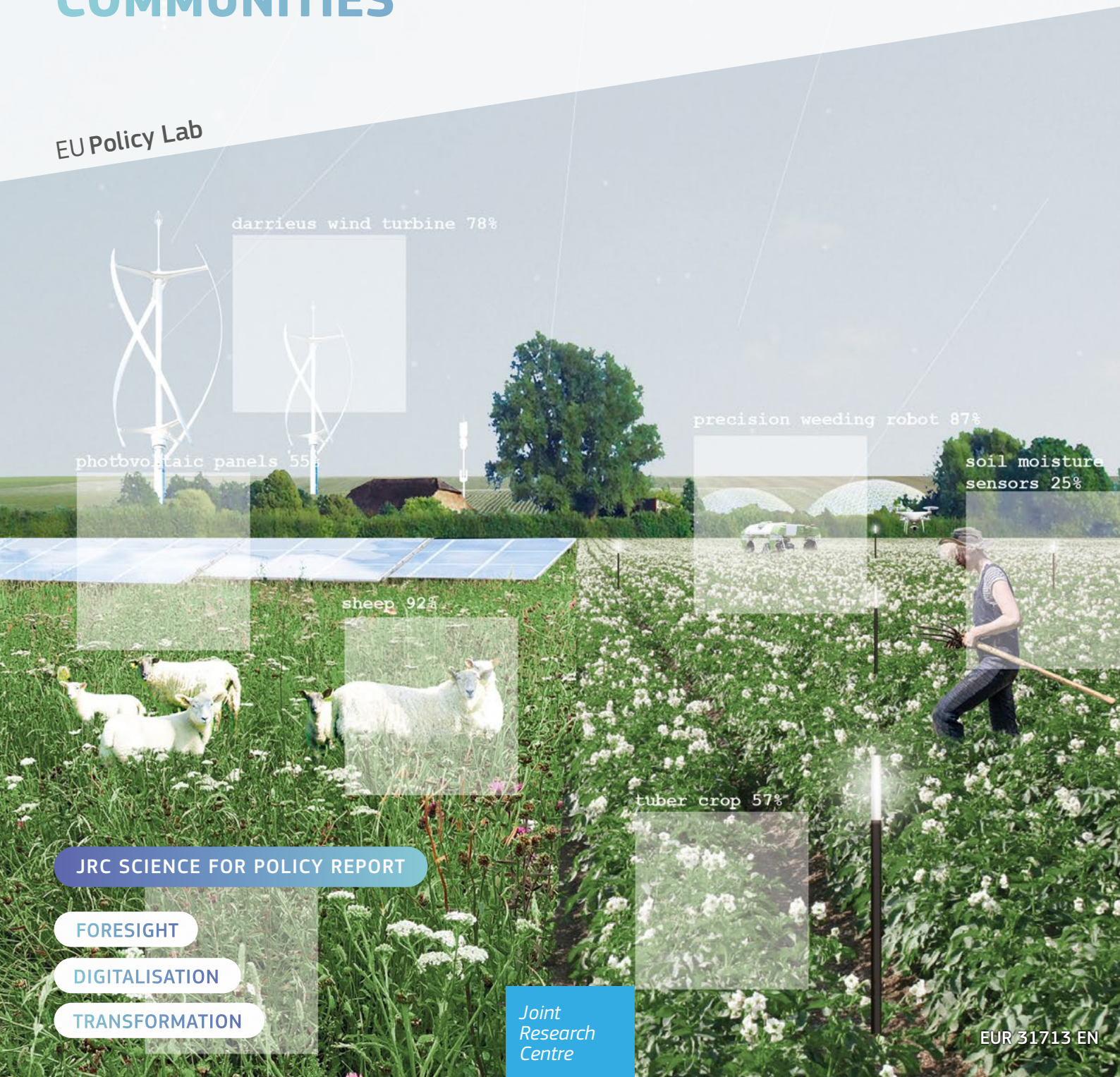

JRC SCIENCE FOR POLICY REPORT

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DIGITAL TRANSITION: LONG-TERM IMPLICATIONS FOR EU FARMERS AND RURAL COMMUNITIES

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Foreword

by Catherine GESLAIN-LANEELLE

Director Strategy and Policy analysis

Directorate General for Agriculture and Rural Development,

European Commission

Dear readers,

How can agriculture, one of the oldest human activities, reinvent itself in the digital age?

This is where foresight can help, with participatory approaches to identify transformations at play and shape the future.

Earlier cooperation with the Joint Research Centre already provided some milestones on our journey to the future.

In 2020, the study "Farmers of the Future" invited to build transformative resilience, highlighting the importance of networks, in particular farmers' connections with consumers and rural areas.

In 2021, a participatory foresight process contributed to developing a long-term vision for "stronger, connected, prosperous and resilient rural areas" throughout the EU. Digital connectivity is part of the ensuing areas of action.

In 2022, the Commission strategic foresight documents set the direction of travel "towards a green and digital future". Agriculture was part of the critical sectors explored through a deep-dive process.

With this report, we went the extra miles, navigating transformative futures to anticipate the role of digitalisation, discuss building blocks for a shared vision and draw strategic conclusions.

So, this foreword is just as an explorer's map guiding us through uncharted territories of the digital transformation of farming and rural life. This exploration was made possible thanks to the people who participated in this journey: farmers, rural actors, experts, policy makers, who are called to work all together on the optimal path towards the future. We wanted a comprehensive, human-centric, and participatory approach, involving key players and stakeholders. Around 12 workshops were conducted across the EU, where participants brought their unique expertise to the table for a rich debate. Many thanks to all of them and, of course, the authors of the report, whose dedication, enthusiasm, and hard work served as the compass for this journey.

As we know, farmers are facing huge challenges, from climate change and environment degradation to food security and rapidly evolving societal demands. Rural communities are also confronted with demographic changes and the risk of poverty. But they also offer many opportunities. In this complex landscape, digital technologies emerge as a powerful force. Under which conditions can they offer the promise of sustainability and resilience?

The current common agricultural policy (CAP) has already leveraged the impact of digitalisation on economic, environmental, and social sustainability. However, the digital progress that we witness is unprecedented while at the same time we know other policy areas beyond the CAP can impact our farmers and rural communities.

In our reflection to prepare the future and plan accordingly, we, in the Directorate General for Agriculture and Rural Development, asked ourselves: how will the future unfold for farmers and rural communities? How will the digital revolution transform their lives? What will be the challenges that they will be called to face and how can digitalisation help (or not)? How can farmers and rural communities drive the digital transition? How to make sure that no one is left behind? What future policies will they need?

The possible replies that you are about to discover in this study are highly relevant for shaping the future we want. By exploring possible transformative futures, with disruptive events such as military conflicts in outer space or (even more) extreme weather events, the report unfolds both the opportunities and the challenges that digitalisation brings. A purpose-driven digital transformation shaped in line with values and principles can lead us to the positive future we need.

As a forward-thinking society, we must meet the challenges of the digital age with determination and eagerness to embrace change, serving the common good.

I invite you to be curious and open to possibilities and the potential of the digital era as you navigate through these pages.

Welcome to this journey of discovery and transformation!

Contents

Abstract

Successfully managing the green and digital transitions is a crucial factor that could increase the resilience and strategic autonomy of the EU and shape its future. Yet digitalisation of agriculture and rural areas raises vital questions about winners and losers, costs, benefits, and long term implications.

This foresight exercise aims to explore the interplay between digital transition, policies and the resilience of the agricultural sector and rural areas, against the backdrop of potential disruptive and transformative changes. The report presents the outcomes of this exploration, proposing building blocks for an effective EU digital transition strategy for agriculture and rural areas supported by a hands-on policymaker's toolkit.

Acknowledgements

We would like to thank all the participants of the workshops for their time, active support and valuable input into the study. Without their insights and enthusiasm, this study would not have been possible.

We are grateful for the continued support and close collaboration with colleagues from the Directorate General for Agriculture and Rural Development (DG AGRI), in particular Evangelia Mourmoura, Florence Buchholzer, Fabio Cossu, Orsolya Besene Szaplonczay, Koen Mondelaers and Pierluigi Londero. We are also grateful to representatives of EU Member State administrations who participated in the creation of the toolkit.

We would also like to thank those colleagues in DG AGRI and other Commission departments who supported the study through their participation in several workshops.

We are grateful to Judith Schueler, Kristina Šermukšnytė-Alešiūnienė, Thanos Balafoutis, Monica De Cet, Julieta Contreras, Gianluca Brunori and Jacek Podlewski for their support in organising some of the workshops.

We wish to acknowledge the contribution of the JRC colleagues Anne-Katrin Bock, Greta Hauer, Alessandro Borsello, Lucia Vesnic-Alujevic, Laurent Bontoux, Joao Farinha and Jennifer Rudkin to the study. We also wish to acknowledge and thank the following JRC colleagues who supported this project by providing essential assistance and support and advice, notably Maya Lamanna, Sara Armas del Rio, Georgios Veis and Thomas Hemmelgarn.

Executive summary

Successfully managing green and digital transitions is crucial for ensuring a sustainable, fair, and competitive future of the European Union. The term 'digital transition' is used in this study in a broad sense, including the socio-technical processes surrounding the introduction and use of digital technologies, encompassing changes to interactions in the farm and rural systems and their environment. Long-term implications of digital transition for farmers and rural communities will depend on how we shape those processes.

In agriculture, digital technologies promise more efficient and sustainable production of food and biomaterials. For rural areas, digital connectivity is perceived as one of the key elements to improve quality of life, ensure geographically balanced development and economic prosperity. However, digitalisation in agriculture and rural areas does not guarantee positive outcomes by itself. Indeed, it also creates new challenges and vulnerabilities, if not introduced in a thoughtful way. Public support for digitalisation should be planned and executed in a way that enables it to meet the general objectives of creating sustainable food systems and stronger, connected, resilient, and prosperous rural areas and communities.

Digital transition is a process that will unfold in a transformative and disruptive environment that agriculture will face, shaped by the challenges of climate change and environmental degradation, geopolitical instability, changing supply networks, and evolving consumer demand. This will require resilient agriculture and rural areas. In terms of transformational resilience, when absorptive or adaptive capacities are not enough, more significant changes are necessary to transform the system itself.

Transformative foresight scenarios with wild cards as disruptions were used in the study to envision what such transformations could entail. In the face of disruptions in energy, technology, social and environmental aspects, new forms of self-organisation, decentralisation and new economic and social relationships emerge. When examining the scenarios, some common elements of the needed transition can be identified.

- Focusing primarily on the economic growth paradigm increases the vulnerability of agriculture and rural areas to shocks. With transformation, finding a balance between economic viability and broader well-being considerations becomes particularly important.

- The context is crucial, and responses to challenges may need to be more decentralised and better tailored to local circumstances.
- The response to challenges is more effective if more caring and trust-based relationships with partners are promoted.

In this transformation, digitalisation can play the role of a catalyst, helping to better cope with shocks, acquire knowledge, build communities and relations, and adopt systems-related thinking. However, digitalisation can also hinder this process by reinforcing inequalities, creating lock-ins and introducing new rigidities in the system. Therefore, adopting digital technologies should not be seen as the ultimate goal in itself. Instead, a directed digital transition that supports social challenges is necessary through responsible innovation that anticipates the intended and unintended impacts of digital technologies.

As shared objectives for the European common agricultural policy (CAP) are agreed at the EU level, a corresponding governance framework for digitalisation in agriculture should be established. This framework would facilitate and manage the responsible use of digital technologies and data in agriculture, ensuring transparency, accountability, and the protection of the agri-rural community and broader public interests. It should build on the commonalities and synergies in Member States' digital strategies developed as part of their CAP plans.

The study identified a set of issues which need to be considered when developing such digitalisation strategies:

- Digital transition processes should primarily support the broader purpose: the resilience of agriculture and rural areas, green transition, digital citizenship (the ability to actively participate in society with the help of digital technology) that empowers farmers and communities, and the wellbeing of the people (quality of life and opportunities to contribute meaningfully to the world).
- The approaches to digitalisation should reflect values such as trust, fairness, equality, power and sovereignty (the ability to influence and shape the processes, decisions and outcomes related to digital technologies), as well as care (nurturing and protecting).
- Implementation should be guided by principles of collaboration and sharing, accessibility, people-centred design, sufficiency, and circularity.
- The implementation of a digital strategy should be accompanied by key enablers: capacity building for digital skills and knowledge, fostering an effective digital ecosystem and data governance, investing in infrastructure and connectivity, and securing adequate funding and investment.

The study provides a toolkit aimed at supporting policymakers in their considerations of digital transition process. An inclusive discussion of what these elements mean in a specific context and how they can be integrated into the actions taken by all parties can help create a common strategic perspective.

Introduction

Context

The agricultural sector is facing today key challenges such as climate change, feeding a growing population increasing social demands and the need to provide a living to farmers while reducing its environmental impact. At the same time, rural areas also face a unique set of challenges including demographic change, high risk of poverty and a lack of access to basic services such as health, education, transport, etc. Digital technologies can play an essential role in helping agriculture and rural communities to meet their socio-economic and environmental objectives by becoming sustainable and strengthening their resilience for the needs of present and future generations[1],[2], [3].

The green and digital transitions are two major developments pushed forward by the European Union[4] to shape a sustainable future. In agriculture, in combination with other key factors[5], digital technologies could enable more efficient and environmentally sustainable production of food and biomaterials[6]. For rural areas, digital connectivity is one of the key elements to improve the quality of life, ensure geographically balanced development and economic prosperity[7]. Together, green and digital transitions could increase the EU's resilience and strategic autonomy[8]. Yet, digitalisation of agriculture and rural areas raises vital questions about winners and losers, costs, benefits, and long-term implications.

The EU's common agricultural policy (CAP) supports the digitalisation processes across all areas that fall under its remit (from competitiveness and income, through environmental care and rural areas to food and health). The current CAP aims at modernising agriculture and rural areas by promoting the creation and sharing of knowledge, innovation and digitalisation. In that context, all

1 Tisenjopfs et al. (2021)
2 Debryune et al (2021)
3 Bellon-Maurel et al (2022)
4 Muench et al (2022)
5 Ibid.
6 MacPherson et al (2022)
7 European Commission (2021)
8 European Commission (2022)

Member States have developed digitalisation strategies within their national CAP strategic plans, outlining how they will promote digitalisation in agriculture and rural areas in a strategic way, with a focus on adopting advanced technologies, creating infrastructure and knowledge, and developing skills.

The current CAP offers a wide range of tools relevant for the digitalisation, such as eco-schemes, payments for agri-environmental and climate management commitments, as well as investment and cooperation aid, including support for preparing and implementing smart village strategies[9]. It also supports uptake of digital technologies (also by administrations) and skills development, through support for knowledge exchange and dissemination of information, farm advisory systems and the European Innovation partnership (EIP) for agricultural productivity and sustainability.

