



European
Commission

FOOD 2030

Research and Innovation

Pathways for action 2.0

Research and innovation policy
as a driver for sustainable,
healthy, climate-resilient and
inclusive food systems



Research and
Innovation

Food 2030 Research and Innovation – Pathways for action 2.0: Research and innovation policy as a driver for sustainable, healthy, climate-resilient and inclusive food systems

European Commission
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FOOD 2030

Research and Innovation – Pathways for action 2.0

Research and innovation policy as a driver for sustainable,
healthy, climate-resilient and inclusive food systems

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CONTENTS

FOREWORD	3
ABBREVIATIONS	5
A VISION 2.0 FOR SUSTAINABLE FOOD SYSTEMS RESEARCH AND INNOVATION IN EUROPE	7
PATHWAY 1: GOVERNANCE FOR FOOD SYSTEMS CHANGE	29
PATHWAY 2: URBAN FOOD SYSTEMS TRANSFORMATION	45
PATHWAY 3: FOOD FROM THE OCEAN AND FRESHWATER RESOURCES	55
PATHWAY 4: ALTERNATIVE PROTEINS FOR DIETARY SHIFT	69
PATHWAY 5: FOOD WASTE AND RESOURCE-EFFICIENT FOOD SYSTEMS.....	78
PATHWAY 6: THE MICROBIOME WORLD	88
PATHWAY 7: NUTRITION AND SUSTAINABLE HEALTHY DIETS.....	100
PATHWAY 8: FOOD SAFETY SYSTEMS OF THE FUTURE	111
PATHWAY 9: FOOD SYSTEMS AFRICA	122
PATHWAY 10: DATA & DIGITAL TRANSFORMATION.....	134
PATHWAY 11: ZERO POLLUTION FOOD SYSTEMS.....	143

FOREWORD

European food systems are at a decisive moment in their history. They are at a crossroads where we must navigate the complex and intertwined challenges of ensuring food security, while guaranteeing environmental sustainability and economic prosperity. For our wellbeing and for that of future generations, we need to transition towards sustainable and healthy food systems that are regenerative and respect the planet's limits.



The European Commission's pioneering Food 2030 initiative, launched in 2016, steers research and innovation (R&I) policy to transform food systems in such a way that they deliver multiple benefits simultaneously. These benefits will be felt in nutrition and health, climate mitigation and adaptation, sustainability and circularity, and will ultimately empower communities. The holistic systems approach advocated in the Food 2030 initiative transcends sectors, disciplines and institutional silos. It has set the direction and successfully supported and challenged the R&I community to step up its ambitions and investments in this area. At the intersection of several key policy priorities, Food 2030 is aligned with, and aims to deliver on, the European Green Deal, the Farm to Fork and Circular Bioeconomy Strategies, the new European Research Area and new European Innovation Agenda.

With this in mind, I welcome the report Food 2030 Research and Innovation Pathways for Action 2.0. The document outlines eleven R&I Pathways to transform food systems at local, regional, national, and international levels. It is my hope that the report inspires the R&I community and EU innovators and helps strengthen the food systems science-policy interface.

I am sure that in the coming years, the strategic approach of Food 2030 to R&I policy will help shape our food systems and the wider bioeconomy, benefiting citizens, the environment and climate. By harnessing the power of R&I, we can move towards sustainable food systems that are not only productive and resilient, but also environmentally friendly and fair, while providing healthy food for all.

In this endeavour, the EU is well-positioned to lead by example. Food 2030 underlines the need for a collaborative spirit through current



and future EU R&I funding programmes and strategic agenda setting, where governments, academia, research institutions, businesses, civil society and local communities join forces. It calls for approaches where experts and scientists in ecology, public health, technology, urban planning and the social sciences and humanities come together and engage broadly to design solutions that work for all of society.

The challenges are clear. But so is our ability and determination to innovate to address them. Europe's excellence in R&I puts us at the leading edge of this transition. For example, we have shown how food systems innovation in cities and regions can be a catalyst of change. Many promising advances have been made in areas with huge potential for our future competitiveness: sustainable aquaculture, alternative protein foods, microbiome-based solutions, better nutrition and dietary shift, food safety and food fraud, sustainable and intelligent food packaging, and food waste within a circular bioeconomy. We need to continue to be science-evidence-based, to experiment and demonstrate. The food system transition will involve each and every one of us, wherever we live.

I am inspired by the dedication and creativity of all those working towards this shared vision. Together, we have the potential to redefine the future of food systems in Europe, setting a global example for others to follow. I urge all stakeholders to embrace the challenge before us. Let's double down on our commitment to be the leaders of the transition to a sustainable and just food future.



Iliana IVANOVA

*European Commissioner for Innovation, Research,
Culture, Education and Youth*

ABBREVIATIONS

AI	Artificial Intelligence
AU	African Union
Bioeast	Central eastern European initiative for knowledge-based agriculture, aquaculture and forestry in the bioeconomy
CBE JU	Circular Bio-based Europe Joint Undertaking
Desira	Development Smart Innovation through Research in Agriculture
EFSA	European Food Safety Authority
EIT	European Institute of Innovation and Technology
EIT Food	EIT's knowledge and innovation community for food systems
ERA	European Research Area
ERA-NET	European Research Area network
FAO	Food and Agriculture Organization of the UN
FNSSA	Food and Nutrition Security and Sustainable Agriculture
FOSC	Food System and Climate: assessing the impact of climate change on food and nutrition security and designing more sustainable and resilient food systems in Europe and beyond
GHG	Greenhouse Gas
HLPD	High-level Policy Dialogue

IHME	Institute for Health, Metrics and Evaluation
IA	Innovation Action
IPCC	Intergovernmental Panel on Climate Change
JPI	Joint Programming Initiatives
KIC	Knowledge and Innovation Community
LEAP-AGRI	A long term EU–Africa research and innovation partnership on food and nutrition security and sustainable agriculture
LIFE	Financial instrument for the environment
NCD	Non-Communicable Disease
OECD	Organisation for Economic Co-operation and Development
PRIMA	Partnership on Research and Innovation in the Mediterranean Area
R&I	Research and Innovation
SCAR	Standing Committee for Agricultural Research
SDG	Sustainable Development Goal
SPI	Science–Policy Interface
SRIA	Strategic Research and Innovation Agenda
UNEP	United Nations Environment Programme
UNFSS	UN Food Systems Summit

A VISION 2.0 FOR SUSTAINABLE FOOD SYSTEMS RESEARCH AND INNOVATION IN EUROPE

1. FOOD 2030 – A RESEARCH AND INNOVATION POLICY TO TRANSFORM FOOD SYSTEMS

This report is entitled Food 2030 Research and Innovation – Pathways for action 2.0. It is an update of a previous version released in October 2020¹, which, in turn, built on the 2016 European Commission staff working document² that set out the ambition of **Food 2030** as the EU research and innovation (R&I) policy framework to help drive the transition towards **sustainable, healthy** and **inclusive food systems**.

This update is set within an evolving policy context affected by geopolitical uncertainties, including the Russian war of aggression against Ukraine, the fallout of the COVID-19 pandemic, rising concerns around food and nutrition security, accelerating biodiversity loss and climate change impacts. Furthermore, it takes place during a time of increasing spread of misinformation, loss of trust in expertise, rise in populism, increasing social anxiety regarding the future of humanity, combined with important advances in artificial intelligence (AI), which is expected to bring both positive and negative impacts. The complexity of tackling all these issues related to bringing about the needed transformation of our food systems will require more than technical and academic fixes; the issues are multiple and interconnected, encompassing social, legal, economic, environmental, financial, ethical and philosophical dimensions, all of which will need to be fully embedded in future R&I policies and programmes.

The Food 2030 pathways are being deployed via **Horizon Europe**, the EU's framework programme for R&I (2021–2027), which provides funding to support a diversity of projects and initiatives, in Europe and beyond. It is important to note that the pathways, however, do not cover all of the thematic areas requiring EU investments in R&I related to food systems. Additional important areas of work, such as sustainable agriculture, healthy soil, agroecology, alternative pesticides, rural growth, precision farming, health and well-being, biotechnology, combating biodiversity loss, integrated water management, circular bioeconomy, cultural heritage and rural development aspects, are dealt with by other, complementary, Horizon Europe work streams.

¹ European Commission, Directorate-General for Research and Innovation, de Froidmont-Görtz, I., Faure, U., Gajdzinska, M., Haent Jens, W., Krommer, J., Lizaso, M., Lutzeier, H.-J., Mangan, C., Markakis, M., Schoumacher, C., Tallarico, T. and Zampukas, N. (2020), Food 2030 pathways for action – Research and innovation policy as a driver for sustainable, healthy and inclusive food systems, Publications Office of the European Union, Luxembourg.

² European Commission, Directorate-General for Research and Innovation (2016), European research & innovation for food & nutrition security, Publications Office of the European Union, Luxembourg.

Many of the pathways have strong interconnections, and it is there that co-creation across the different parts of the food systems can lead to the expected co-benefits and greater farm-to-fork coherence, taking on a holistic perspective. In addition to developing an R&I policy agenda that translates into Horizon Europe's multiannual calls for proposals, Food 2030 is expected to deliver on issues linked to the renewed European research area (ERA) policy priorities and the EU circular and sustainable bioeconomy strategy and action plan. Investments in food system R&I also provide promising avenues for the NextGenerationEU recovery package to deploy a reinforced EU budget to help repair the immediate economic and social damage caused by the COVID-19 pandemic, kick-start the recovery and prepare for a better future.

The modernisation of the pathways was supported by a participatory expert workshop held on 10 March 2023 in Brussels, where about 90 experts with diverse backgrounds and experiences were invited to collectively reflect on the way forward. Each pathway acknowledges the experts' contributions.

Figure 1.1 The 11 Food 2030 pathways and co-benefits³.

FOOD 2030 Pathways	 Nutrition	 Climate	 Circularity	 Communities
 PATHWAY 1 GOVERNANCE FOR FOOD SYSTEMS CHANGE	+++	+++	+++	+++
 PATHWAY 2 URBAN FOOD SYSTEMS TRANSFORMATION	++	+++	+	+++
 PATHWAY 3 FOOD FROM THE OCEAN & FRESHWATER RESOURCES	++	+++	+++	+++
 PATHWAY 4 ALTERNATIVE PROTEINS FOR DIETARY SHIFT	+++	+++	++	+++
 PATHWAY 5 FOOD WASTE & RESOURCE- EFFICIENT FOOD SYSTEMS	++	+++	+++	++
 PATHWAY 6 THE MICROBIOME WORLD	+++	+++	++	+++
 PATHWAY 7 NUTRITION & SUSTAINABLE HEALTHY DIETS	+++	++	+	++
 PATHWAY 8 FOOD SAFETY SYSTEMS OF THE FUTURE	+++	+++	++	+++
 PATHWAY 9 FOOD SYSTEMS AFRICA	+++	+++	+++	+++
 PATHWAY 10 DATA & DIGITAL TRANSFORMATION	+++	+++	+++	+++
 PATHWAY 11 ZERO-POLLUTION FOOD SYSTEMS	++	+++	+++	+++

³ 'Plus' symbols indicate the diversity of impacts of each pathway to the respective co-benefit, where + = one impact, ++ = two impacts, +++ = three impacts or more.

Figure 1.1 lists the 11 Food 2030 pathways and shows the diversity of co-benefits (identified positive effects of the Food 2030 R&I policy framework) that can be derived from their implementation. The subsequent chapters describe each pathway by setting out their systemic challenges and specific policy contexts, also highlighting existing and perceived barriers and lock-ins and enablers of change. The chapters then summarise some R&I issues meriting further investment and provide overviews of the Food 2030 results so far.

Food 2030 makes use of Horizon Europe to help fund and deliver R&I on these pathways, but far more can be achieved if we work together. Collaborating closely with public and private funders and performers of R&I into other food systems will provide more focus, joined-up actions, impact and leverage of R&I funding and resources. Food 2030 will continue to convene regarding these issues and foster better R&I governance. We hope that Food 2030 and its pathways can serve as an inspiration to others to take on more systemic approaches to how R&I policy can be built up, fostered and deployed.

2. POLICY CONTEXT

Food 2030 does not take place in isolation but plays a role in an evolving European and global policy context. As highlighted by António Guterres, UN Secretary-General, ‘food systems hold the power to realize our shared vision for a better world’⁴. There is now widespread recognition that our food systems are affected by and the source of a wide range of simultaneous challenges: climate change, pollution, resource scarcity, urbanisation, a growing and ageing population, malnutrition, biodiversity loss, soil degradation, food loss and waste, and food poverty, to name a few. In addition, the COVID-19 pandemic and the Russian war of aggression against Ukraine have further increased the urgency of making our food systems more sustainable and resilient. These geopolitical events underlined the interconnectedness and pivotal importance of functioning food supply chains and the need to further increase the resilience of EU food systems to disturbances and shocks⁵, while ensuring food and nutrition security and environmental sustainability.

It is no longer disputed that food systems transformation is needed that will enable us to live and thrive within planetary boundaries and ensure food and nutrition security for all and in the long term for future generations. This requires a better understanding of the complex interactions between the components of our current food systems, and innovative ways to accelerate and develop solutions that can contribute to systemic change. These messages were reinforced in 2023 by the Intergovernmental Panel on Climate Change (IPCC) at the launch of its synthesis report⁶.

Europe is well placed to lead in this endeavour, with its European Green Deal setting out a roadmap for transforming the EU economy, aiming for climate neutrality and

⁴ UN (2021), ‘Secretary-General’s chair summary, statement of action on United Nations Food Systems Summit’, press release, 23 September 2021.

⁵ UNFSS (2021), *COVID-19 and Food Systems: Rebuilding for resilience*, Food Systems Summit brief.

⁶ IPCC (2023), *IPCC Climate Change 2023: Synthesis report*, Geneva.

sustainability, with a focus on energy, mobility and food systems. The ambition and need to transform food systems are addressed through various recent EU strategies, including the farm-to-fork strategy⁷, the biodiversity strategy⁸, the bioeconomy strategy⁹, the circular economy action plan¹⁰ and the new European industrial strategy¹¹. Also highly relevant are the EU's commitments to the [UN's sustainable development goals](#) (SDGs) and the 2015 Paris Agreement under the UN Framework Convention on Climate Change.