At the same time, the EU's Digital Decade policy aims for a successful digital transformation of Europe by 2030 through four planks: digital skills, infrastructure, and transformation of businesses and digitalisation of public services. It establishes a set of rights and principles that will guide this digital transformation. It also encourages the building of connectivity and data infrastructure, large-scale pilots, and testing and applying innovative technologies in agriculture.

In line with EU priorities in the Green Deal[10] and a Europe Fit for the Digital Age[11], it is vital to ensure that fair the green and digital transitions are managed successfully. To provide an appropriate future policy framework in this regard, a clear understanding of the long-term implications of the digital transition for farmers and rural communities is needed. Foresight can help with that through a systematic exploration of different possible long-term futures. It offers policymakers a structured and participatory approach for identifying, understanding and directing change[12]. The purpose of foresight is not to predict the future but to generate useful insights to increase awareness and enable shaping the future through action in the present.

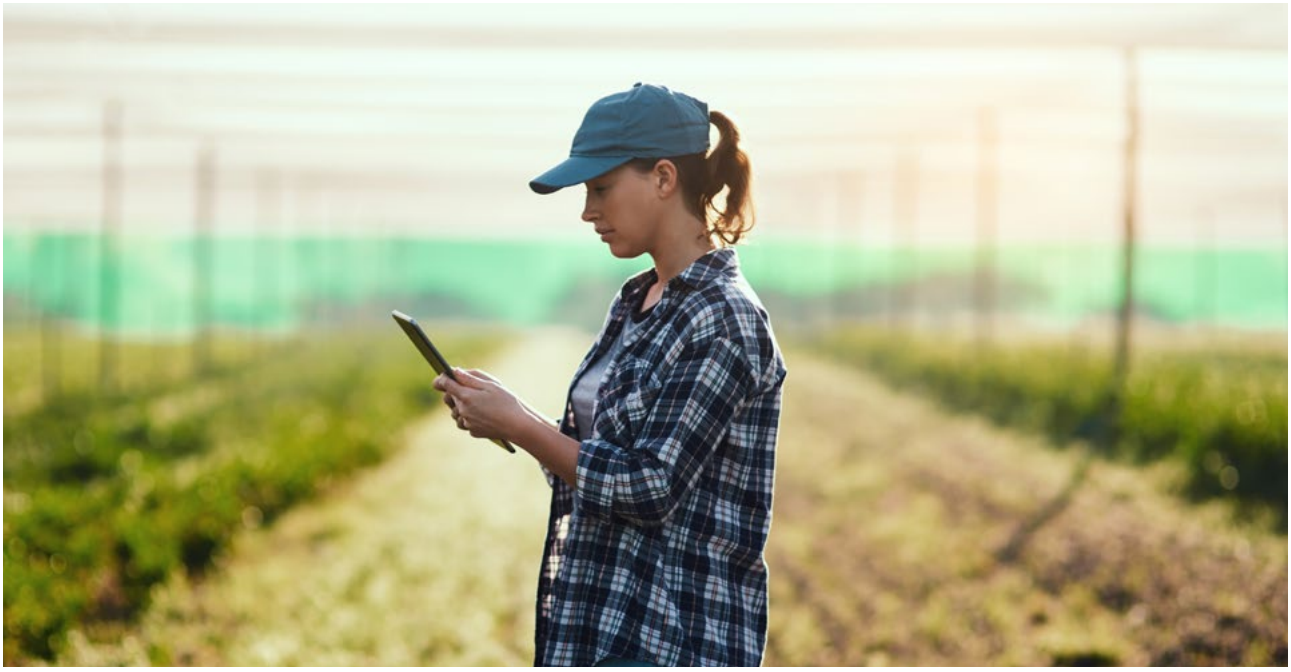
Digitisation in the agricultural context can be understood as the use of digital technologies at the level of single business or body[13].

In contrast, **digitalisation** refers to the integration of digital technology and infrastructure into business, governance or education. The term **digital transition** (or its synonym, digital transformation), is used in this study in a broad sense, meaning more than adoption of digital tools. It also includes the socio-technical processes surrounding the introduction and use of digital technologies, encompassing changes to interactions in the farm systems and its environment – technologies, organisations, people, and the environment[14].

The foresight study

The aim of this study was to examine the interplay between digital transition, policies and the resilience of the agricultural sector and rural areas, against the backdrop of potential disruptive and transformative changes. The tailored foresight methodology provided support for further development of the common agricultural policy in terms of anticipatory governance, vision, strategy and policy development, while connecting the dots with relevant EU strategies and programmes. The study timeframe up to 2040 aimed to move discussions beyond the current budget and policy-planning horizon. This foresight study was carried out by the European Commission Joint Research

9 https://ec.europa.eu/enrd/smart-and-competitive-rural-areas/smart-villages/smart-villages-portal_en.html
10 European Commission (2019)
11 https://commission.europa.eu/publications/factsheets-europe-fit-digital-age_en
12 Ghiran et al (2020)
13 Klerkx et al (2019).
14 Rijswijk and Klerx (2021)



Centre (JRC) in close collaboration with the Commission Department for Agriculture and Rural Development (DG AGRI).

The study builds on the previous JRC work on agri-food systems and rural areas such as Farmers of the Future[15], Long-Term Vision for Rural Areas[16], Concepts for a Sustainable EU Food System[17], as well as JRC Reference Scenarios[18] and the report Towards a Green and Digital Future[19]. The study also considered the findings of two Horizon 2020 projects – DESIRA and SHERPA on relevant aspects of digital transformation in rural areas[20].

This previous work established that a transformative resilience will be needed to 'bounce forward' to adapt to future crises. As farming and rural areas are facing accelerating technological change, automation, and digitalisation, the earlier studies emphasised the importance of digital knowledge and skills for thriving in the future. Building on this finding, this foresight study zooms in on the implications of digital technologies for transformative resilience. The study also follows up on one of the insights from previous work, to acknowledge various values, perceptions, and narratives around agriculture, in order to re-frame the discussions.

The study does so by putting forward a vision framework that outlines the purpose, values and principles that should guide digital transition of agriculture and rural areas. Finally, this study advances the debate on digitalisation of agriculture and rural areas by proposing building blocks for an EU digital transition strategy and a practical toolkit for policymakers at various governance levels.

The results of this collective intelligence-building exercise aim to inform digitalisation policy and strategy at the EU and/or national levels, help stress test policy options, and engage key stakeholders at the policy implementation stage.

Structure of the report

The structure of the report is as follows:

- Chapter 2 explains the methodology.
- Chapter 3 presents transformative scenarios for the future of agriculture and rural areas.
- Chapter 4 focuses on the various roles digitalisation can play.
- Chapter 5 describes the different strands of a vision of digital transition in agriculture and rural areas.
- Chapter 6 outline an EU digital transition strategy building process.
- Chapter 7 proposes recommendations for strategy delivery.

15 Krzysztofowicz. et al (2020)
16 Bock,and Krzysztofowicz (2021)
17 Bock et al (2022)
18 Vesnic Alujevic et al (2023)
19 Muench et al (2022)
20 DESIRA H2020 project: https://desira2020.agr.unipi.it; SHERPA H2020 project: https://rural-interfaces.eu/

CHAPTER 2

The foresight process

Digital transition is a complex process of societal change involving a variety of stakeholders with their own views and assumptions around technology[21]. It is essential to explore these multiple perspectives to stimulate productive conversations on the implications of digital transition for farmers and rural communities. Foresight can help with that by offering policy makers a systematic, structured and participatory approach to identify, understand and direct change[22]. Foresight engages with the mid to long-term future and harnesses collective intelligence of a diverse range of participants to generate relevant insights about the future, raising awareness and facilitating anticipation. The purpose of foresight is not to predict the future, it informs present day action to shape the future.

This study in 2022 – 23 brought together a wide group of participants from farming, digital technologies, EU institutions, national administrations, international organisations, rural areas, and academia.

The foresight process included a number of participatory workshops. Figure 1 illustrates the main stages of the process and the foresight approaches used.

STAGE 1: Study scope & methods

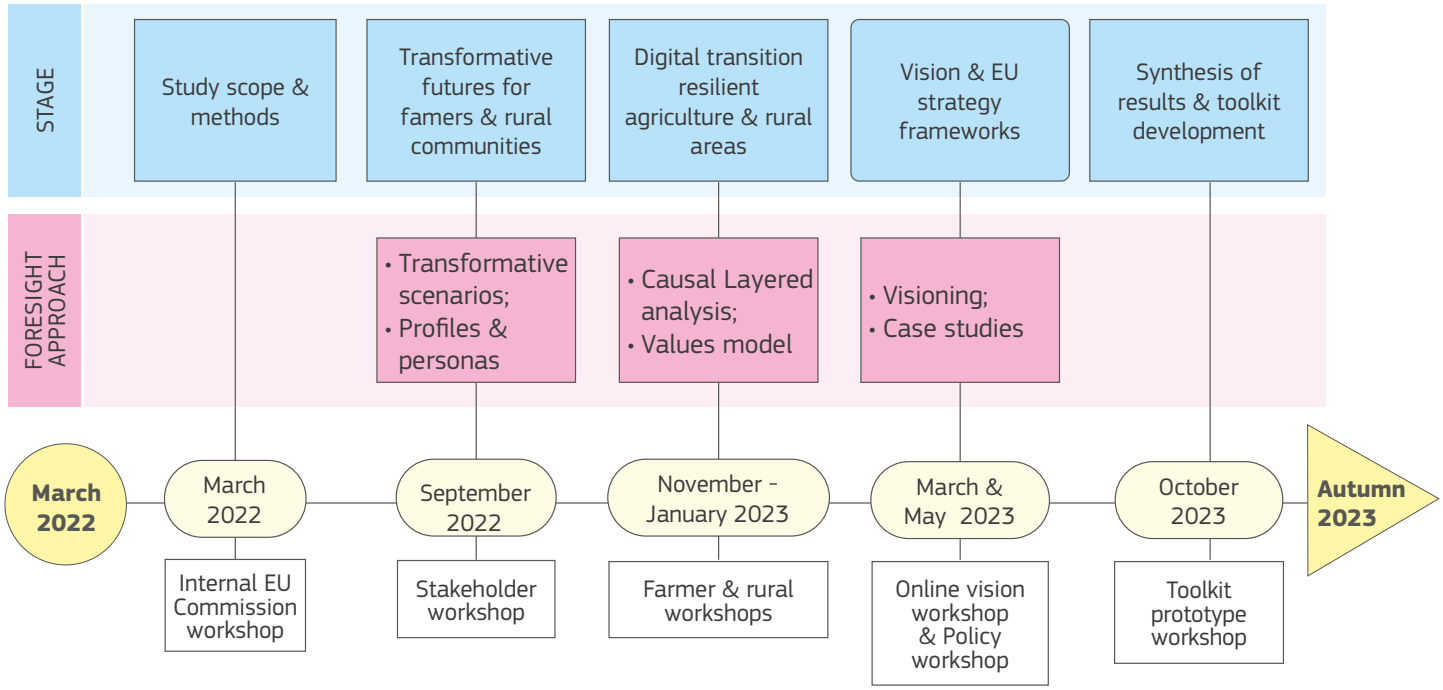
The foresight process started with an internal workshop in which participants from various Commission departments took part. The scoping workshop helped identify priority aspects of the study. The workshop participants also tested different foresight approaches that could help achieve the goals of the study.

STAGE 2: Transformative futures for farmers and rural communities

At the second stage of the process, a broader group of stakeholders from EU and international organisations, farming, research, technology, and rural areas participated in an interactive

21 Rijswijk (2022)
22 Ghiran et al (2020)

Figure 1 Overview of the foresight process and approaches



workshop. The aim of the workshop was to explore the implications of potential future disruptions and the role digitalisation could play in the resilience of agriculture and rural communities in transformative futures.

The foresight approach

Transformative scenarios

To explore the future disruptions and the implications of digital transition for farmers and rural communities across various plausible futures we used a transformative scenario approach[23]. Foresight scenarios are neither predictions nor projections or descriptions of desirable futures. The purpose of the scenarios is to identify alternative development trajectories and discuss their implications for specific policies.

The transformative scenario approach comprises two scenario stages – an exploratory scenario stage in which tensions and crises are examined as they evolve, and a transformative scenario stage in which an external event triggers the transformational process[24].

At the exploratory stage, a set of four JRC reference foresight scenarios on the global standing of the EU in 2040[25] was adapted. These scenarios present four distinct, internally consistent and plausible futures, which combine elements of geopolitics, environmental sustainability, economy, social values, regulatory environment and demographics.

Adapting the scenarios for this purpose involved adding the aspects that are relevant for agriculture and rural areas as regards digital transition. This happened partially through desk research as well as at the workshop.

To generate transformative scenarios, participants used a set of wild cards, i.e. potentially disruptive events in various categories such as energy, geopolitics, or social (see the full list of wild cards in Annex 2).

23 Erdmann and Schirrmeister (2016)
24 Warnke and Schirrmeister (2018)
25 Vesnic Alujevic et al (2023)

Figure 2. Overview of the reference scenarios at the exploratory stage

STORMS

This is a world where societies became more self-centred and retreated inwards, strengthening the role of nations and regional blocs.

END GAME

This is a world where economic growth and competitiveness trump well-being and social equalitiy.

STRUGGLING SYNERGIES

This is a world where there is a strong multilateral determination to fight climate change while side-lining other aspects of sustainability.

OPPOSING VIEWS

This is a world where society is divided into a regenerative and an exploitative alliance and both try to impose their paradigm.

Source: Vesnic Alujevic et al. 2023

Wild cards are low probability/high impact events or developments that occur suddenly leaving very little time for adaptation[26]. As a foresight tool, wild cards can help expand the ability to consider potential futures and a wider range of alternatives and perspectives[27].

Participants could choose one or two wild cards per scenario to imagine the disruptions or transformations that these wild cards would bring to agriculture and rural areas. The wild cards served not to predict any specific type of disruption out of multiple possible ones, but rather to expand participants' thinking and increase their ability to anticipate the developments.

The participants chose the following wild cards to transform their scenarios:

- Geopolitical disruption: accumulation of debris and testing of anti-satellite weapons lead to military conflict in space, massive economic damage and loss of surveillance capabilities.
- Energy disruption: energy becomes a luxury good: prices have increased drastically limiting energy use by a large proportion of European businesses and people.
- Energy disruption: the spread of renewable energy micro grids allows small communities to manage their own energy production and markets.
- Social disruption: deteriorating access to food and ideological cleavages lead to increasingly violent social conflicts targeting, among other things, agriculture and the food industry.
- Social disruption: severe shortage of agricultural labour leads to rethinking of operations, more attractive conditions for workers and better appreciation of farm jobs.
- Environmental disruption: extreme weather events destroy 40% of Europe's agricultural production capacity and infrastructure.

Using these wild cards as starting point, the participants imagined how agriculture and rural areas would change under the influence of the chosen trigger event.

The output of the workshop was a set of possible transformative futures for agriculture and rural areas in 2040 and the role digital technologies could play in them. The foresight team further refined and complemented the scenarios to arrive at distinct and coherent narratives (see the final narratives in Chapter 3). The team also further

26 Grote et al (2011)
27 Barber et al (2006)

analysed the roles of digital technologies regarding their possible implications discussed in Chapter 4.