[The farm-to-fork strategy](#) was adopted in 2020. It calls for a food system transition in respect of planetary boundaries that is fair and just, and sets out objectives, targets and a collection of tangible actions that will help this transition become a reality. One of its flagship actions is the [legislative framework for a sustainable food system](#). Its goal is to promote policy coherence at the EU and national levels, embed sustainability in all food-related policies and strengthen the resilience of food systems. The farm-to-fork strategy highlights R&I as 'key drivers in accelerating the transition to sustainable, healthy and inclusive food systems, from primary production to consumption'. It recognises that 'R&I can help develop and test solutions, overcome barriers and uncover new market opportunities' and specifically mentions Horizon Europe as a strategic programme for R&I.

The R&I ambitions relevant to the farm-to-fork strategy are built on the lessons learned from and advocacy work of Food 2030, which, since 2016, has convened meetings and fostered a systems approach to R&I policy in this area. The farm-to-fork strategy is also supported by findings and recommendations set out in the EU Scientific Advice Mechanism opinions *Towards a Sustainable Food System*¹² and *Towards Sustainable Food Consumption – Promoting healthy, affordable and sustainable food consumption choices*¹³. These two scientific opinions highlight the need for food to be considered a common good and not just a trading commodity, and that the EU's transition towards a sustainable food system must rely on the widespread adoption of healthy and sustainable consumption practices, which are largely influenced by food environments. Their evidence bases are in full alignment with Food 2030, and hence the opinions and Food 2030 are mutually reinforcing.

Another key set of policies highly relevant to food systems are the [common agricultural policy](#) and the [common fisheries policy](#). These are long-standing key pillars of EU policy, which have been progressively modernised and tend to focus more on sectoral primary production ambitions. Moreover, one of the common agricultural policy objectives focuses on R&I, which has now also been integrated into many Member States'

⁷ European Commission (2020), [Commission communication – A farm to fork strategy for a fair healthy and environmentally-friendly food system](#), COM(2020) 381 final.

⁸ European Commission (2020), [Commission communication – EU biodiversity strategy for 2030: Bringing nature back into our lives](#), COM(2020) 380 final.

⁹ European Commission (2018), [A Sustainable Bioeconomy for Europe: Strengthening the connection between economy, society and the environment – Updated bioeconomy strategy](#), Publications Office of the European Union, Luxembourg.

¹⁰ European Commission (2020), [Commission Communication – A new Circular Economy Action Plan For a cleaner and more competitive Europe](#), COM/2020/98 final.

¹¹ European Commission (2023), [Commission staff working document – Co-creation of a transition pathway for a more resilient, sustainable and digital agri-food ecosystem](#), SWD(2023) 263 final.

¹² European Commission, Group of Chief Scientific Advisors (2020), [Towards a sustainable food system – Moving from food as a commodity to food as more of a common good](#), Independent expert report, Publications Office of the European Union, Luxembourg.

¹³ European Commission, Group of Chief Scientific Advisors (2023), [Towards Sustainable Food Consumption – Promoting healthy, affordable and sustainable food consumption choices](#), scientific opinion No 14, Publications Office of the European Union, Luxembourg.

common agricultural policy strategic plans to foster agricultural knowledge generation and transmission, innovation and digitalisation, and make use of Horizon Europe, its partnerships and missions, all of which are expected to contribute significantly to the European Green Deal. R&I efforts in primary agriculture are crucial for advancing sustainable and healthy food production. Initiatives such as the EU mission ‘A soil deal for Europe’ (see Box 6) are pioneering innovative solutions for the sustainable management and restoration of soil in rural and urban areas, as healthy soil is the basis for healthy and sustainable food.

The recent European Environment Agency report entitled *Transforming Europe's Food System – Assessing the EU policy mix*¹⁴ assesses the policy coherence between the farm-to-fork strategy, the common agricultural policy and the common fisheries policy regarding reaching the sustainable food systems goals. It reveals the following.

- Policies unevenly address key actors of the food system, so it is unlikely to lead to significant change: while consumers are over-targeted, key actors in the middle of the food value chain (e.g. manufacturers and retailers) are mostly involved in voluntary actions.
- Policies are not consistent with actions to phase out unsustainable activities. To correct this, we need a significant reorientation of common agricultural policy spending, and various measures to address the availability and price of unsustainable products.
- The strong investment in research projects is not yet complemented by adequate levels of support for accelerating and upscaling radical innovations.
- Cultural and social lock-ins still need to be addressed and all stakeholders should be allowed to effectively participate in decision-making processes.
- There are incoherencies between policy goals and ambiguity regarding the desired direction of change in the EU food policy mix.

Moreover, the EU also has a long-standing and extensive EU Food Law, which covers aspects related to food safety, novel foods and traceability. Traceability is a risk management tool necessary for managing the food safety systems of the future and the one health approach. There are many other sectoral EU policies, regulations and initiatives that also have an impact on food systems and can help both give direction to and gain benefits from R&I, such as those addressing food waste reduction or the genetically modified organisms legislation for plants¹⁵. Ensuring policy coherence is by no means a small feat.

To complement and support policy implementation, a variety of EU funding instruments exist that can contribute to food system transition, for example the EU's financial

¹⁴ European Environment Agency (2022), [Transforming Europe's Food System – Assessing the EU policy mix](#), EEA report No 14/2022, Publications Office of the European Union, Luxembourg.

¹⁵ Adopted in July 2023: European Commission (2023), [Proposal for a regulation of the European Parliament and of the Council on plants obtained by certain new genomic techniques and their food and feed, and amending Regulation \(EU\) 2017/625](#), COM(2023) 411 final, Brussels.

instrument for the environment ([LIFE programme](#)), for environment, nature conservation and climate action; the European Agricultural Fund for Rural Development, for common agricultural policy implementation; and the European Maritime, Fisheries and Aquaculture Fund, for common fisheries policy implementation. EU financial support directed at R&I, however, is driven through two main instruments: the EU framework programme for R&I (Horizon Europe) and the [Development smart innovation through research in agriculture \(Desira\) initiative](#), nested under the Development Cooperation Instrument, which aims to contribute to the climate-relevant, productive and sustainable transformation of agriculture and food systems in low- and middle-income countries.

At the global level, awareness of the need to fix our food systems has also increased in recent years. In 2021, the first UN Food Systems Summit (UNFSS) was a pivotal moment in this process that also contributed to food systems being more embedded in climate-, biodiversity- and health-related discourses. As of November 2023, 12 EU Member States have signalled their commitment to developing national food system strategies as an outcome of the UNFSS process: Czechia, Denmark, Germany, Ireland, Spain, France, Italy, Hungary, Malta, Poland, Finland and Sweden. The role of science was key to the UNFSS process and was acknowledged as a driver that supports food system changes. The need to strengthen the science–policy interface (SPI) for improved food systems governance was also addressed and supported by the European Commission through a dedicated high-level expert group, which delivered its findings and recommendation as a follow-up of the UNFSS in July 2022 in the form of the report *Everyone at the Table: Transforming food systems by connecting science, policy and society*¹⁶. The report concludes that food systems SPIs must be better supported and interconnected, and provides the recommendations and pathways needed to achieve that, such as multilateral governance, multisectoral task forces, and a network of networks of thematic SPIs working on or around food system issues. It highlights that food systems transformation is predominantly a social issue, so the concept of SPIs needs to evolve into one of science–policy–society interfaces, where society is engaged in the process.