Profiles & personas

To bring the transformative futures to life and explore the human perspective, a selection of 12 farmer profiles from the JRC Farmers of the Future study[28] was used in the transformative futures workshop. For rural areas, a separate set of personas that might be relevant in diverse types of rural areas in 2040 was developed and used during a workshop with the Horizon Europe DESIRA and SHERPA project partners in Stage 3 of the process. See Annex 3 for the description of the personas used in this workshop.

> Profiles and personas is a design-based tool used to create engagement in imaging the future through creation of fictional individuals situated in a future scenario with descriptions of their psychology, actions and daily life.[29]

The farmer profiles and rural personas helped the participants explore the changing roles of digital technologies and the extent to which these technologies would help or hinder farmers and other rural groups to cope with the shocks and disruptions of the transformative futures.

STAGE 3: Digital transition and the resilience of agriculture and rural areas

The third stage of the foresight process focused on the deeper exploration of the implications of digital transition from the perspective of farmers and rural communities. A series of interactive workshops took place in the Netherlands, Lithuania, Poland, Greece, France, Italy, and with the partners from the Horizon Europe project DESIRA. The local hosts in each country helped bring together diverse groups of participants consisting of farmers, rural actors, technology providers, advisors, and public administrations.

The farmer and rural workshops focused on unpacking the perceptions around the role of digital technologies identified in the transformative futures stage. The discussions among the workshop participants helped throw light on the tensions and limitations of the current perceptions. The workshops also involved reframing the current views and imagining the new ways of thinking about digital technologies that would help build alternative futures.

The foresight approach

Causal-layered analysis & values model

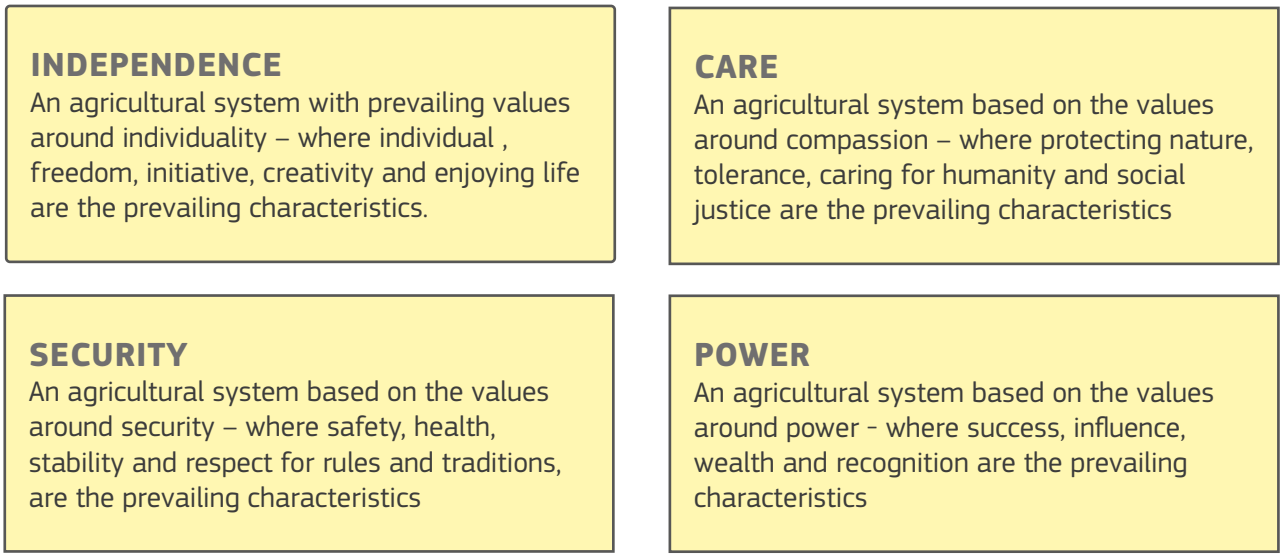
The roles of digital technologies identified in Stage 2 served as a starting point to explore farmers' and rural stakeholders' perceptions, values and assumptions around digital technology.

Prevalent implicit assumptions and values of farmers and rural communities influence how they see the world and how they act[30]. Their views and values can thus affect the use or non-use of digital technologies and inform the development of digital transition strategies. In the absence of standard foresight tools that identify such assumptions, values and perceptions, we adapted the causal-layered analysis (CLA) methodology and the personal values model[31] for the workshops with the farmers and rural stakeholders[32].

> CLA is a multi-layered approach[33] that identifies the driving forces and perceptions underpinning diverse perspectives about an issue. It helps go deeper into stakeholders' underlying assumptions to explore alternative futures[34].

28 Krzysztofowicz et al (2020)
29 Fergnani (2019)
30 Scharfbillig et al (2021)
31 Ibid.
32 Heinonen et al. (2017)
33 Inayatullah, S., (2004)
34 Heinonen et al (2017).

Figure 3 Values model for developing digitalisation strategies



Source: Adapted from Scharfbillig, M. et al. (2021)

The personal values model consists of 19 different values that are in complementary or conflictual relations to each other[35]. These values are aggregated into four higher order values: Openness to Change, Conservation, Self-enhancement, and Self-Transcendence. For the purpose of our study, following the feedback from the workshops, these four categories were articulated as Independence, Security, Power, and Care to represent a set of prevailing values in the agri-rural contexts.

Using the adapted personal values model (Figure 3)[36], the participants developed strategies that could help farmers or rural communities survive today and thrive in the future based on their perceptions around digital technologies and value systems recognised as prevalent now and potentially beneficial in the future.

STAGE 4: Vision and EU digital strategy frameworks

Having analysed the views and assumptions behind digitalisation across the countries, the fourth stage of the process was dedicated to the development of the vision and strategy framework for digital transition. The goal of the first workshop at this stage was to develop a vision framework that includes the purpose, values and principles of digital transition for resilient agriculture and rural areas in Europe. This workshop gathered the participants of the previous stages of the process.

The goal of the policy workshop that also took place at this stage was to test the emerging vision framework through specific case studies and discuss building blocks for an EU digital transition strategy that could contribute to the resilience of farmers and rural communities across Europe in the long-term. The participants of this workshop

35 Scharfbillig et al (2021)
36 Ibid.

included representatives from EU Institutions (Commission, Parliament, European Social and Economic Committee, Committee of the Regions) and member state administrations.

The foresight approach

Visioning

> Visioning is a participatory approach to build a shared, aspirational, and desired vision of the future for a group of stakeholders.

One of the key contributions that foresight analysis makes to policy-making is to help develop a meaningful, aspirational, credible, and inspiring vision of the future[37]. In this foresight study, the purpose of the visioning was to develop building blocks for an EU vision on digital transition for farmers and rural communities. The visioning consisted of identifying through a participatory process the purpose, values, and principles that should guide digital transition in agriculture and rural areas. The initial vision framework that came out of this process is described in detail in Chapter 5.

Case studies

In the policy workshop of this stage, participants tested the vision framework by applying it to specific digital transition-related policy case studies (see Annex 4 for the case studies list). Case studies included a range of current and potential policy initiatives that cover various aspects of digital transition such as infrastructure, skills, governance, technology deployment etc. The participants examined the extent to which the purpose, values, and principles of digital transition were reflected in the case studies and discussed what kind of policy tools or measures would be needed to achieve the case study goals in line with the vision framework. The final chapter of this report presents the summarised thinking from the policy workshop.

37 Ghiran et al (2020)

STAGE 5: Synthesis of results & toolkit development

In the final stage of the process, the foresight team behind the study integrated the outcomes of all the workshops (see the detailed list of workshops in Annex 1) and complemented them with desk research and analysis where necessary.

The results of the workshops also informed the development of a hands-on toolkit for policy-makers. The toolkit aims to support to policy-makers in their reflection on the digital transition process. The toolkit contains activities that could help align a digital transition strategy with the vision framework, put in place the key enablers for the adoption and use of digital technologies, and stress test digital strategies against transformative futures.

The design of the toolkit involved consultations with the national experts to identify the most challenging elements of a digital strategy development and the type of support they would find useful at different stages of developing a national/local strategy. Based on the inputs received from the experts, combined with the insights from the policy workshop, a prototype toolkit was developed. The prototype was further tested in a separate workshop with the national experts. The feedback of the experts helped adjust and refine the toolkit. See Chapter 6.3 for the description of the toolkit.

CHAPTER 3

Transformative futures for farmers and rural communities

Digital transition unfolds in a transformative and disruptive environment. Agriculture and rural areas face a variety of challenges, such as climate change, environmental degradation, geopolitical instability, changing supply networks and evolving consumer demand. These challenges can shape a multitude of futures. Digital technologies may or may not be helpful in addressing these challenges and withstanding the shocks. This chapter sketches out four potential transformative futures for agriculture and rural areas.

The purpose of these futures is to help explore how technologies can be favourable under disruptive circumstances and how they can contribute (or not) to the resilience of farming and rural communities. These transformative futures are based on the adapted and enriched reference scenarios[38] (see chapter 2 on the foresight approach). They are neither projections extrapolated from the present or past data nor desirable futures. Rather, these futures are alternative plausible trajectories that could be used as a tool to stress-test the resilience of agriculture and rural areas and to explore the role of digital technologies in it.

Each transformative future starts with a description of the geopolitical context (based on the reference scenarios) and the climate outlook, followed by the key characteristics of agriculture and rural areas in the EU, and prevalent technologies in agriculture. The narratives finish with the outline of disruptive events (wild cards) and the transformation that occurred in agriculture and rural areas after the events.

The four transformative futures are presented in the following order: navigating storms, community revival amid technological collapse, reclaiming digital sovereignty, and resilient roots to withstand the shocks. Table 1 presents an overview of the key elements of each transformative future.

38 Vesnic Alujevic et al (2023)

Table 1 Overview of transformative futures for farmers & rural communities in 2040

	Title of the transformative future			
	NAVIGATING STORMS	**COMMUNITY REVIVAL AMID TECHNOLOGICAL COLLAPSE**	**RECLAIMING DIGITAL SOVEREIGNTY**	**RESILIENT ROOTS TO WITHSTAND THE SHOCKS**
Reference scenario	**Storms** The EU is self-centred; extreme weather events push for survival-oriented action. An increase in temperature of 3°C is expected by the end of the century.	**End game** A powerful elite supported by big tech corporations steers economies and prioritises wealth. Social inequalities and environmental degradation are accelerating. Temperature increase of 4 °C is expected by the end of the century.	**Struggling synergies** The EU is part of a global multilateral effort that limits global warming to 1.5°C. The main focus is on energy transition at the expense of other environmental sustainability issues, such as biodiversity loss, soil health, and water scarcity.	**Opposing views** A bipolar world in which the EU leads a global regenerative alliance on the path to carbon neutrality. In contrast, an exploitative alliance is entrenched in high resource consumption. Temperature increase of 2 °C is expected by the end of the century.
Agriculture & rural area characteristics	The primary focus is on ensuring the production of staple foods and energy resources needed to sustain EU citizens. Self-sufficiency drives fierce competition for land use. Agricultural practices are geared towards maximising land productivity and resource efficiency, leading to the adoption of low-input methods & diversification.	Large food monopolies control what is grown, produced and consumed; farmers are contract workers in large holdings; depopulation continues in rural areas. Genetic modification and synthetic meat are commonplace to provide food in the face of water scarcity, pests and diseases caused by extreme weather events.	Competition between multiple sustainability initiatives; small diversified farms are outnumbered by large corporate monoculture farms; technocratic governance across the supply chain; rural areas are depopulating.	Agriculture and food are sustainable and circular; alternative proteins gain traction and many farming models are tailored to local contexts. Rural areas gain recognition and power, with opportunities for sustainable economic growth reversing depopulation.
Technology	Precision farming, genetic engineering & other technologies to improve productivity & minimise losses; digital business is tightly regulated; multiple competing agricultural data platforms exist.	High-tech industrial farming, controlled environment farming, synthetic food and cellular agriculture are the norm.	High tech farming controlled by dominant groups in the supply chain; AI and digital twinning used in farming; carbon farming technologies; technology is used to maximise efficiency & support sustainability claims.	Precision farming technologies, blockchain technology, AI and Internet of Things have become commonplace to optimise resource use, enhance crop productivity, reduce input usage, and increase yields.
Wild cards	**Energy disruption**: Energy becomes a luxury good; **Social disruption**: Deteriorating access to food and ideological cleavages	**Environmental disruption:** extreme weather events destroy 40% of Europe's production capacity and infrastructure **Energy disruption**: the spread of renewable micro-grids	**Geopolitical disruption**: Accumulation of debris and testing of anti-satellite weapons lead to the loss of surveillance capabilities, economic damage and conflict in space; **Social disruption** Severe shortage of agricultural labour	**Geopolitical disruption**: Accumulation of debris and testing of anti-satellite weapons lead to the loss of surveillance capabilities, economic damage and conflict in space
Transformation	Food supply chain is disrupted, leading to food security issues and social unrest; Competition between land for renewable energy and agriculture intensifies the tension between urban and rural areas. To overcome the crisis, local communities and farmers form self-governing food and energy networks. Open source & low-energy-consuming frugal digital technologies that are adapted to the local needs play a key role in supporting local autonomy.	Extreme weather events disrupt energy and internet infrastructure, leading to food insecurity and social unrest. Farmers and rural communities come together to bypass centralised food distribution systems imposed by the government. They adopt no-tech & low-input production methods, supported by renewable energy micro grids. Emergence of shorter supply chains & local & regional autonomous self-sufficiency approaches.	Large food monopolies struggle to adapt to technology failures. Farmers form peer-to-peer communities to share the knowledge and digital tools taking control over their data and food production. Demand for and shortages in manual labour lead to better pay and working conditions on farms. People from cities start returning to rural areas, revitalising these communities.	Farmers who relied on technologies are severely affected by tech failures; however low-tech regenerative farms managed to mitigate the effects on food systems. Green tech producers who exported their production outside the EU re-orient towards the single market. The resilience of regenerative agriculture and the strong ties in rural areas made it possible to avoid social tensions and conflicts.

NAVIGATING STORMS

Amid the energy crisis, the fight for agricultural land as a target for energy infrastructure development intensifies.

Navigating storms

Overview of the 'Storms' reference scenario

In this scenario, the EU finds itself in a world of continuous deprivation, weakened food supply chains, growing water scarcity, and a rapid spread of diseases. As a result, the EU adopts a self-sufficiency approach, isolating itself from the rest of the world. Trade with external partners has dwindled, and GDP is on a downward trajectory. The reduced global efforts towards climate change mitigation steer the planet to an increase in temperature of 3°C by the end of the century (compared to pre-industrial levels). This development has caused stark increases in extreme climate events, which affect the liveability of many regions.

Agriculture and rural areas

Food is considered a strategic security asset. The refocusing of the food system and supply networks to the European single market has reinvigorated agriculture in parts of Europe where abandonment was rampant. The focus is now on commodities and the availability of staple products within the EU. Exports are managed through complex quota and exchange agreements. Research and innovation focuses on adaptability to climate change and increasing yield.