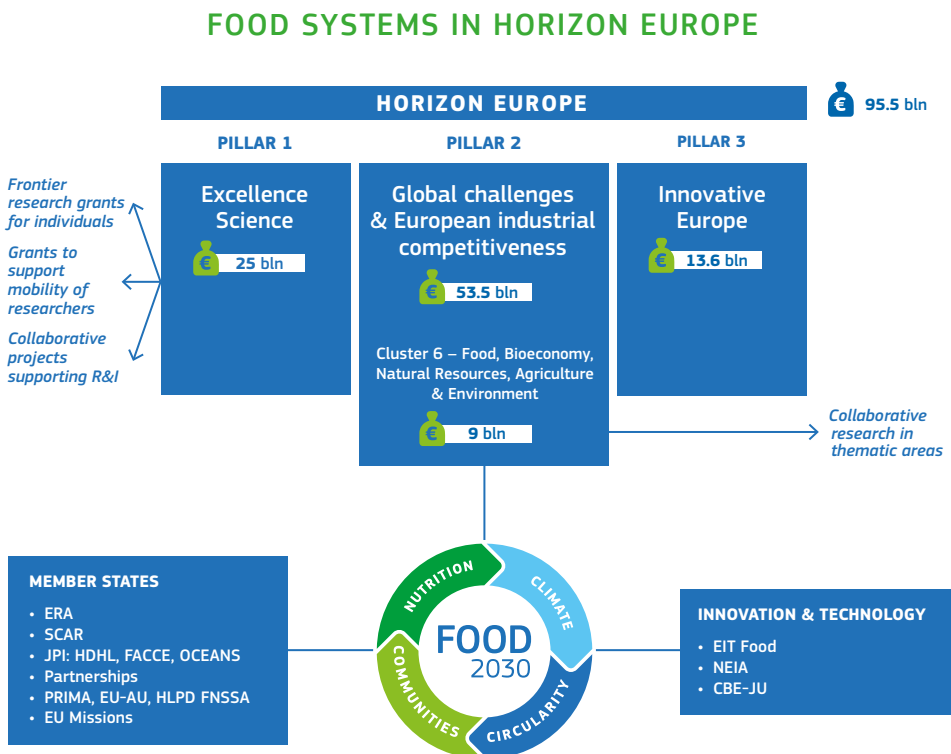
Many food- and agriculture-related policy initiatives, whether European or international, point to the key enabling role of science and R&I in providing the evidence base to help policymaking and decision-making and providing innovative solutions that can help accelerate the needed transition. The next section attempts to provide a snapshot of the EU's food systems R&I landscape connected to Horizon Europe, with which Food 2030 is closely interacting.

3. RESEARCH AND INNOVATION LANDSCAPE

The EU R&I policy landscape related to food systems has evolved over the years. Figure 1.2 provides a rough snapshot of the landscape as of November 2023, but is not meant as an exhaustive overview.

¹⁶ European Commission, Directorate-General for Research and Innovation, Webb, P., Sonnino, R., Fraser, E. and Arnold, T. (2022). [Everyone at the Table – Transforming food systems by connecting science, policy and society](#), Publications Office of the European Union, Luxembourg.

Figure 1.2 Funding and governance of the EU's food-system-related R&I, 2021-2027



NB: CBE JU, Circular Bio-based Europe joint undertaking; EIT, European Institute of Innovation and Technology; EU-AU HLPD, African Union–EU High-Level Policy Dialogue; FACCE, joint programming initiative on agriculture, food security and climate change; FNSSA, food and nutrition security and sustainable agriculture; HDHL, Healthy diet, healthy life; JPIs, joint programming initiatives; NEIA, new European innovation agenda; Oceans, healthy and productive seas and oceans; PRIMA, Partnership for Research and Innovation in the Mediterranean Area; SCAR, Standing Committee on Agricultural Research.

The EU-level R&I landscape related to food systems makes good use of the Horizon Europe multiannual EU framework programme for R&I. It is the world's largest public-sector R&I strategic programming and funding mechanism, which enables top-down and bottom-up R&I activities to be supported. Horizon Europe covers 2021–2027 and builds on its predecessors, the first of which was launched in the early 1980s. It is structured in three pillars, as shown in Figure 1.2.

- **PILLAR 1** of Horizon Europe supports frontier research and breakthrough scientific ideas, teams up the best researchers from Europe and beyond and equips them with skills and world-class research infrastructure. It provides grants to individual researchers and research teams, based on excellent science. A recent analysis by the European Research Council¹⁷ provides a very good overview of scientific achievements and reveals that about 100 grants relevant to the Food 2030 Pathways were attributed to single researchers totalling EUR 230 million during the previous Framework Programmes of Horizon 2020 (2014-2020) and Seventh Framework Programme (FP7) (2007-2013).
- **PILLAR 2** of Horizon Europe focuses on science and technologies that address major global challenges, such as climate change, energy and health, and addressing the UN's SDGs. It has total funds of EUR 53.5 billion, of which roughly EUR 9 billion are granted to R&I projects responding to calls for proposals under Cluster 6 'Food, Bioeconomy, Natural Resources, Agriculture and Environment'¹⁸. In this cluster, two out of seven intervention areas are directly related to sustainable food systems: the 'agriculture, forestry and rural areas' intervention area, focusing predominantly on primary production, and the 'food systems' intervention area, through which Food 2030 is deployed and which mostly addresses post-farm-gate R&I. Investments in these two intervention areas alone have amounted to approximately EUR 450 million per year under Horizon Europe so far (EUR 338 million per year for the intervention area on agriculture and EUR 113 million per year for the intervention area on food systems). These two agri-food intervention areas work in close cooperation to ensure system-wide R&I coverage from food production to consumption, in line with the common agricultural policy, the farm-to-fork strategy and other EU Green Deal ambitions.
- **PILLAR 3** of Horizon Europe implements activities to boost and better connect innovators in Europe and generally enhance the European innovation landscape. Under this pillar, the European Innovation Council (EIC) was established and activities of the European Institute of Innovation and Technology (EIT) are promoted. The EIC aims to support researchers, companies and start-ups in scaling their innovations up to the market. It offers expertise and fosters connections among various food system stakeholders. For example, in the 2023 work programme, the EIC had two agri-food-related challenges: the EIC accelerator challenge 'Novel technologies for resilient agriculture', with an indicative budget of EUR 65 million, and the EIC pathfinder challenge 'Precision nutrition', with an indicative budget of EUR 32.7 million. The EIT supports the knowledge triangle, combining research, entrepreneurship and education (e.g. online courses on food systems). It supports business creation and innovation projects, which are offered within its knowledge and innovation communities (KICs). EIT Food is a KIC focused on sustainable food systems and was established in 2016. The European Commission contribution to EIT Food in 2021–2022 was EUR 103.2 million and the EIT grant from 2023 to 2025 (multiannual grant agreement) for EIT Food represents EUR 179.2 million.