The primary focus is on ensuring the production of essential food and energy resources needed to sustain Europe's citizens. Self-sufficiency drives fierce competition for land use. Agricultural practices undergo a significant shift, with the emphasis shifting towards maximising land productivity and resource efficiency. Depopulating rural areas become reoriented towards the provision of food, as farming becomes an attractive career choice.

Technology

Public policies influence the development and uptake of digital technologies that focus on productivity. Precision agriculture technologies and low-input agriculture gain prominence as farmers strive to make the most of limited land resources. The race to engineer and cultivate crops that are most suitable for the region's climatic conditions intensifies, with a strong emphasis on drought-resistant varieties and water-efficient irrigation systems.

Transformative process

As energy prices soar due to limited availability of resources and energy becomes a luxury good, the EU's self-sufficiency strategy is compromised. The scarcity of affordable energy hinders the use of advanced technologies and forces most farmers to adopt alternative low-energy and low-input production methods. Interruptions in the availability of fuel causes disruptions in food transportation across the supply chains.

Amid the energy crisis, the fight for agricultural land as a target for energy infrastructure development intensifies, leading to land grabbing in some regions and nationalisation of land as a response. This competition for land creates tension and sparks conflicts between rural and urban areas, exacerbating existing disparities and highlighting the differing priorities and needs of rural and urban communities.

The deteriorating access to food fuels social unrest and leads to conflicts. As food scarcity looms, social movements emerge, demanding equitable distribution and access to essential resources. The need for localised food systems and community-led initiatives drives food production and distribution. To address the crisis, policies promoting consumer-farmer networks gain traction, encouraging shorter supply chains and reducing dependency on external sources. With time, these measures promote a sense of resilience and self-reliance.

At the same time, local and regional approaches to agricultural self-sufficiency are emerging. The focus shifts towards innovative autonomous decentralised solutions that optimise energy usage in agricultural activities. The search for decentralised solutions extends beyond the energy sector to encompass various aspects of agriculture and rural development. While complex AI-based machinery and precision farming tools are no longer viable, open source frugal digital technologies that have low energy consumption and are suitable for local capacities play an important role in supporting local autonomy. They facilitate the sharing of knowledge, resources and best practice within the farming and rural communities.

COMMUNITY REVIVAL AMID TECHNOLOGICAL COLLAPSE

The disruption of energy and internet connectivity infrastructure due to extreme weather events leads to frequent power outages, unstable internet connection and soaring energy prices.

Community revival amid technological collapse

Overview of the 'End game' reference scenario

With the prioritisation of economic growth and wealth generation, material standards rise for some, but social inequalities increase. Former welfare states retreat into the core tasks of providing security, because of the abundance of conflicts arising. With 4 degrees of temperature increase expected, the extreme effects of climate change become very frequent and costly. There is a collapse of natural ecosystems on land and in the sea.

Agriculture and rural areas

Thanks to efficiency through virtualisation, a service-based model, automation and high demand for synthetic alternatives to meat, the food industry is booming. Food companies compete fiercely and focus on product innovation and security of sourcing to substitute natural foods sources that are no longer viable.

Large food monopolies dominate the market, controlling what is grown and consumed. Farmers work as contracted producers, growing only what they are told by the industry. Agriculture is a domain of large automated holdings preoccupied with protecting itself from the weather – most production comes from large controlled-environment greenhouses and rural facilities for synthetic and cellular agriculture.

Rural areas have transformed into vast depopulated areas, with most land used for energy production, recreation, agriculture or industry. The biodiversity of the areas has been sacrificed for the sake of maintaining economic growth. The once-thriving rural communities have become ghost towns, as people have migrated to the cities in search of better opportunities.

Technology

Technology is also industry-driven and farmers have to buy or rent equipment and software imposed by the industry. They lack the knowledge to solve problems on their own, as agricultural knowledge and advice is monopolised.

Synthetic food, controlled-environment farming and cellular agriculture have become the norm. Crops grow in large-scale indoor facilities with little exposure to pests and diseases. Meat and animal products are produced in large centralised bioreactors. These facilities are heavily regulated, with strict guidelines on the use of pesticides and fertilisers.

The traditional concept of farming has disappeared, replaced by a highly mechanised and automated system. The use of drones and robots has become commonplace, with farmers merely monitoring the machines from afar. The industry has a tight grip on the production process, with every aspect of farming optimised for maximum profit.

Transformative process

The disruption of energy and internet connectivity infrastructure due to extreme weather events leads to frequent power outages, unstable internet connection and soaring energy prices. As the centralised energy grid becomes less reliable, the work and transportation of cellular agriculture products is heavily disrupted and food security is compromised in many parts of Europe. Deteriorating access to food leads to social unrest, which threatens stability. As food shortages and rising prices hit urban areas, protests and riots erupt in some areas of the EU. The government responds by centralising and imposing strict controls on the distribution and sale of food, exacerbating existing inequalities and leading to further social unrest.

In response to these challenges, people move back to rural areas with local communities and farmers organise themselves through town hall meetings and provide food directly to those in need, bypassing the centralised food distribution system altogether. As global connectivity is severely disrupted, most of the technological solutions are decentralised with local networks and data centres and 3D printing as the principal manufacturing method.

Farmers turn to regenerative methods and approaches adapted to local conditions[39]. After the initial shock, a more diverse and resilient food system that is better equipped to respond to local needs gradually emerges across the EU. These efforts are supported by the newly established local autonomous micro-grid renewable energy infrastructure, which provides the necessary power to operate community-based food distribution systems. Through these initiatives, neo-rural local communities are gradually able to take control of their food and energy supply.

39 As defined in Farmers of the Future study, see Krzysztofowicz et al (2020)

RECLAIMING DIGITAL SOVEREIGNTY

Small independent farmers start to come together to exchange knowledge and share resources in the face of a harsh economic situation.

Reclaiming digital sovereignty

Overview of the 'Struggling synergies' reference scenario

The economy prospers in the Global North and large parts of the South and there is a more balanced distribution of dividends worldwide. National public bodies fight for what is nonetheless an imperfect compromise on governance, environmental and social standards in international forums, such as the WTO. The climate outlook for 2100 is 1.5°C warmer. A hasty quest for climate change mitigation left other sustainability challenges unaddressed. Too much effort was placed solely on topics such as the energy transition.

Agriculture and rural areas

Little has changed in EU agriculture and food industry due to the technological lock-ins and path dependency. Increased effects of climate change, heavy environmental regulation and pervasive "green-washing" by the increasingly consolidated food industry lead many farmers to abandon the sector and discourage new entrants. Although sustainability indicators are slowly improving, the "blame game" and issues of unfair competition with non-EU players prevent a larger consensus from emerging. A multitude of sustainability initiatives fiercely compete and strive to project their sustainability to attract consumers.

The governance system is technocratic and favours the interests of the consolidated supply chain. Diverse small-scale farm systems exist, although large corporate monoculture farms dominate, leading to a concentration of power in the hands of a few large players.

Technology

In this scenario, precision farming, carbon farming technologies, drones and sensors are widely used by corporate actors to optimise production and reduce costs. These agricultural technologies are controlled by the dominant supply chain actors, and small-scale farmers are left out of the decision-making process. Technologies help corporates maximise the efficiency of production and support their sustainability claims.

Advanced technologies are primarily used in urban areas and in agricultural production, leaving rural areas behind. As a result, people are increasingly moving to the cities, leading to a decline in rural populations. Those who remain in rural areas often commute to the cities for work, leading to a loss of community and a lack of investment in rural areas. This exacerbates the rural-urban divide.

Transformative process

Due to the loss of satellite capabilities, farms that relied heavily on complex digital tools face challenges in harvesting and monitoring their crops, and lose the ability to optimise yields and reduce inputs. The supply chain can no longer guarantee the same products, features and quality. Social upheavals increase due to rising prices and the perceived lack of progress and prospects for a better future.

Small independent farmers start to come together to exchange knowledge and share resources in the face of a harsh economic situation. They form peer-to-peer communities. These communities operate on the principle of digital sovereignty, where farmers have control over their data, tools, and technologies. Through these communities, farmers start to develop their own digital tools and technologies, based on their needs and requirements, rather than being restricted to the tools provided by the profit-driven agro-food monopolies.

The technology failure of the highly automated corporate farms increases the demand for manual agricultural labour and regenerative farming methods on smaller plots of land. Corporate farms are forced to provide better pay and working conditions to attract manual workers. The shortage of labour and stagnating economy in the urban areas encourages more people to move back to rural areas to escape poverty, leading to a certain revitalisation of rural areas.

RESILIENT ROOTS TO WITHSTAND THE SHOCKS

A variety of sustainable techniques have enabled sustainable food systems to be established.

Resilient roots to withstand the shocks

Overview the 'Opposing views' reference scenario

The world is divided into a regenerative alliance and an exploitative alliance which both try to impose their paradigm. Europe is at the forefront of a global regenerative alliance that prioritises social equality and environmental sustainability. It is on the right path to become carbon-neutral by 2050. Local ecosystems are recovering, and soil health and productivity have greatly improved. The EU exports green technologies to enable other regions to achieve similar environmental targets.

Despite greenhouse emissions reduction in some countries, the global situation is mixed, with a 2-degree increase in temperate predicted by the end of the century.

Agriculture and rural areas

Investment in regenerative agriculture, which relies on a variety of sustainable techniques, have enabled sustainable food systems to be established. Deep changes in diets, as well as a focus on self-sufficiency and health, have transformed the demand for agricultural products, with most types of intensive agriculture no longer viable. Following inflationary pressure, multi-stakeholder platforms and social innovation has brought all the participants in the food supply network together, creating feedback loops reinforcing the path to sustainability. Agri-tech start-ups play a huge role in circularity and zero waste/zero pollution solutions. There is diversity of models and structures, adapted to local circumstances. This shift also results in less livestock, as alternative protein sources gain traction, reducing the environmental footprint associated with intensive animal farming.

As rural areas gain recognition, the rural population obtains more rights and influence in decision-making processes. This empowerment helps combat rural depopulation and creates opportunities for sustainable economic growth.

Technology

Renewable energy, precision farming technologies, blockchain, AI and Internet of Things have become commonplace and enabled farmers to optimise resource use, enhance crop productivity, reduce input usage, and increase yields. Primary producers have reclaimed their power from retail, leading to shorter and local supply chains.

Transformative process

The technological disruption due to the satellite failure severely hampered the ability of technologically advanced farms to optimise irrigation, plan planting schedules and detect crop diseases or pests. It also increased the uncertainty and risk in agricultural operations, potentially leading to lower yields and reduced productivity, resulting in higher food prices. In contrast, regenerative farms were more resilient to such disruptions due to their inherent ability to adapt, the simpler farming practices used, and their increased self-reliance. Due to a high share of regenerative farms in the EU, the initial shocks to the food system were minimal and EU agriculture bounced back to normal production rates in the short term.

In the face of the crisis, the green tech industry re-oriented from technology export to supporting domestic producers affected by the technology failures. While the economic damage caused by these events diverted some resources and investment away from agriculture and rural development, the resilience of regenerative agriculture and the strong ties in rural areas made it possible to avoid social tensions and conflicts. This setback did not hinder the progress made in sustainable farming practices, renewable energy adoption, and efforts to increase social cohesion.

CHAPTER 4

Digitalisation and transformative futures

As the world becomes increasingly turbulent, the combination of volatility, uncertainty, complexity and ambiguity means that going back to a more stable environment is very unlikely. Agriculture is experiencing multiple crises, linked to climate, geopolitics, health and economic factors that will only grow in the future. As shown in Chapter 3, technology, energy-related, environmental or social disruptions can create systemic shocks, threatening food security and social stability. Yet, in the longer term disruptions can also lead to transformation of current agri-food models and lead to more resilient food systems and communities.

Society can cope with individual shocks by either resisting (absorptive capacity) or adopting a degree of flexibility (adaptive capacity). However, in times of multiple crises - when disturbances are not manageable anymore - bigger changes are needed, which in extreme cases will lead to a transformation (transformative capacity)[40]. Resilience is thus not only the ability to withstand and cope with shocks but more importantly, to "bounce forward", towards a systemic transformation[41].

Digital technologies and dimensions of resilience

The social and economic dimension of resilience refers to the ability to tackle economic shocks and achieve long-term structural change in a fair and inclusive way[42]. Digital technologies can increase economic resilience by creating new opportunities for rural businesses and farmers[43]. E-commerce platforms, digital marketing tools, and online marketplaces can help them reach a wider customer base and diversify their revenue streams. Precision farming and data-based solutions can increase profitability through optimisation of inputs, reduction of expenses or more efficient production[44] [45].

Prioritising local needs and promoting community

40 Manca et al (2017)
41 Sauer, J. and J. Antón (2023)
42 European Commission (2020)
43 Lezoche et al (2020)
44 European Parliament (2016)
45 McFadden et al (2022b)

empowerment are also essential for building economic resilience. This involves engaging farmers and rural communities in decision-making processes, empowering them to take control of their livelihoods and food systems, and fostering a sense of ownership and agency. Digital transition can increase social resilience in rural areas by improving access to essential services and fostering community engagement. E-health services can provide remote healthcare access, e-learning platforms can support education, and online platforms can facilitate social connections and collaboration.

Environmental resilience is about reaching climate neutrality, while mitigating and adapting to climate change, reducing pollution and restoring the capacity of ecological systems to sustain our ability to live within planetary boundaries. Digital tools and precision farming technologies can improve the environmental resilience of agriculture. By collecting and analysing data on weather conditions, soil quality and crop health, farmers can make more informed decisions regarding irrigation, fertilisation and pest control, and can respond appropriately to crises.

This enables better resource management, optimised production and reduced environmental impact. Additionally, digital platforms can facilitate knowledge sharing and collaboration among farmers, enabling them to share best practice and collectively address challenges. By adopting digital solutions that promote environmentally conscious behaviour and lifestyle, rural communities can contribute to climate change mitigation and adaptation efforts. Digital technologies can also enable them to organise and respond to emergencies more effectively, increasing community resilience in the face of natural disasters or crises.

In terms of geopolitical resilience, the disruptions related to international security, supply chain stability or dependency on imported technology and raw materials highlight the need to strengthen EU's open strategic autonomy and invest in research and development. Open strategic autonomy can be understood as the EU's commitment to open and fair trade while reducing its dependency and strengthening its security of supply across key technologies and value chains.

The foresight scenarios described in Chapter 3 used wild cards as disruptions to imagine how these dimensions of resilience could lead to a transformation. Reviewing the potential agri-food sector responses to environmental, social and technological disruptions in the four different scenarios of global development, certain common themes emerged. Prioritising growth increases the vulnerability of agriculture to shocks – with transformation, the balance between economic viability and well-being becomes particularly relevant. Responses often need to be decentralised and adapted to local circumstances - this requires more agility and better, more caring, relationships with partners and the creation of trust. Transformed agriculture systems would also encourages a more open knowledge system, co-created by the community.

Digitalisation roles

Digitalisation can in principle support this transformative process across the different dimensions of resilience – social and economic, environmental and geopolitical. Digitalisation can play the role of a catalyst, helping to better deal with shocks, acquire knowledge, build communities and relations and adopt systems thinking. Yet, under certain circumstances, they can stall it – preserving the lock-in to the current unsustainable situation.

Coping with shocks – digitalisation and managing risks

There is increased incidence of crisis situations affecting farming and rural communities. Extreme weather events are envisaged to increase. The Peseta IV study[46] explores the diverse impact categories for the EU (i.e. human mortality from

46 Feyen et al (2020).

heat and cold waves, windstorms, water resources, droughts, river and coastal flooding, wildfires, habitat loss, forest ecosystems, agriculture, and energy supply). The study shows that the consequences will be severe and varied across regions. Geopolitical and market shocks (including due to pests and disease outbreaks) will affect prices, value chains and trade, having significant impact on the economics of agricultural production.

The usual actors will be less likely to absorb the shocks. Financial and insurance companies will become more risk-averse; supply chain companies (food industry, retail) will also be facing shocks themselves; consumers will want to spend less; administrations will have to face multiple crises in restrained fiscal environment.

Digitalisation can support the response to crises – increase the capacity for better forecasting. From smart water management and disease control management in livestock to preventive and responsive management of forest fires, the deployment of remote sensing and underlying digital platforms (for example livestock electronic identification tags) promises to revolutionise early warning capabilities across various fields in. This will also benefit rural communities that are heavily impacted by extreme events.

The internet of things, with its wide range of sensors, promises to constantly monitor fields, weather, supply chain and economic situation, to warn of emerging problems[47]. Apart from risk mitigation, digital technologies can help with various risk management strategies – from fintech and insurtech[48] providing innovative financial and insurance solutions to new approaches in disaster risk management and biosecurity measures.

47 Qazi and Khawaja (2022)
48 Fintech and insurtech refer to new technological innovations in the fields of finance and insurance.

Wisdom – digitalisation and good judgment

The future scenarios show that agriculture and rural areas will operate in an environment of increased complexity. A faster pace of events, together with more social demands and pressure to adapt will require stakeholders to take more decisions, and increasingly different decisions to those taken in the past. The consequences of these actions will also be visible more quickly, with faster feedback loops and more dependencies.

At the same time, increasing computational speed and power, coupled with the availability and ubiquity of data flowing in and out of our devices, homes, work and public spaces, are enabling the collection, processing and analysis of large volumes of data. Increased access to information, knowledge and analytics with the help of artificial intelligence algorithms will lead to more tools to support decision-making[49].

Apart from individual business decisions, collective decisions will face the same challenge. The engagement and empowerment of citizens in their relationship with the government is crucial for more adaptive open governance systems. Rural communities can be empowered by digitalisation – for example, by giving people access to information or an active role in decision-making. However, digitalisation can disempower rural communities, resulting in an uneven balance of power between the more and the less digitally connected and skilled local actors. The future challenges will require faster and more evidence-based decision making that can be supported by digital tools, such as spatial decision support systems.

The challenge for digitalisation is that users, swamped by information, will have a hard time distilling the relevant information from it. As more information is available - rather than helping, it becomes overwhelming and difficult to interpret. Understanding the rationale for the choices made by the decision-support software, trusting the underlying data and making sure humans are in the decision making loop are some of the main issues for the digital transition. Increasing the digital literacy and skills of farmers, rural communities, advisors and public administrations is thus of paramount importance.

Good systems – digitalisation and systemic approach

The future scenarios show that, to face the challenges, agriculture and rural areas will have to transform to more sustainable models. Adapting a few, isolated processes and parameters will not be enough – the change has to apply to the farm as a system with interconnected physical/biological components (soil, plants, and animals), practices, materials and socio-economic aspects.

Also, the rural green transition or the changing social and economic model to reach long-term sustainability is becoming a major issue for both urban and rural regions. Our understanding of the world is increasingly based on understanding complexity and systems – with a new approach to focus on the relations between various elements of the systems, their functions, rules, purpose, and outputs.

Today, different digital tools can help farmers optimise processes and monitor specific activities, but they do not necessarily connect them together. Digital platforms promise to integrate various separate tools and build a systemic approach to analysing and managing a farm. In the future, farm-level digital twins (virtual counterparts to real-world systems) could be a more standard part of decision-making in the agricultural sector[50], used to monitor and predict the functioning of the farm by farmers, businesses, academia, local and

49 Ryan (2022)
50 De Baerdemaeker (2023)

regional administrations and even national and EU governments[51]. Together, they will be able to identify and test solutions to find the most suitable and sustainable option. This testing ability would allow the farmers to react and adapt more quickly to changes.

The challenge for digitalisation is to move from targeted/narrow applications into broader, modular, interoperable and connected applications. These technologies can also help farmers learn about the systemic aspects of their activities and help imagine how to transform those systems[52]. They should also be able to accommodate the informal knowledge, as the output from IT systems interfaces with farmers' past experience, beliefs and peer group opinions.

Community – digitalisation and embeddedness

For farming to be an attractive profession, it should be meaningful, purpose-driven and avoid harm to physical and mental health. Farmers often find themselves pitched against their communities and isolated. Moreover, cooperation and collaboration are seen as critical for positive futures through digital social innovation. Initiatives such as data cooperatives are envisaged; these collaborations enable trust to be increased at local level.

Digital social innovation, where innovators, users, and communities collaborate using digital technologies to co-create knowledge and solutions in the areas of community cohesion, well-being, and democracy promises to change the role of farmers in society[53]. Telepresence, extended reality, and other communication and collective decision-making digital solutions could also change the involvement of stakeholders and citizens in co-creating various processes, including political ones[54]. These tools can also mean bringing together farmers to share best practice and face risks together - strengthening farming community.

The challenge for digitalisation is not to add to stress and help practice digital well-being and improve health and safety[55]. Using and monitoring digital tools can lead to anxiety, digital fatigue, and distraction with "notification overload" affecting mental health.

Autonomy and interdependence – digitalisation and relations

There are increasing demands from social, administrative and supply chain actors on how farming processes run – and have a say in the decision-making process on the farm. Farmers see this interference in running their business as a constraint, but have to coordinate with a growing number of actors – input providers, processors and retailers, authorities etc.[56].

Coordination and communication technologies promise to integrate and bring transparency to relations with other parties who have a stake in agricultural production[57]. The challenge for digitalisation will be to provide connections that make transparency useful for all actors, to improve the activity of the whole network, bring the right granularity of information at the right time and place information in the proper context.

Digitalisation preventing the transformation

The digitalisation process can also prevent the transformation towards more sustainable food systems and rural development, its implementation bringing negative effects[58]. Instead of enabling resilience, it can reinforce the problems that agriculture and rural areas are facing currently,

51 Amiri-Zarandi and Hazrati Fard (2022)
52 Bulten and Schoorlemmer (2023)
53 European Commission (2023c)
54 European Commission (2023b)
55 EU-OSHA (2020)
56 European Parliament (2019)
57 Calafat-Marzal et al (2023)
58 Barrett and Rose (2022)

making them more vulnerable and with less capacity to react and eventually locked in on the current trajectories[59][60].

From the perspective of users, digitalisation can create new dependencies and vulnerabilities[61]. High costs of digital solutions, as well as service, maintenance, and training costs (continuous investment in skills) have an impact on the whole farming business. This requires farms to make adequate turnover to reach a return on investment and requires them to introduce more rigid processes, thus reducing the room for manoeuvre in making various business decisions. Users also bear the costs of errors and misuse of digital tools, but overruling IT systems may have important consequences (on contract relations with supply chain partners or insurance claims).

In terms of the digital environment, the lack of trust in relationships with IT suppliers can also undermine the safe use of digital technologies[62]. When the suppliers' business models are based on the value of data created this can lead to a breach of privacy and conflicts over ownership and control of data. Digital transition may lead to a concentration of power in the hands of a few tech companies or intermediaries. This can result in a lack of control and autonomy for farmers and rural communities, as they become dependent on external platforms, algorithms, and decision-making systems. Where diversification in technology choices is impossible, it creates dependency on a single system or supplier.

This may also affect the quality of decisions, with a bias towards collecting quantitative data and difficulties capturing qualitative indicators. The rapid adoption of digital technologies may lead to the displacement of traditional farming systems and practices in agriculture and rural areas. This can have social and cultural consequences, as traditional livelihoods and local knowledge may be eroded.

Vulnerability to extreme weather effects and security are also an issue. As farmers and rural communities rely more on digital technologies for essential services and infrastructure, any disruptions in connectivity, power supply or data security can have significant consequences for their functioning. Cybersecurity and data governance are another crucial aspect of technological resilience. Concentrating data and knowledge increases the vulnerability of the system to cyberattacks. The environmental footprint of energy and material use of digital technologies can also hinder the drive for more circular business models.

Digitalisation may also have a negative effect on equality and fairness. It may exacerbate existing inequalities in rural areas, where some communities may lack access to reliable internet connectivity, digital skills or the necessary hardware. This can create a digital divide, further marginalising certain groups with low digital literacy and hindering their ability to benefit from the digital transition.

Finally, digital transition requires robust and reliable technological infrastructure for rural areas and technological solutions adapted to different types and scales of farming. Lack of investment in broadband connectivity and infrastructure as well as neglecting data security measures and backup systems will reduce the technological resilience of agriculture and rural areas and prevent them from developing useful solutions.

59 European Parliament (2017)
60 Hackfort (2021)
61 Duncan et al (2021)
62 Rose et al (2022)

CHAPTER 5

Towards a shared vision of digital transition

The need for a profound transformation of current agri-food systems is widely recognised and well documented[63], [64], [65]. The dominant agri-food model that relies on intensive agricultural production concentrated in some regions or farms and dependent on industrially produced inputs and fossil fuel is linked to the decreasing social-economic resilience of farms and rural areas[66].

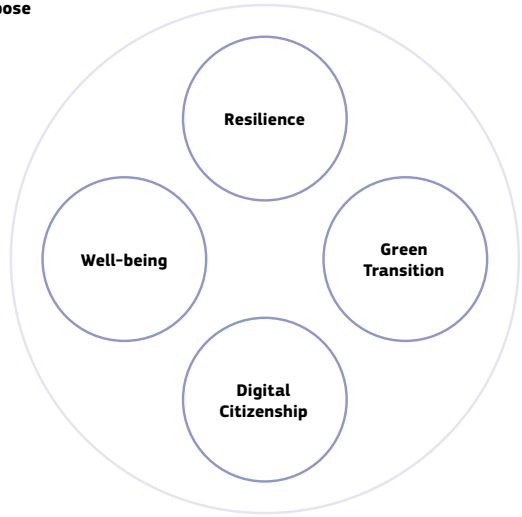
As discussed in Chapter 4, digital technologies have the potential to contribute to the environmental sustainability of the agri-food system through efficiency gains and minimising inputs and transaction costs[67],[68]. At the same time, the increased use of digital technologies currently has a very high environmental impact. This impact results from the resources required to manufacture digital technologies, the energy to run them and the resulting non-recyclable and partially toxic waste. As a recent example, Microsoft's and Google's water consumption increased by 34% and 20% respectively from 2021 to 2022 as their artificial intelligence and large language models projects required cooling of data centres due to the high computing power required by these technologies[69]. The sustainability of digital technologies themselves thus needs to be tackled as a priority.

Improvements in efficiency and minimising costs and inputs are not enough to address the power asymmetries that drive the dominant systems and the scale of the challenges in the agri-food system[7071]. The control over digital technology that is in the hands of the large agri-food corporations and tech giants, who extract value through data, reinforces the dominant agri-food model and locks farmers into new (digital) dependencies and industrial modes of production[72].

63 McGreevy et al (2022).
64 Schroeder et al (2021)
65 Wolfert et al (2021)
66 Knickel et al (2018)
67 FAO (2020)
68 Schroeder et al (2021)
69 O'Brien et al (2023)
70 Fraser (2022)
71 Rotz et al (2019)
72 Prause et al (2021)

Figure 4 Vision Framework

Purpose



Resilience

The ability to cope with shocks and bounce forward towards systemic transformation. Digitalisation should increase economic, social, environmental, and geopolitical resilience.

Green Transition

The fundamental shift in production and consumption patterns needed to live within planetary boundaries. Digitalisation could ensure better systems management that increases efficiency and productivity.

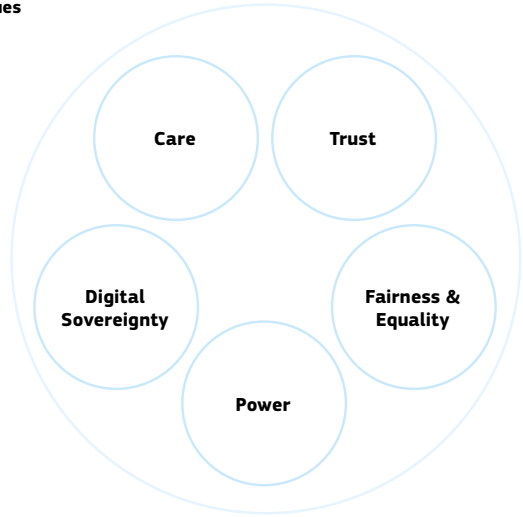
Digital Citizenship

The ability to participate actively in society with the help of digital technology. Key aspects are digital rights and privacy, access, literacy, engagement, empowerment, and the right to not go digital and still thrive.

Well-being

Quality of life and opportunities to contribute meaningfully to the world. Digitalisation should contribute farmers' and rural communities' well-being by improving work conditions, access to services and infrastructure, and strengthening social ties.

Values



Trust

Confidence, reliability and mutual faith in the digital systems, technologies, organisations, and processes. Digital infrastructures and services should be safe by design, transparent, neutral and cybersecure, and respect users' privacy and data security.

Fairness & Equality

Encompasses fair pricing, payment terms, and relationships in the supply chain. Fairness is also about the equal distribution of benefits of digital technologies and access to digital technologies.

Power

The ability to influence and shape processes, decisions, and outcomes related to digital technologies and their implementation. It includes empowering farmers and rural communities to have a voice, agency, and control over their own digital transition.

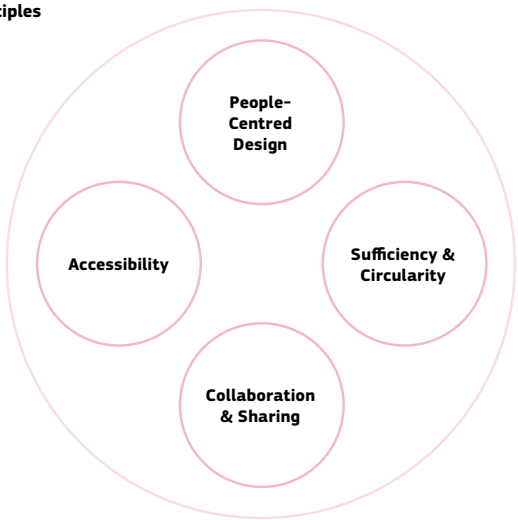
Digital Sovereignty

Implies reducing dependency on companies or platforms that gather large amounts of data, leading to the accumulation of power and knowledge, often outside rural and farming communities or even national jurisdiction.