¹⁷ European Commission, Directorate-General for Research and Innovation, Webb, P., Sonnino, R., Fraser, E. and Arnold, T. (2022). [Everyone at the Table – Transforming food systems by connecting science, policy and society](#), Publications Office of the European Union, Luxembourg.

¹⁸ European Commission (2021) [Presentation outlining Horizon Europe. Investing to shape our future.](#)

The European Commission also has a central steering role in the work of the Member-State-led Standing Committee on Agricultural Research (SCAR) (see Box 1). In addition, given that Member States have their own national R&I policies and funds, one of the objectives of Food 2030 is to develop a food system ERA that aligns national R&I policies and fosters joint programming¹⁹ (see Box 2).

Box 1. SCAR

SCAR is a committee that was established in 1974 and represents more than 35 countries – all EU Member States, EU candidate countries, EU associated countries and some other non-EU countries. The committee became a source of advice on European agricultural and wider bioeconomy R&I and is a catalyst for strategic agenda setting and the coordination of EU and national R&I programmes aiming to strengthen the ERA. In 2016, it established a working group on food systems with the explicit mandate to support the Food 2030 EU R&I policy framework and to co-create the Horizon Europe Food Systems partnership. SCAR also conducts regular foresight analyses, the last of which was the fifth SCAR foresight analysis, published in 2020, in which the food system transition was underlined as urgent.

Box 2: Joint programming initiatives

Joint programming initiatives are structured and strategic processes whereby Member States agree, voluntarily and in partnership, on a common vision and strategic research and innovation agenda (SRIA) to address major societal challenges. Three joint programming initiatives (the joint programming initiative on agriculture, food security and climate change, Healthy diet, healthy life and Healthy and productive seas and oceans) have implemented several activities, such as joint calls, knowledge hubs and task forces to target food systems-related issues, and also nexus activities, which in turn led to the funding of numerous European research area networks (ERA-NETs), such as the ERA-NET Cofund on ICT-enabled agri-food systems (EU contribution EUR 5 million, total cost EUR 15 million).

EU R&I, however, is only a fraction of the total public-sector R&I investments that are managed by EU Member States. At the national level, virtually every EU Member State has a science base in agriculture, food and nutrition, and the green transition will depend heavily on how quickly these science bases can develop and extend innovation to food systems. A study carried out by SCAR revealed that, from 2007 to 2020, an estimated almost EUR 18.4 billion of EU funding was provided to projects related to food systems. This accounts for 15 % of the total EU public funding available during that period. To

¹⁹ The ERA was created in 2000 with the ambition of creating a single, borderless market for research, innovation and technology across the EU. The new ERA policy agenda sets out 20 ERA actions for 2022–2024, such as promoting attractive research careers, promoting talent circulation and mobility, promoting gender equality or academic freedom and strengthening research infrastructure.

date, however, not all EU Member States have national long-term food system strategies to guide R&I efforts in their countries. An ambition of Food 2030 is to act as a guiding framework to inspire and complement EU Member States' R&I policies²⁰.

Horizon Europe is also contributing to several types of international cooperation co-funded institutional partnerships related to agriculture and food systems. The African Union (AU)–EU High-Level Policy Dialogue (HLPD) on Science, Technology and Innovation is the main dialogue platform for formulating joint AU–EU cooperation activities in this field. This platform and the Union for the Mediterranean Regional Platform on Research and Innovation cover Africa–Europe cooperation on R&I across the whole African and European continents. The former has given rise to the food and nutrition security and sustainable agriculture (FNSSA) partnership, and the latter is linked to the Partnership for Research and Innovation in the Mediterranean Area (PRIMA) (see Boxes 3 and 4)²¹.

Box 3: FNSSA partnership

The FNSSA partnership sets out a 10-year SRIA and roadmap for R&I co-funding. The partnership has channelled a joint investment of EUR 381 million to four priorities: the sustainable intensification of agriculture, agriculture and food systems for nutrition, the expansion and improvement of agricultural trade and markets, and cross-cutting topics. The FNSSA partnership is further associated with another European Commission instrument called Desira (funded in the international development context, outside Horizon Europe), which aims to contribute to the climate-relevant, productive and sustainable transformation of agriculture and food systems in low- and middle-income countries.

Box 4: PRIMA

PRIMA is an Article 185 TFEU partnership with an active period of operation extending from 2018 to 2024. Under the Horizon 2020 programme, the total EU contribution planned for PRIMA amounts to EUR 220 million. PRIMA unites R&I funders to devise an SRIA for the Mediterranean, in particular addressing agriculture, water and food issues and their nexus. PRIMA unites countries from both shores of the Mediterranean basin, which contribute an additional EUR 275 million. PRIMA's interim evaluation showed that the partnership is achieving its objectives and has demonstrated its positive impact on the R&I ecosystem in the Mediterranean region. Given the considerable demand from the PRIMA participating states for the extension of PRIMA, the Commission adopted a proposal for amending the Basic Act in June 2023. This proposal reflects the EU's commitment to continuing its participation in PRIMA for 2025–2027 under Horizon Europe, with a financial contribution of EUR 105 million.

²⁰ [EU research policy on sustainable food systems](#)

²¹ PRIMA will develop solutions for a more sustainable management of water and agri-food systems in the Mediterranean basin. It is a 10-year initiative (2018–2028), funded from 19 participating countries (currently EUR 274 million) and a EUR 220 million contribution from the EU. Its main objective is to devise new R&I approaches to improve water availability and sustainable agriculture production in a region heavily distressed by climate change, urbanisation and population growth.

At the start of Horizon Europe, a new wave of partnerships was launched to coordinate activities and networks around dedicated thematic issues. This gave rise to 49 partnerships, four of which are directly related to the overall food systems transition. These partnerships include the European partnership ‘Accelerating farming systems transition – agroecology living labs and research infrastructure’ (co-funding rate 50 %), the European Partnership for Agriculture of Data (co-funding rate 30 %), the European Partnership for Animal Health and Welfare (co-funding rate 50 %) and the **Sustainable Food Systems Partnership for People, Planet and Climate** (hereafter ‘the food systems partnership’) (co-funding rate 30 %) (see Box 5). Here we focus on the food systems partnership, which aims to deploy the Food 2030 approach. It will put in place an R&I governance mechanism engaging Member States and food system actors in delivering innovative solutions providing co-benefits for nutrition, climate, circularity and communities.

These [European partnerships](#) are examples of initiatives fostering collaboration in food system R&I policy development and supporting pertinent research infrastructure. They provide a strategic approach to R&I programming, a pooling of resources and an actionable framework for long-term commitments and are hence contributing to the strengthening of the ERA. A number of these initiatives are connected to Food 2030, either directly by providing funding opportunities through the Food 2030 pathways or indirectly through joint advocacy, cooperation agreements, working groups, advisory boards, strategic steering, co-creation, etc.