Care

Nurturing and protecting the well-being of farmers, rural communities, and the commons. Care implies an active consideration of possible negative outcomes and inequalities of digitalisation.

Principles



Collaboration & Sharing

Involves farmers, rural communities, the private sector, governments, and tech companies working together. This can be achieved through forming networks, sharing knowledge, data, practices, tools, and infrastructure, as well as promoting cross-border networking and collaboration.

Accessibility

Ensuring accessibility and affordability of digital technologies and services to all farmers and rural communities, regardless of their location, income, or the size of their operation.

People-Centred Design

Factoring the needs and preferences of farmers and rural communities in the development of digital tools and services through an iterative process of user feedback and design.

Sufficiency & Circularity

Ensuring that digital technologies are environmentally, socially and economically sustainable, durable, open for modification, recyclable, and are used frugally.

Therefore, transforming the agri-food system to move it beyond the dominant paradigm calls for the key values and principles that underpin the current agri-food system to be reconceptualised[73]. The role of digital technology thus also needs to be re-imagined, to ensure that it is able to support diverse agri-food models and prioritises agro-ecological and regenerative food systems, within the food and digital sovereignty frameworks[74 75].

The insights that emerged from the foresight study show that digitalisation is not an inherently positive process. For it to support the transformation of agriculture and rural areas, the first step is to build a clear and shared vision for digital transition that could provide a strategic direction for policymaking. Two questions guided our analysis in this study, building on the review of various frameworks and codes of good practice regarding digitalisation in agriculture and rural areas[76]:

- **What is the purpose of the digital transition from the perspective of farmers and rural communities?**
- **What are the values and principles that should guide this transition?**

The sections that follow outline the resulting vision framework (Figure 4) and describe how its elements can support the digital transition of agriculture and rural areas.

Purpose of a digital transition for agriculture and rural areas

The fundamental question that any vision should address is that of purpose: What do we need the digital transition for and what should it look like in 2040? According to the vision framework that emerged in this foresight study, the purpose of the digital transition is manifold:

- to support resilience and the green transition in agriculture and rural areas,
- to enable digital citizenship that empowers farmers and communities,
- to increase people's well-being.

Digitalisation is thus a means of achieving this aspiration rather than a goal in itself.

Resilience

As discussed in Chapter 4, resilience of agriculture and rural areas has multiple dimensions which all need to be considered.

Economic resilience allows groups to cope with rapid market changes by adapting production and consumption. Digitalisation should increase the economic resilience of farmers and rural communities in various ways. It should boost farms' economic performance by reducing the costs of production and inputs, minimising transaction costs and diversifying income sources. In rural areas, digitalisation should support economic resilience by improving quality of work (e.g. by offering remote work possibilities), creating job opportunities and attracting new businesses[77].

Social resilience is the ability of farmers and rural communities to maintain social cohesion, solidarity, and trust in the face of social disruptions such as conflicts and demographic changes. Digitalisation should help by strengthening community-based institutions, participatory decision-making and social safety nets, while also rebalancing inequalities.

Environmental resilience entails coping with climatic changes, increasing biodiversity and protecting nature. Digitalisation can help in this respect through early warning and natural resource management systems, including via increased efficiency.

73 McGreevy et al (2022)
74 Fraser (2022)
75 Lioutas et al (2021)
76 See, for example Wolfert et al (2022); Metta et al (2022); Issa et al (2022)
77 Brunori et al (2022).

Geopolitical resilience refers to the ability of a state or region to withstand and adapt to the disruptions related to international security, supply chain stability or dependency on imported technology and raw materials. Digitalisation can support geopolitical resilience by promoting diversification and innovation. Digital technologies can enable farmers to diversify their production, explore new markets, and innovate in response to global trends and challenges. This can enhance their resilience to geopolitical shifts and contribute to the overall resilience of the agricultural sector. However, dependencies on imported digital technologies or critical raw materials can impede digital transition of agriculture. To address this, it is important to support the development of domestic digital technologies, capacities and alternative raw materials[78]. This can be achieved through policies and investments in research and development, education and training, and the creation of supportive regulatory and business environments.

Green transition

Green transition refers to the fundamental shift in production and consumption patterns needed to live within planetary boundaries[79]. While climate neutrality and sustainability in all its dimensions are the drivers behind the green transition, digitalisation is one of the instruments that can make this transition fair and inclusive. In agriculture and rural contexts, digitalisation could ensure a better systems management that increases productivity through more precise application of feed, water, energy, fertilisers, and pesticides. Digitalisation could also promote small-scale development adapted to the local context and managed in a bottom-up way (e.g. e-commerce platforms that enable small-scale farmers to sell directly to the customers and reduce food miles; digital cooperatives to pool and share farmers' resources or tools).

Digital citizenship

Another purpose of the digital transition is to enable digital citizenship, which is the ability to participate actively in society with the help of digital technology. The key aspects of digital citizenship are digital rights and privacy, access, literacy, engagement, and empowerment. The empowerment refers to the opportunities and resources to use digital technologies for self-governance, entrepreneurship, better well-being for farmers and rural communities, all contributing to the common good. At the same time, it is important to offer the opportunity to not go digital and still thrive, for those who wish to do so.

Digital rights entail free access to information for everyone, with the right to take informed decisions about private data collection and use. People should have the capacity to understand the implications of using technologies that concern them. To this end, early development of digital skills should be a priority in rural areas.

Well-being

In recent years, well-being has become increasingly important for civil society and government alike[80],[81]. Well-being is understood in this context as quality of life and opportunities to contribute meaningfully to the world[82]. It encompasses such dimensions as economic opportunities, social connections, health and environment. For rural areas, well-being has unique challenges compared to urban settings[83].

In the rural context, the issues of access and equality (or fairness and inclusiveness) have a vital role for communities' well-being. Access means both *access to* services, education, jobs etc and *access via* enablers, such as transport, infrastructure and digital connectivity. For farmers, well-being is intrinsically linked to their work and close ties with their communities. Digital transition should improve or contribute to all dimensions of the well-being of farmers and rural communities.

78 Spain's National Office of Foresight and Strategy (2023)
79 Muench et al (2022)
80 OECD (2020)
81 Matti et al (2023)
82 WHO, Promoting well-being. Retrieved from https://www.who.int/activities/promoting-well-being
83 Muller et al (2021)

The purpose of digital transition can be further articulated through specific objectives that make increased resilience, sustainability, digital citizenship and well-being more tangible. Such objectives need to be aligned with the broad sustainability goals outlined in the European Green Deal and the priorities set for an EU Fit for the Digital Age. The objectives should have farmers and rural communities' interests at heart and could be further developed as part of national or regional digital strategies, focused on a specific farming and rural context.

Values

Digitalisation is a value-laden process, as it is shaped by the values and priorities of the individuals, organisations and institutions involved in designing, implementing and using digital technologies. The development and use of technologies embody specific values and assumptions about the world, society and human behaviour.

> Values are a mix of biological and evolutionary factors combined with individual and social histories. Values are stable over time and signal a preference for one direction over another, based on core motivations such as safety, belonging, esteem and self-direction.
>
> Group values have a normative social influence on individual citizens. Values are very relevant for policymaking, as citizens' actions and inclinations are strongly influenced by what they find valuable. Changing people's behaviour through democratic policymaking thus needs to take into account values-related issues[84].

To support resilience, the use of digital technologies in agriculture would have to reflect different values such as trust, fairness, equity, power, sovereignty, and care. These values, although present in some form within the agricultural digitalisation discourse, need to become central and guide policymaking at all levels. These values should shape the design of digital technologies, their use and governance, the data that is collected and analysed, and the decisions that are made based on this data[85].

Moreover, the adoption and use of digital technologies are also influenced by social, economic, cultural, and political factors that vary across different contexts (e.g. levels of digital literacy and skills, availability and quality of digital infrastructure, the influence of peer groups, affordability, etc.). These factors shape the perceptions and attitudes of different stakeholders towards digital technologies and influence the extent to which they are adopted and used.

Therefore, it is important to recognise the value-laden nature of digitalisation and to promote a more participatory and inclusive approach that takes into account the values and perspectives of different players. By doing so, the digital transition for agriculture and rural areas is likely to be guided by values that promote a fair and green transition.

In the process of this foresight study a number of key values that should guide digital transition emerged from the discussion across the workshops. While the list is not exhaustive and can be expanded based on the local context, it foregrounds the most critical values as regards the purpose of digital transition. These values could be integrated into the strategies and actions related to the digital transition for famers and rural communities. They are briefly outlined below.

Trust

The value of trust can be defined as confidence, reliability and mutual faith that farmers and rural communities have in the digital systems, technologies, organisations (e.g. public administration or advisors) and processes employed in agriculture and rural areas.

A lack of trust is a common obstacle for better uptake and use of technologies among farmers and

84 Scharfbillig et al (2021).
85 Bogaart et al (2021)

rural communities[86]. Examples of such trust issues could be the reluctance of farmers or communities to use a digital tool/service or share certain data or farmers' mistrust of the advice offered by technology providers, due to the perceived vested interests at play.

While there is no universal approach to addressing trust issues, some avenues to explore could be:

- Promoting incentives, including financial ones, for data sharing.
- Setting up networks and spaces to address the fears or concerns of farmers and rural communities.
- Providing peer-to-peer support for farmers interested in testing digital tools.
- Helping set up independent public advisory systems wherever such systems are absent.
- Developing trustworthy digital infrastructure and services, to remove the administrative burden.

Trustworthy means that the digital infrastructure and services are governed by rules that respect privacy and ensure the security of users' data. They are safe by design, transparent, neutral and cybersecure.

Transparency refers to the openness of a tool with regard to its functioning and user's data. Trustworthy infrastructure should be designed in a way that protects users' data from unauthorised access, use, or manipulation.

Fairness and equity

Fairness in the agricultural context encompasses the issues of fair pricing, payment terms, and relationships in the supply chain. Fairness also refers to ensuring that the benefits of digital technologies are distributed equitably among rural communities, and that everyone has equal access to digital technologies.

Fairness is a growing concern in the agri-food chain, as farmers often struggle with unstable relationships in the supply chain and low prices for their products. Digital technologies such as blockchain[87] can help build trustworthy and transparent supply chains by providing equal access to information for all parties. Such technologies boost fairness as they correct the pricing imbalance by recording transactions in real-time, and help farmers sell commodities by lowering transaction fees[88].

Power & sovereignty

The value of power is the ability to influence and shape the processes, decisions and outcomes related to digital technologies and their implementation. It encompasses empowering farmers and rural communities to have a voice, agency and control over their own digital transition. Power relations are baked into existing digital tools: the organisation that owns the technology and the data has the power to shape the lives of farming and rural communities. The value of power may be in tension with the value of fairness and equity, if the benefits of digital technologies are concentrated in the hands of a few large corporations or wealthy groups, leaving small-scale farmers and rural communities with very little control over decisions that affect their life or business.

The disbalance of power in the process of digital transition can be addressed by putting the value of sovereignty at the centre. Two aspects of sovereignty are important in this context: food sovereignty linked with the concept of food democracy, and digital sovereignty. Food sovereignty refers to the right of people to define their own food systems, and to have control over the resources and processes involved in food production and distribution. Food sovereignty can help to ensure that the digital transition does not lead to the concentration of power and control over food systems in the hands of a few actors.

Digital sovereignty implies reducing dependency

86 McFadden et al (2022a)
87 Blockchain is a technology that enables a secure sharing of information by storing transaction data in blocks that cannot be manipulated.
88 Samoggia. and Beyhan (2022)

on the companies or platforms that gather large amounts of data, leading to the accumulation of power and knowledge, often outside the rural and farming communities or even national jurisdiction[89].

Europe's ability to act independently in the digital world involves prioritising the development and implementation of policies and technologies that promote greater data control and autonomy for EU farmers and rural communities. This can be achieved through the creation of a trusted digital ecosystem that is secure, transparent and interoperable across Member States.

Another way to increase digital sovereignty is by promoting the development of EU-based technologies that support the collection, processing and analysis of data, reducing dependence on the technologies and services offered by non-EU organisations. This could include investment in research and development in emerging technologies such as blockchain, artificial intelligence and big data analytics.

The EU digital strategy could also encourage the adoption of open-source software and promote the standardisation of data formats, ensuring that EU farmers have access to the tools and technologies necessary to compete globally while retaining control and autonomy over their data. Open data and open source requirements can counteract power concentration and the associated dependencies, while antitrust regulations can prevent data monopolies. Ensuring privacy and data protection as well as adapting competition and regulatory policies is necessary to protect the potential of European technology start-ups and small businesses[90].

Care

The care value refers to nurturing and protecting the well-being of farmers, rural communities and the commons. This emphasises active consideration of possible negative outcomes and inequalities resulting from digitalisation in various spheres:

- **Social sphere** – addressing the digital divide to ensure that everyone including smallholders, women, young people, and marginalised or vulnerable groups, has equal opportunities to access and benefit from digital resources; avoiding harmful or exploitative practices and considering the long-term social and ethical consequences of digital transition (e.g. with regard to data).
- **Economic sphere** – considering potential disruptions and ensuring that the digital transition benefits everyone and does not lead to employment loss or further marginalisation of vulnerable groups.
- **Environmental sphere** – leveraging digital tools for monitoring and managing natural resources, mitigating risks and promoting sustainable land and water management practices.

Overall, reconciling the values of power and care in the digital transition of agriculture and rural areas requires a more inclusive and participatory approach that prioritises the interests of farmers and rural communities, promotes collaboration and partnership among different stakeholders and ensures that the use of digital technologies is responsible and sustainable.

Principles

The vision for the digital transition also encompasses the main principles that should guide this transition. These principles include **collaboration and sharing, accessibility, people-centred design, sufficiency and circularity**.

Collaboration and sharing

Digital transition should be a collaborative effort involving farmers, rural communities, private sector, governments, and tech companies. Farmers should be able to collaborate and share their knowledge, data and agro-ecological practices on digital platforms that are collectively owned

89 Lange et al (2022)
90 Madiega (2020)

and adapted to their needs. Digital technologies can bring new knowledge and practices to rural communities, but they can also threaten local knowledge and cultural heritage if they are not designed and implemented in a way that is sensitive to local context and values.

By forming networks farmers, researchers, advisors, technology developers and policymakers can co-create digital solutions that are tailored to the needs and challenges of agriculture and rural communities. Supporting cooperation between advisory services and knowledge providers is especially pertinent as these networks can help fill the gaps in knowledge and expertise that may exist within individual organisations and facilitate knowledge exchange and technology transfer. Collaborative networks can also help to build trust among stakeholders and encourage experimentation and innovation in developing and deploying digital technologies. By working together, stakeholders can share the risks and costs of innovation and collectively achieve better outcomes.