Box 5: Sustainable Food Systems Partnership for People, Planet and Climate

The Sustainable Food Systems Partnership for People, Planet and Climate²² is a direct deliverable of Food 2030. Its ambition is to leverage investments and to develop and implement an EU-wide long-term R&I agenda to accelerate the transition to diets that are healthy and food that is safe and sustainably produced and consumed in resilient EU and global food systems. The overarching vision is that, by pooling resources and joining forces, its actors will jointly contribute to environmentally friendly, socially secure and fair, economically viable, healthy and safe food systems in Europe to help achieve the farm-to-fork strategy objectives, in line with the global ambitions of the UNFSS. It will focus its activities on four predominantly post-farm-gate work streams to change the way we eat, process and supply food, but also to better connect and govern food systems. Resources are also provided to establish a food systems observatory, to establish a knowledge hub of living labs and to foster knowledge sharing.

The R&I landscape for food systems would be incomplete if we did not mention the existing EU flagship missions on soil health (see Box 6), climate adaptation, cities,

²² SCAR (2023), [Sustainable Food Systems Partnership for People, Planet and Climate – Strategic research and innovation agenda \(SRIA\). FoodPaths \(2023\)](#) is designing a prototype sustainable food system partnership that will serve as the first version of how the future partnership might function from 2024 onwards and, in doing so, is bringing the partnership to life.

oceans and cancer, which are all relevant to the food systems transition. They demonstrate political commitment and provide a clear direction of travel for five key societal challenges. They set ambitious but attainable objectives with measurable targets and deadlines, foster collaboration across diverse fields, industries and participants, and embrace experimentation and bottom-up approaches to achieve the mission's anticipated results.

Box 6: EU missions in Horizon Europe – EU mission 'A soil deal for Europe'

The EU missions are new instruments of Horizon Europe (2021–2027). Instead of targeting specific technologies or industrial sectors, the missions focus on setting and achieving clear, measurable and ambitious goals related to key societal challenges. Five missions were introduced in 2021, covering challenges such as climate change and beating cancer, and a sixth one is to be introduced in 2023. Each EU mission will operate as a portfolio of actions – such as research projects, policy measures or even legislative initiatives – to achieve a measurable goal that could not be achieved through stand-alone EU-funded research projects or individual actions.

The EU mission 'A soil deal for Europe'²³, with a budget of EUR 320 million for 2021–2023, aims to develop concrete solutions for restoring soil functions and thus help the transition to healthy soil by 2030. To this end, it has the objective of establishing a network of 100 living labs and lighthouses in rural and urban regions, and aims to foster the development of a common European framework for monitoring soil to generate and disseminate knowledge and appropriate solutions for soil health. The mission will also foster knowledge of and innovation in the link between soil health and food. Given that around 95 % of all our food originates from soil, soil health is the very foundation of food systems. Soil needs to be in a healthy condition so that it can produce sufficient food to feed everybody and support many vital ecosystem services, nutrient cycling and carbon sequestration.

Lastly, the European Commission also has a central steering role in accelerating and strengthening responsible innovation and investment, boosting skills and capacities and supporting cases for bioeconomy and food systems demonstration, testing and deployment. This also includes building a New European Innovation Agenda (NEIA) to boost the development of innovative solutions by helping create "regional innovation food valleys" to develop and test solutions; and advancing competitive circular bio-based industries under the Circular bio-based Europe joint undertaking (CBE JU), a partnership between the European Union and the Bio-based Industries Consortium (BIC).

²³ European Commission (2021), [A Soil Deal for Europe – 100 living labs and lighthouses to lead the transition towards healthy soils by 2030: Implementation plan](#), Brussels.

Horizontal aspects

Over the years, the R&I policy has placed increasing emphasis on the way in which R&I should be performed to deliver greater impact and to ensure solutions are more in sync with societal and planetary needs. Multi-actor approaches, responsible R&I and the need to adopt a systems approach have underpinned this trend. One way to operationalise these ambitions is the use of the living lab concept (see Box 6), which has been deployed extensively via the seminal [Fit4Food2030](#) project and the Food 2030 pathways on urban food systems and governance and is also at the heart of the food systems and agroecology partnerships and the EU mission ‘A soil deal for Europe’, which seeks to develop 100 living labs across Europe.

Living labs²⁴ are defined as practice-driven, place-based organisations that facilitate and foster open, collaborative innovation and real-life environments where both open innovation and user innovation processes can occur and where bottom-up-driven R&I can be designed and implemented.

- The living labs established by projects stemming from the Food 2030 urban food systems pathway supported place-based solutions by employing the multi-actor approach, especially for engaging citizens and enabling changes on the ground, and also connecting urban and rural areas to create multipurpose desirable outcomes.
- The Commission report [Urban food system transformation in the context of Food 2030](#) – Current practice and outlook towards 2030 reflects on the future of sustainable and resilient food systems in urban areas, based on the experiences of 22 EU-funded R&I projects representing 154 city initiatives related to food that employed place-based solutions.
- The EU-funded project [CLEVERFOOD](#) has established a **Food 2030 Connected Lab Network for living labs**, communities of practice and other co-creation initiatives working on transforming the food system at the local, regional and national level.²⁵
- As an example of what can be done through an EU-funded project, [FoodSHIFT 2030](#) established FoodSHIFT Accelerator Labs for maturing, combining, upscaling and multiplying existing food systems innovations across nine front-runner cities/regions and FoodSHIFT Enabler Labs in twenty-seven follower cities/regions. Each FoodSHIFT Accelerator Lab has defined an innovation focus and innovation actions to increase the technological and societal readiness levels of existing food systems innovations within ten major themes and eleven SDGs across the Labs.
- Living labs will be extensively employed in the planned Horizon Europe partnerships on agroecology and sustainable food systems. For the latter

²⁴ Transformative Social Innovation Theory (2016), ‘[European Network of Living Labs \(ENoLL\)](#)’.

²⁵ see the ‘Governance for food systems change Chapter for more information.

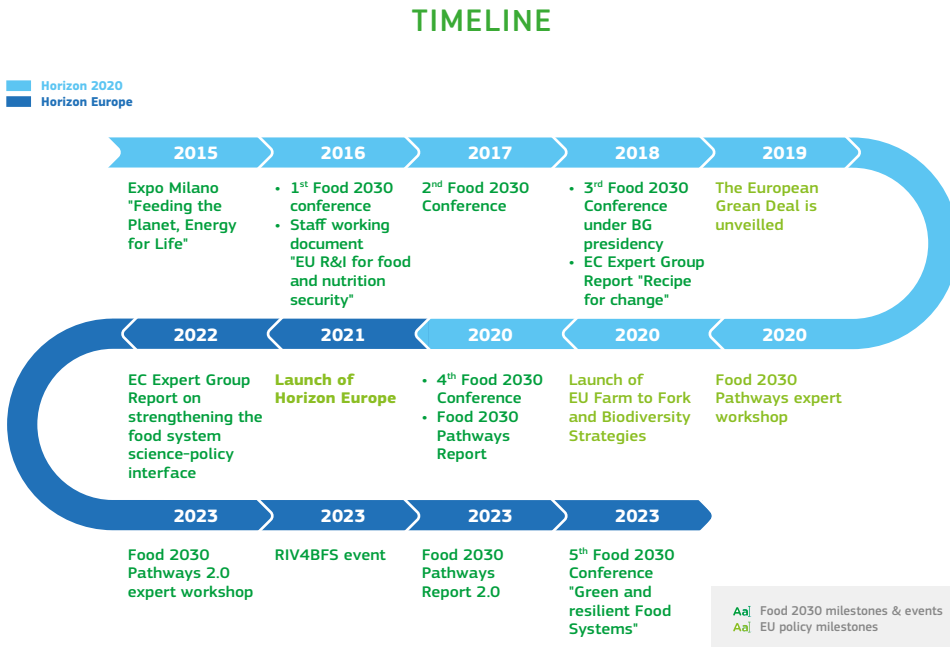
partnership, they will serve as practice-driven organisations that facilitate collaborative innovation and real-life environments to support sustainable food systems transformation. The partnership will create a knowledge hub of living labs to enable knowledge sharing and dissemination. Living labs and lighthouses within the context of the EU mission ‘A soil deal for Europe’ are defined as follows: lighthouses are places for the demonstration of solutions and of exemplary achievements, while living labs are collaborative R&I initiatives between multiple actors that experiment in laboratories on the ground (e.g. urban areas, forest sites or industrial settings) to find solutions to the problem of degrading soil, based on a jointly agreed objective.

4. FOOD 2030 – LOOKING BACK AND ASSESSING RESULTS

How it came about

Figure 1.3 provides an overview of the historical evolution of Food 2030. It all began during the 2015 Milan World Expo, which acted as a pivotal moment for raising awareness of food system challenges. Its overarching theme was ‘feeding the planet, energy for life’, encompassing technology, innovation, culture, traditions and creativity and how they relate to food and diets. The EU convened over 200 events over a 6-month period, supported by an [EU scientific steering committee](#). At the EU closing conference on 15 October 2015, with the support of three commissioners, the European Commission underlined the need to develop a European R&I area for food systems. This ultimately led to the formation of the idea of Food 2030 in 2016. Since then, the European Commission’s Directorate-General for Research and Innovation has been advocating and convening events around the urgency of reshaping the European R&I policy landscape for food systems, which had been fragmented, sectoral and focused largely on technology and primary production. In October 2016, the directorate-general held the first Food 2030 High-Level Conference, during which it launched a European Commission staff working document that was co-created with multiple European Commission services. The document (entitled [European research and innovation for food and nutrition security](#)) set out an ambitious, impact-driven R&I policy framework for sustainable food systems, called Food 2030, which underpinned the development of EU R&I policy within the context of the last calls of Horizon 2020 and the whole of Horizon Europe. Since its start, Food 2030 has led to the organisation of multiple high-level conferences related to World Food Day, including an official Bulgarian Presidency event in Plovdiv, in 2018. These convening moments and the many reports that have been published over the years have served to mobilise a diversity of actors, raise awareness and foster a new way of undertaking R&I that can better deal with the complexity inherent to food systems transformation and foster greater interdisciplinarity and transdisciplinarity.

Figure 1.3 Food 2030 timeline



The premise behind the idea of Food 2030 is that R&I policy plays a pivotal role in attaining sustainability objectives and transforming the food systems; innovation cannot be seen as business as usual. The transition to sustainable food systems requires a **systems approach** and the application of **systems thinking** that considers the intricate interconnections and dynamics within the entire food ecosystem. Instead of viewing individual components in isolation, this methodology analyses how various elements, such as production, distribution, consumption and waste management, interact and influence one another. By recognising the complex web of relationships, feedback loops and unintended consequences, systems thinking aims to unearth comprehensive insights and devise more effective strategies for addressing challenges such as food security, sustainability and resilience. This approach encourages a shift from linear solutions to integrated solutions, fostering a deeper understanding of the systemic causes and effects shaping our food systems and enabling informed decision-making for a more interconnected and sustainable future²⁶.

Food systems are adaptive and complex, interconnected with various policy domains such as agriculture, environment, energy, health, education, infrastructure and planning. This means food systems are multifunctional, multisectoral and multi-actor, making traditional linear models insufficient to capture their complexity²⁷. The need for a systems approach

²⁶ Weber, K. M. and Rohrer, H. (2012), 'Legitimizing research, technology and innovation policies for transformative change: combining insights from innovation systems and multi-level perspective in a comprehensive "failures" framework', Research Policy, Vol. 41, No 6, pp. 1037–1047.

and for innovative interactions underscores the crucial role of R&I in supporting systemic food systems transformation. This need for a more holistic and mission-oriented approach is what motivated the framing of Food 2030 back in 2016. Consequently, the European Commission moved towards a systems approach R&I framework for food systems transformation and towards a more mission-driven approach to tackle complex societal challenges that cannot be solved by any one EU Member State alone and that require breaking disciplinary, sectoral and institutional silos²⁸. Food 2030 ultimately helped set out **what** R&I needed to be done, **how**, **by whom** and **with whom**, and **for what**.

Between 2018 and 2020, the European Commission established a Food 2030 high-level expert group, which delivered a report with R&I recommendations for the years to come. Using food systems thinking, the experts reworked Food 2030 and integrated it into their recommendations²⁹. The Fit4Food2030 project, which ran between 2017 and 2020, created a platform to mobilise a wide variety of stakeholders at the levels of cities, regions, countries and Europe to advance and implement the Food 2030 framework in their specific contexts. Several Member States and regions set up policy labs for this purpose. Some, such as the Flemish Region (see Box 7), took inspiration from this to cocreate a [food strategy](#), together with a broad coalition composed of representatives from the agri-food chain, civil society and research and policymakers.

Box 7. The Flemish food strategy

The Flemish Food Strategy consists of four strategic pillars, inspired by the European Commission's Food 2030 research policy framework: (1) Healthy and sustainable food for all; (2) Food system within ecological limits (3) Full commitment to a resilient food economy; (4) Food connects farmers to citizens.

(Department of Agriculture and Fisheries, 2023, p. 7)³⁰

What it is and where we are

Food 2030 is a vision and policy framework based on the premise that through a well-governed and more systemic R&I policy we can develop more impactful solutions to the urgent, complex and interconnected challenges inherent to food systems that need to be transformed to respect planetary boundaries, to provide healthy, safe and nutritious food and diets for all and to sustain a diverse, fair, inclusive and thriving food economy.