Data sharing can help farmers make informed decisions and support the development of new services and applications that benefit the agriculture sector. For instance, data on soil health, weather patterns and pest and disease outbreaks can be shared among farmers and agronomists to improve crop yields and reduce the use of pesticides and fertilisers at parcel, farm and landscape level.

Sharing equipment and infrastructure can also help to reduce the costs of adopting digital technology. For example, pooling resources such as drones, sensors, and other equipment can help small-scale farmers access digital technologies that would otherwise be unaffordable.

The EU already plays a role in facilitating collaboration through programmes such as the Horizon framework programme, the Digital Europe Programme, support for Digital Innovation Hubs and the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI). These programs provide funding for cross-sectoral and interdisciplinary research and innovation, thus facilitating collaboration and knowledge exchange across national and regional borders.

While many tools that support cooperation and networking exist already, they need to be reinforced and scaled up to increase the uptake of technologies and facilitate the change in behaviour. To this end, scaling up EIP-AGRI and research results to end-user readiness is key in creating business cases that would clearly demonstrate the added value of digital technologies for a diversity of farmers.

Finally, there is a clear need to promote networking and collaboration between Member States and across public administrations, to share experience and best practice on digital transition across the EU. Such cross-border networking could take place via CAP networks and the Rural Pact and Smart Villages initiatives across the European countryside.

Accessibility

Digital tools and services should be accessible and affordable to all farmers and rural communities, regardless of their location, income or the size of

their operation. It is important to recognise specific challenges faced by rural areas in accessing and using digital technology and develop tailored solutions to address them. An example of such tailored solutions could be the provision of hybrid services (e.g. access to medical facilities on site in addition to e-health services) wherever necessary for those who are not able or willing to use digital tools or services. This would help ensure equal opportunities and fair distribution of benefits, while avoiding a digital divide.

People-centred design approach

The design and use of digital tools and services should be based on the needs, preferences, and engagement of farmers and rural communities in their development. Digital tools or services should be simple and easy to use, and address their unique challenges[91].

In practice this approach would mean developing farming applications and software that are user-friendly and tailored to the specific crops or animals that a farmer might be managing. Similarly, it might lead to digital infrastructure designs that account for the limitations and challenges of internet connectivity in rural conditions.

People-centred design also involves an ongoing process of user feedback and iterative design, drawing the users, i.e. the farmers and rural communities, into the process of designing and improving digital services. They would be involved in the early stages of development, testing and providing feedback to ensure the digital solutions are aligned with their everyday needs, capabilities, and expectations. This would ensure that the digital tools or processes are accessible to all groups of people, meet their needs and make a meaningful contribution to their lives. An example of such a participatory approach could be inspired by the 'Smart village' approach and strategies undertaken in several rural communities across Europe.

Sufficiency & circularity

The environmental footprint of digital technologies (energy consumption and raw materials; recycling and disposal) and the rebound effects[92] that often accompany their use is one the concerns that policymakers need to act on. While digital technology can improve efficiency and productivity in agriculture, it cannot address all environmental issues on its own and in some case can exacerbate the problems. Therefore, it is of critical importance that digital tools and services are manufactured, designed and implemented in a way that is environmentally, socially and economically sustainable. They should contribute to environmental restoration, social equality and economic stability.

This relates not only to increasing the efficiency of resource use and production. It also implies aiming for sufficiency in digitalisation: going for 'enough' rather than 'more'[93], by promoting the frugal use of digital tools, and favouring quality of solutions over quantity. The environmental lifecycle impacts of ICT devices and systems include both energy-related and material-related impacts, which can be addressed through such approaches as adequate energy-efficiency requirements, durability and reliability requirements, sustainable sourcing, and green public procurement[94].

Sufficiency in digitalisation is also closely linked to the principles of circularity and 'reuse-recycle-repair'. Digital tools used by farmers and rural communities must be durable, open for modification and recyclable. There should be safeguards in place against planned obsolescence and dependencies on technology suppliers, to avoid lock-in.

By acting on these principles, digital transition can increase the resilience, sustainability, profitability, and productivity of agriculture, while also contributing to the social and economic development of rural communities.

91 Schnebelin (2022)
92 Rebound effects refer to a phenomenon in which the gains in the efficiency improvements of technology are counteracted by its increased use.
93 Lange et al (2022)
94 Alfieri and Spiliotopoulos (2023)

Building an EU digital transition strategy

The vision framework discussed in the previous chapter outlines the purpose of the digital transition, as well as the values and principles that should guide it. Bringing this vision to life calls for an EU digital transition strategy focused on agriculture and rural areas. While some Member States have a digitalisation strategies for agriculture in place[95], others are still at the beginning of the strategy formulation process. An EU strategy could help develop a comprehensive and coordinated approach to the digital transition in agriculture and rural areas, across Member States.

The proposal for an EU digital strategy that this foresight process put forward rests on key building blocks that include the vision elements described in the previous chapter and the key enablers for the adoption and use of digital technologies. EU policymakers should consider these building blocks when developing an EU digital transition strategy for agriculture and rural areas. Incorporating them at different stages of the strategy building process could empower stakeholders, encourage collaboration, and increase the effectiveness of digital transition efforts.

Key enablers for the adoption & use of digital technologies

The EU digital transition strategy should include putting in place the key enablers that support the process of digital transformation. These key enablers are: capacity building, developing a digital ecosystem and data governance, investing in infrastructure and connectivity, and providing adequate funding.

Capacity building

Farmers and rural communities should have the necessary skills and knowledge to effectively use and benefit from digital tools and services. Building this capacity involves bringing together education,

95 Examples: Spain's Digitisation Strategy for the agri-food, forestry sector and rural areas: https://www.mapa.gob.es/es/ministerio/planes-estrategias/estrategia-digitalizacion-sector-agroalimentario/digitisationstrategy_tcm30-513192.pdf
Hungary's Digital Agriculture Strategy: https://digitalisjoletprogram.hu/files/47/ce/47ce5027f5cdb585095631589cc9e5b5.pdf
France's Roadmap for Digital Agriculture: https://agriculture.gouv.fr/telecharger/129515
Finland's Smart Agriculture 2023 Roadmap: https://maaseutuverkosto.fi/agrihubi/aiheet/alymaatalous/mita-on-alymaatalous/
Netherland's Vision for the digitalisation of the agri-food sector: https://open.overheid.nl/documenten/ronl-04ea5231-e96a-4d18-8a11-f982078d5544/pdf

training, targeted advisory and technology brokerage services and technical support. The target group for capacity building programmes is not just farmers and rural inhabitants, but also educators, advisors and local administrators who wish to upgrade their knowledge and/or keep up with technological development.

It is also important to ensure that policymakers at all levels have sufficient understanding of digital technologies and their potential impact on agriculture and rural areas, so they can make informed decisions effectively. The digital transition process should therefore also cover public administrations. This requires a coordinated approach between all levels of agricultural knowledge and innovation system (AKIS), to promote collaboration between education, training, advisory and industry bodies, any of whom could deliver targeted capacity building programmes for people with diverse needs and levels of digital literacy.

The focus of capacity building programmes could be on digital literacy, from basic IT skills to more advanced and specialist skills, data management and data analysis skills. At the same time, capacity-building programmes for farmers and rural actors could focus on using digital technologies to preserve and share existing knowledge, local heritage and specialised know-how across generations. Reskilling and continuous upskilling of farmers and rural inhabitants also requires us to create the right incentives and communication strategies, as well as spaces for exchange with peers and testing digital tools in a safe environment, through on-farm demonstrations, etc.

Digital ecosystem and data governance

Digital tools generate and use a large amount of data, making it an essential element of digital transition, beyond the narrow definition of data as a statistical entry. Data can enable accurate decision-making, increase productivity and improve the quality of products and services. Data can also empower farmers and rural communities to identify opportunities for innovation and development. So it is critical to establish a common EU digital ecosystem and data governance, to regulate the collection, management, ownership, sharing and use of data in agriculture and rural areas – harnessing the potential of the data economy for agriculture and rural communities[96]. Without a proper digital ecosystem and data governance, the digital transition of agriculture and rural areas would stall, and the vast potential of emerging technologies would not be realised.

This digital ecosystem should draw on the key principles discussed in the vision framework such as collaboration, sharing and accessibility. It will include farms, public administration bodies, private bodies and a set of integrated platforms, applications and databases that facilitate data collection, storage, analysis and sharing. Building a common ecosystem for digital solutions that are interoperable and compatible will ensure that farmers and rural communities can easily access new digital services and tools and use them effectively.

Data governance requires a comprehensive and dynamic regulatory environment that keeps up with the rapid pace of technological change. It should also be seen in a global context and the current challenges around the availability of raw materials and hardware production outside Europe.

Data governance encompasses interoperability rules, data quality standards, and regulations on the ownership, processing, storage, and sharing of data. In particular, data privacy and security need to be at the heart of data governance. This calls for us to develop regulations and standards that protect the privacy and security of data, including personal data, and ensure that the data is used ethically and for its intended purposes. This includes developing data protection laws, data anonymisation standards, and secure data storage and transfer protocols.

Furthermore, encouraging data sharing and

96 European Commission (2023a)

collaboration among farmers, researchers, administrations, and private sector parties through various incentives is also an important part of the data governance system. Examples of such incentives include funding opportunities for collaborative data projects, "data schemes" that reward farmers for using certain technologies and sharing the data (akin to eco schemes), and the creation of platforms or data cooperatives that facilitate data sharing. It might also be necessary in some cases to envisage payment for specific types of data that can be useful for creating new services.

Cybersecurity is an issue that affects all sectors of society and is an essential element of data protection. Agricultural businesses store large amounts of data, from crop yields to equipment use and weather patterns. Unauthorised access to this data can lead to its misuse, identity theft, and loss of proprietary data, such as breeding techniques or genetically modified (GM) crop information. Cybersecurity issues can also involve spreading false information about an agricultural business or product, leading to reputational damage and economic losses.

The EU digital transition strategy for agriculture and rural areas should take into account the possibility of cyber-attacks and data breaches and establish contingency plans to address them. These plans could include procedures for responding to cyberattacks, recovering lost data and protecting affected individuals from harm. The strategy should include support for developing cybersecurity measures such as the use of firewalls, antivirus software, intrusion detection software and other security measures that protect against cyber threats.

Finally, a data governance regime should have a multifunctional approach to data, in which the combined data collected from farmers and the administration can be used to develop new applications or services for farmers or demonstrate new use cases for technologies.

Infrastructure & connectivity

A proper digital governance also requires investment in the technological infrastructure of hardware, software, and networks capable of handling the increased data requirements for the new digital technologies to operate effectively. Sharing data standards and robust digital infrastructure is vital for enabling the digital single market and avoiding market fragmentation. Beyond the need for high-speed connectivity (broadband, mobile, wifi, IoT sensor network for monitoring, etc.), a key enabler for the adoption and use of digital technologies could be an integrated system of interconnected databases and registers, based on an enhanced integrated administration and control system[97] that is connected and interoperable with all other relevant systems. This would help simplify e-governance and optimise the number of data entries, thereby reducing the administrative burden for farmers.

Funding and investment

High initial investment and ongoing maintenance costs for digital transition can often be significant hurdles for farmers and rural communities. Therefore, a vital building block of the EU digital transition strategy for agriculture and rural areas should be a comprehensive funding and investment ecosystem that creates synergies between various EU funding schemes and measures. Adequate funding is necessary to support the deployment of digital technologies and infrastructure, provide training and support, facilitate research and innovation and increase cooperation between stakeholders in the sector.

Promoting synergies between various funding schemes and measures – such as the common agricultural policy (CAP), the European Regional Development Fund (ERDF), the European Investment Fund, Horizon Europe and the Digital Europe Programme – is an essential step. Synergies can be promoted by encouraging collaboration between funding agencies and

97 https://agriculture.ec.europa.eu/common-agricultural-policy/financing-cap/assurance-and-audit/managing-payments_en

organisations and between administrations, streamlining administrative procedures and promoting the sharing of information and best practice.

Further, the EU should support the establishment of public-private partnerships that leverage private sector investment, expertise and market knowledge to support the digital transition. Public-private partnerships can leverage private sector investment, unlocking funding opportunities to support digital transition. They can also facilitate the development of innovative technologies, products and services that meet the needs of farmers and rural inhabitants if the principles of co-design are applied. Public-private partnerships also play a critical role in breaking down silos and achieving outcomes that would be difficult to achieve through a single public or private sector organisation.

Lastly, it is necessary to ensure that the funding resources allocated to digital agriculture and digital services for rural communities are targeted the needs of specific areas and accessible to all stakeholders, taking into account digital divide and inequalities. This can be achieved by promoting transparency in funding allocation and utilisation, enabling capacity building and training, and helping small and medium-sized farms and rural business to access funding opportunities. It is also important that the funding rules are flexible enough to accommodate specific challenges faced by farmers or rural communities. For example, adapting public procurement rules to smaller size public institutions in rural areas (local schools, hospitals, etc.) could help these institutions deliver vital services for the community. Similarly, investment schemes should account for a growing interest among farmers to pay for access to digital services rather than acquiring expensive hardware. Adapting existing funding rules to allow multiple funding sources for projects could also help improve access to digital services in rural areas.

Digital transition strategy – getting started

Digital transition is a process that requires a well-structured, continuous, and iterative implementation process. The following recommendations could help EU policy-makers in the implementation stage of the digital transition strategy:

- **Develop a roadmap** containing key milestones, a concrete timeline and clear objectives and targets for the digital transition process in agriculture and rural areas, adjusted to the specific context.
- Create a dedicated **coordination structure for alignment and coordination** with other EU strategies related to digitalisation, health, environment, competitiveness and other areas. This structure should also promote the sharing of experience and best practice across different Member States, to promote mutual learning and facilitate the replication of successful initiatives.
- Determine the **roles and responsibilities** of various EU institutions and Member States in the digital transition process. National strategies should take into account the specific needs, local conditions and capacities of each Member State, as well as the regional and local contexts. Building collaborative networks across national borders and public-private partnership institutions is essential for achieving the objectives of the strategy.
- **Allocate resources** based on, among other things, an assessment and streamlining of existing funding mechanisms related to digital transition, both within the agricultural sector and rural communities and across other sectors.
- Adjust the **CAP performance monitoring and evaluation framework** to keep track of progress in the digital transition. Close collaboration with Member States, farmers, rural communities, academia, industry and civil society organisations can help identify issues and bottlenecks in the implementation process.

- Ensure **regular feedback on and updating** of the digital transition strategy, to allow enough space for a flexible approach that can help adapt to the continuously changing context and emerging issues. Integrating feedback mechanisms allows for timely adjustments and course corrections to be made, resulting in an iterative approach.

Toolkit for digital transition strategies at EU/national/ local levels

The foresight study outlined the building blocks for an EU strategy that can guide the process of digital transition at the EU level. However, digital transition of agriculture and rural areas is a complex and context-specific process that requires tailored solutions which take into account local needs, resources, and challenges. Moreover, national and local bodies are often better placed to identify and address local barriers and opportunities for digital transition. It is therefore essential for national, regional or local administrations to develop their own digital strategies for agriculture and rural areas that take into account relevant EU digital transition policies and initiatives.

To facilitate strategic conversations on the implications of digital transition for farmers and rural communities, the JRC created a toolkit for policy-makers who are responsible for the development and implementation of digital strategies.

The toolkit aims to help them in their thinking about the transition process, specifically to:

- Uncover key issues that need to be considered when building the country/region- specific digitalisation vision & strategy.
- Engage with a wide group of stakeholders to develop or improve existing strategies.
- Align the country/region - specific digitalisation strategy with the vision framework.
- Guide policy-makers in integrating the enablers for the adoption and use of digital technologies.
- Increase anticipatory capacity of policymakers and future-proof digital transition strategies.

The toolkit comprises a number of interactive tools that could help policymakers harness the power of collective intelligence to explore the implications of digital transition from a long-term future perspective.

The toolkit contains:

- Guidance on how to use the toolkit
- A set of cards and templates to get a conversation started on the purpose, values and principles that should guide the process of digital transition
- A set of transformative futures for agriculture and rural areas, to stress-test digital policies or strategies
- A set of activities, to structure strategy development process and put in place the key enablers for the adoption and use of digital technologies

The digital version of the toolkit can be downloaded free of charge at: https://knowledge4policy.ec.europa.eu/foresight/topic/digital-transition-toolkit_en

CHAPTER 7

Delivering a digital transition strategy

As the transformation of the agriculture and food system is necessary to address society's major challenges, the transformational aspect of policies is also becoming more relevant. Making policies transformational requires a good understanding of the direction the transition should take, and a multi-faceted policy-mix of instruments addressing multiple stakeholders in multi-level governance. Policies supporting digitalisation in agriculture should focus on the transformational potential of these technologies, taking into account the purpose, values, and principles set out in the vision framework.

The framing and choices of digitalisation processes and tools can shape many different aspects of farming and rural areas. The impact of digitalisation on the profitability of the farm remains one of the main preoccupations, however digitalisation can also encourage the building of the social economy and the creation of social value, for example through better social impact accounting or bringing wider groups of stakeholders into the process[98].

Many digital solutions can help strengthen the position and power of farm holdings vis-à-vis other stakeholders, but thoughtfully designed technology processes can provide support to marginalised farmers and bring elements of social justice and care into the system[99]. The implementation of digital systems will also have an impact on how agricultural knowledge is managed. In some, proprietary data can create barriers; in others, where digital data is blended with indigenous knowledge, it can enable social learning[100]. The organisation of the digital ecosystem can also determine whether it will encourage diverse agricultural models or tend towards uniformity; it can also determine the types of risk management strategies and the resilience of farming and rural areas. Well-designed digital strategies can therefore have important impact on the shape of the transformations towards more sustainable agri-food system as a whole.

Policy can play an important role in shaping the digital transition of agriculture. This foresight study puts forward a robust framework for a comprehensive EU digital transition strategy. As part

98 Berardi amd Valentinetti (2022)
99 Rotz et al (2019)
100 Tumwebaze et al (2022)

of this strategic analysis, several recommendations can be proposed, as to its implementation in view of the common agricultural policy beyond 2027:

- Adopting digital technologies should not be regarded as a final goal in itself – directed digital transition, supporting social challenges, is needed, through responsible innovation that anticipates the intended and unintended impacts of digital technologies.
- The digital transformation of agriculture is happening alongside the digital transition of public administration - these processes should be mutually reinforcing. Digitalisation policies should not limit the flexibility and diversity of digital solutions in the sector, focusing on required outcomes rather than employment of particular technologies. Data governance will remain the most pressing policy issue.
- As shared objectives for the European common agricultural policy are agreed at EU level, a corresponding governance framework for digitalisation in agriculture should be established to facilitate and manage the responsible use of digital technologies and data in agriculture, ensuring transparency, accountability and the protection of the agricultural community and broader public interests.
- With Member States developing their own digital strategies as part of their CAP plans, common items and synergies should be better exploited, to build the EU agricultural digitalisation strategy. EU-wide strategy should take into account the building blocks presented in this report. Policy support for digitalisation should recognise diverse farming models, ensuring diversity of digital solutions and market players in a coherent and reliable technology ecosystem.
- Although the Commission's long-term vision for rural areas already stresses the importance of the digital dimension for making rural areas stronger and more connected, the proposed digital solutions (smart villages, digital connectivity, skills, innovation) should also be directed at the objectives of resilience and prosperity of rural areas.

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Annexes

Annex 1. The Foresight process

The aim of this study was to examine the interplay between digital transition, policies and the resilience of the agricultural sector and rural areas against the backdrop of potential disruptive and transformative changes.

The foresight process brought together a wide group of participants from farming, rural areas, digital technologies, EU institutions, member state administrations, international organisations, and research in 2022 and 2023.

A number of foresight approaches were used to harness collective intelligence through participatory workshops. They included:

- **Transformative Scenarios**: The transformative scenario approach comprises two scenario stages – an exploratory scenario stage in which tensions and crises are examined as they evolve, and a transformative scenario stage in which an external event triggers a transformational process. As a starting point for developing transformative futures, a set of four JRC reference scenarios on the global standing of the EU in 2040 was adapted. At the workshop, the scenarios were first enriched with the elements that are relevant for agriculture and rural areas in the context of digital transition. Afterwards, the scenarios underwent a transformation through the introduction of wild cards (see Annex 2).
- **Profiles & personas:** A design-based approach used to facilitate the engagement and buy-in of diverse groups of actors. In the foresight study, the farmer profiles and rural personas served for exploring the human perspectives of transformative scenarios. See the description of the profiles and personas in Annex 3.
- **Causal-layered analysis** (CLA): CLA is a multi-dimensional approach that identifies the driving forces and perceptions underpinning diverse perspectives about an issue. It helps explore future developments from multiple perspectives and go deeper into the underlying assumptions of stakeholders to build a more robust preferred future. This method was used to explore the perceptions of farmers and other actors around digitalisation and digital technologies.
- **Personal values model**: The personal values model consists of 19 different values that

are in complementary or conflictual relations to each other. In the JRC model that we drew upon, they are aggregated into four higher order values: Openness to Change, Conservation, Self-enhancement, and Self-Transcendence. For the purpose of our study, based on the previous workshops, these four categories were articulated as Independence, Security, Power, and Care to represent a set of prevailing values in the agri-rural contexts.

- **Visioning:** a participatory approach to build shared, aspirational and desired visions of the future for a group of stakeholders. In the foresight study, visioning consisted of identifying the purpose, values and principles that should guide digital transition in agriculture and rural areas.

List of workshops

Scoping workshop | Online, 23 March 2022

The scoping workshop gathered European Commission colleagues from various Directorates to identify priority aspects to be addressed in the study and examine a potential usefulness of different foresight approaches. The participants had a chance to experience foresight in action by engaging in rapid scenario planning and vision building. The results of the workshop informed the design and content of the foresight process.

Workshop 'Transformative Futures for Farmers and Rural Communities' | Brussels, 20-21 September 2022

The workshop brought together participants from farming, digital technologies, EU institutions, international organisations, rural areas, and research. Together, they examined the implications of potential future disruptions and the role digitalisation could play in the resilience of agriculture and rural areas through the exploration of scenarios, farmer profiles and rural personas.

A series of farmer workshops in Member States | November 2022 - January 2023

To gain a better understanding of the views and underlying assumptions behind digitalisation a series of interactive workshops took place in the Netherlands, Lithuania, Poland, Greece, France, Italy, and with the partners from the Horizon Europe projects DESIRA and SHERPA. The Causal-Layered Analysis inspired the foresight approach of these workshops.

Workshop 'Digital transition for resilient agriculture and rural areas: Towards the vision for 2040' | Online, 6-9 March 2023

The goal of the first workshop at this stage was to develop a vision framework that includes the purpose, values and principles of digital transition for resilient agriculture and rural areas in Europe. This workshop gathered the participants of the previous stages of the process.

Workshop 'Digital transition for resilient agriculture and rural communities: From vision to policymaking' | Brussels, 24 May 2023

At the final workshop, representatives from EU Institutions (Commission, Parliament, European Social and Economic Committee, Committee of the Regions) and member state administrations tested the vision framework and discussed the framework for an EU digital transition strategy that could contribute to the resilience of farmers and rural communities across Europe in the long term.

Annex 2. Initial list of wild cards used in transformative futures workshop

The workshop participants worked in groups on a specific scenario. Each group could choose up to two wild cards per scenario out of the following list:

Energy disruptions:

- Melting of ice sheet in the Arctic exposes new reserves of oil and gas.
- Energy becomes a luxury good - prices have increased limiting drastically energy use by a large part of the European population.
- The spread of renewable energy micro grids allows small communities to manage their own energy production and markets.

Environmental disruptions:

- A combination of droughts and floods over three years have destroyed 40% of EU agricultural production capacity and infrastructure.
- Water shortages lead to reduced water accessibility and high prices for agriculture.
- A planetary health approach with a comprehensive set of requirements for sustainability and ethics leads to stringent standards for agriculture.

Supply chain disruptions:

- Increasing number of food safety crises and food scares lead to very low confidence in EU food.
- Far-reaching transparency from farm to fork gives all parties quasi-full information on all aspects of food production.
- Disinformation campaigns in food chain destroy consumer trust.

Social disruptions:

- Deteriorating access to food and ideological cleavages lead to increasingly violent social conflicts targeting, among others, agriculture and food industry.
- Severe shortage of agricultural labour leads to rethinking of operations, more attractive conditions for workers and better appreciation of farm jobs.
- New forms of education, learning and independent advice make access to actionable knowledge very easy.

(Geo)political disruption:

- The return to managed international trade has severely limited EU agri-food export possibilities.
- Accumulation of space debris and the continued testing of anti-satellite weapons lead to military conflict in space, massive economic damage and loss of surveillance capabilities.
- Due to disruptions in the energy infrastructure, agriculture can rely only on the energy it produces.

Annex 3 Farmer profiles and rural personas

To bring the scenarios to life and explore the human perspective of transformative futures, we used a set of 12 farmer profiles developed by the JRC in the Farmers of the Future study. For rural areas, based on materials from the studies Scenarios for EU Rural Areas 2040[101] and The Future of Green Jobs is Green[102], we developed a set of 11 personas that might be relevant in diverse types of rural areas in 2040. Both sets of farmer profiles and rural personas were used to examine the extent to which digital technology would help or hinder farmers or rural communities to cope with the shocks and disruptions of the scenarios. They were not meant to be empirically well-established profiles or to imply any categorisation.

Key features of the farmer profiles

Adaptive farmer: Agile, networked multifaceted agri-business.
Corporate farmer: Branch operations manager.
Intensive farmer: Precision farming, innovative, efficiency – driven large specialised holding.
Patrimonial farmer: Traditional, locked-in, and focused on heritage.
Controlled environment farmer: Soilless high-tech, vertical farming.
Cell farmer: Alternative foods; biotech entrepreneur, producing from cultured cells.
Social care farmer: Service - and society-oriented, focus on social/healthcare services.
Regenerative farmer: Strong environmental and social motivation, holistic approach to agriculture.
Urban farmer: Farming on urban soil.
Lifestyle farmer: Quality of life, self-actualisation, cross-cultural competence.
Serious hobby: Small farms, the objectives focus on occupation rather than profitability.
Community provisioning farmer: Care-giver, nurturer oriented to small, tight networks.

Rural personas

Basic public services:

- **Tidal energy producer**: Sara, female, 28 years old, tidal power plant technician working in a growing local sector in her coastal area; maintains and repairs equipment in a challenging environment, often during extreme weather conditions.
- **Emergency services provider**: Eric, male, 40 years old, has worked as a fire fighter for the last 10 years.

Local administration:

- **Welcome & integration officer**: Anton, male, 57 years old, helps settling down and integrating newcomers, migrants, and remote workers by connecting them with relevant communities and services.
- **Mayor**: Anna, female, 65 years old, has been the mayor of her town for the last 5 years.

Social services & care actors:

- **Digital rehab/retreat centre manager**: Victoria, female, 34 years old, yoga teacher with a master's degree in nutrition and wellness; founded a retreat centre in the village for people with burnout, digital addiction and chronic stress.
- **Health professional:** Jacob, male, 23 years old, recent graduate in medicine; works part-time in several medical centres in the neighbouring villages and remotely.

Socio-cultural actors:

- **Augmented reality nature teacher/guide**: Keith, male, 52 years old, school teacher with a degree in sustainable development and future-oriented education; conducts virtual field trips

101 Bock, A. and Krzysztofowicz, M (2021).
102 Asikainen et al (2021).

to wilderness areas for students and digital tourists; lives in a remote wildlife-rich area.

- **Community centre volunteer**: Martha, female, 70 years old, a retired music school teacher who volunteers in a local community centre; helps organise cultural events.

Economic actors:

- **Circular economy enabler**: Tom, male, 31 years old, links businesses, farms, public canteens etc., to develop circular economy projects in an area.
- **Material passport producer**: Magda, female, 44 years old, materials engineer producing sustainability passports for buildings and consumer products based on the analysis of their environmental footprint; lives in a rural area and commutes to the head office in the nearby city a couple of times per week.
- **Environmental data analyst**: Mikhaela, 25 years old, performs data quality checks regularly, analyses consistency, and designs real-time data dashboards that enable data usage for farmers in the wider area; works remotely.

Annex 4 List of case studies topics used for testing the vision framework

Case study 1: Digitalisation of public services for rural areas

Ensuring that everyone, including persons with disabilities, can access public services online, and benefit from a cutting edge digital environment. Such environment will provide a holistic and easy access to public services with a seamless interplay of advanced capabilities, such as data processing, AI, and virtual reality.

Case study2 : Agriculture 5.0

Artificial intelligence algorithms make it possible to analyse and look for interactions in these large quantities of data, resulting from many sensors and observing many processes. As a next step, these algorithms can make decision suggestions for the farmer or even implement certain decisions independently.

Case study 3: Agricultural data space

European data space for agriculture will facilitate data exchange, processing and analysis in a secured, trusted, transparent and responsible manner to create new opportunities for monitoring and optimising natural resource use stimulating data-driven innovations.

Case study 4: Digital product passport

"Digital Product Passport" allows to electronically register, process and share product-related information amongst supply chain businesses, authorities, and consumers. It will provide information about products' environmental sustainability.

Case study 5: Farm sustainability data network

The EU's Farm Accountancy Data Network (FADN) provides annually key data and information that allows assessing and evaluating the economic and financial performance of all EU farms. Farm Sustainability Data Network (FSDN) will expand the scope of the current network collecting data on EU farms to include data on their environmental and social practices.

Case study 6 : Integrated digital administration

Increased spatial and temporal data resolution allows governments to act on their commitments to adopt "data-driven policy", in particular by enabling policy makers to better understand the impacts of policies; design of highly differentiated and targeted policies; new data-driven monitoring and compliance systems; and improve the ability to measure risk and manage uncertainty.

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