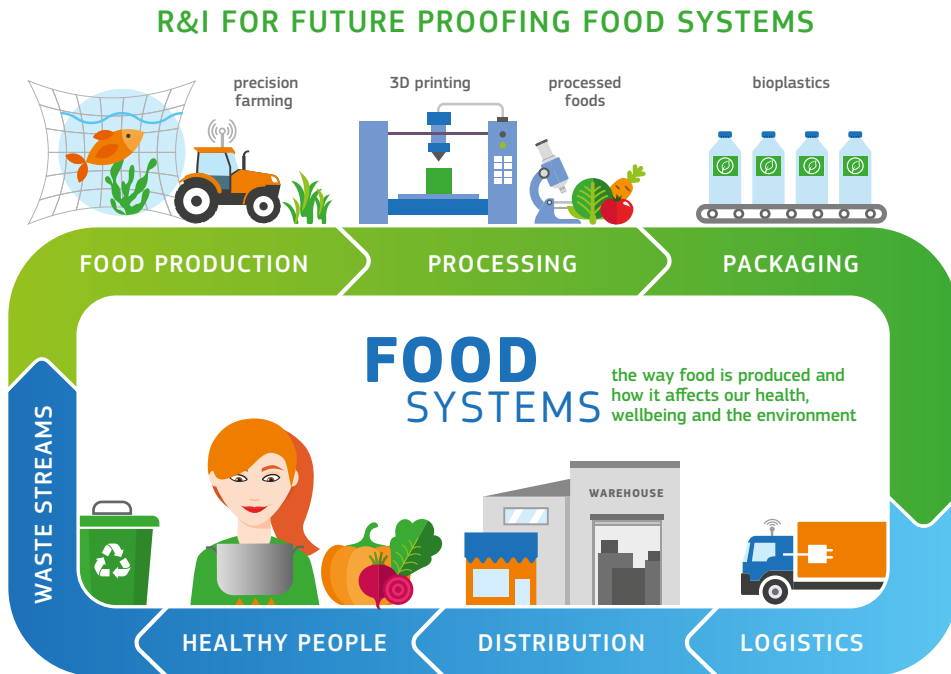
²⁷ Ingram, J. (2011), 'A food systems approach to researching food security and its interactions with global environmental change', Food Security, Vol. 3, No 4, pp. 417–43; Breda, J., Cahill, J., Callenius, C., Caron, P., Damianova, Z., Gill, M., Gurinovic, M., Lähteenmäki, L., Lang, T., Laperrière, A., Mango, C., Ryder, J., Sonnino, R., Verburg, G. and Westhoek, H. (2018), '[A systems approach to research and innovation for food system transformation](#)', policy brief 1, European Union Think Tank of the Fit4Food2030 project.

²⁸ European Commission, Directorate-General for Research and Innovation, Mazzucato, M. (2019), [Governing Missions in the European Union](#), independent expert report, Publications Office of the European Union, Luxembourg; European Commission, Directorate-General for Research and Innovation, Mazzucato, M. (2018), [Mission-oriented Research & Innovation in the European Union – A problem-solving approach to fuel innovation-led growth](#), Publications Office of the European Union, Luxembourg.

²⁹ European Commission, Directorate-General for Research and Innovation (2018), [Recipe for Change: An agenda for a climate-smart and sustainable food system for a healthy Europe](#), report of the European Commission Food 2030 independent expert group, Publications Office of the European Union, Luxembourg.

³⁰ Government of Flanders, Department of Agriculture and Fisheries (2023), [Go4Food, A Flemish food strategy for tomorrow](#). Synthesis, Brussels.

Figure 1.4 Food 2030 – R&I for future-proofing food systems



Food 2030 also acts as a **convening platform** and process within which both R&I and R&I policy can flourish, European competitiveness can grow, citizens and a wide diversity of food systems stakeholders can engage, multiple global challenges can be addressed, new knowledge and evidence can be developed and shared, and innovative solutions – from new products, tools, approaches and technologies to social, governance and institutional innovation and new business models – can be developed, tested and demonstrated (see Figure 1.4).

Finally, Food 2030 applies a systemic approach to connect, scale up and boost EU R&I and investments to provide solutions that can deliver **co-benefits related to four overarching priorities**.

- **Nutrition for sustainable, affordable and healthy diets.** Key issues under this priority include tackling all forms of malnutrition, including obesity; improving nutrition and diets for all and for specific population groups (children, elderly people, the most vulnerable groups, etc.); developing alternative proteins to foster plant-rich diets; incorporating microbiome-based foods to unlock the power of the human

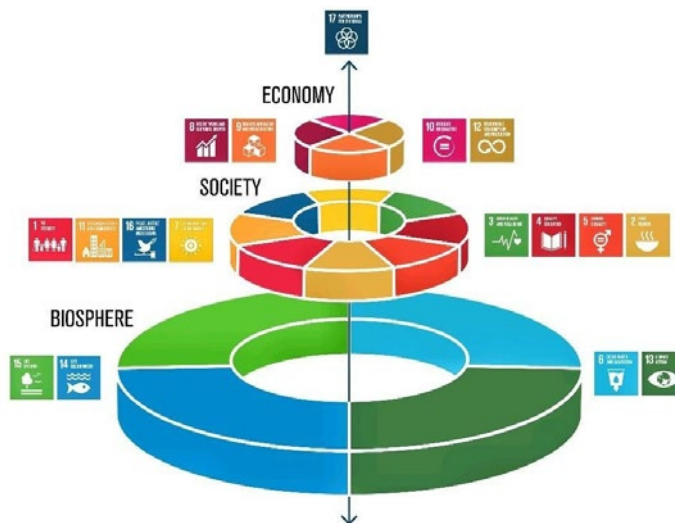
microbiome to improve digestion, nutrient absorption and overall health; exploring how behavioural changes can influence food consumption and dietary habits, improving food authenticity and food safety; encouraging diet diversity by, for example, reviving the use of forgotten crops to improve nutrition and resilience; and supporting healthy diets that are environmentally sustainable. In addition to supporting the new farm-to-fork strategy, this priority also aims to contribute to further development and implementation of [EU food regulations and food safety policies](#), the [Steering Group on Health Promotion, Disease Prevention and Management of Non-Communicable Diseases](#) and the relevant targets of SDGs 2, 3, 8 and 10.

- **Climate-smart and environmentally sustainable food systems.** Key to this priority is that natural resources – water, soil, land and sea – are managed responsibly within the Earth’s capacity to ensure that they are available to future generations. It is meant to foster R&I in support of climate-smart food systems that are adaptive to climate change, preserve natural resources and ecosystem functions, limit environmental degradation and contribute to climate change mitigation. In addition to supporting the new farm-to-fork and biodiversity strategies, this priority also aims to contribute solutions relevant to the common agricultural policy, the common fisheries policy, the EU strategy on adaptation to climate change, EU environmental policies, the Paris Agreement (Conference of the Parties 21) and the relevant targets of SDGs 2, 7, 14 and 15.
- **Circular and resource-efficient food systems.** The third priority aims to achieve circularity and resource efficiency in food systems. Circularity implies sustainable, resource-efficient food systems that can address the 1.3 billion tonnes of food lost and wasted per year at the global level. Challenges in this area include striving towards zero food loss and waste throughout the food systems; more efficient recycling of food loss and waste; rethinking food packaging for better biodegradable options that limit harmful substances such as microplastics; and responding to increasing demand for more tailored and local food, and short food supply chains. Also included here are ways to reduce the use of water and energy across food systems so as to increase resource efficiency across all food system sectors. In addition to supporting the new farm-to-fork strategy, this priority is of relevance to the common agricultural policy and common fisheries policy, the bioeconomy strategy, the EU circular economy package (including the waste directive and climate action policies) and the relevant targets of SDGs 2, 8 and 12.
- **Food systems innovation and empowerment of communities.** This fourth priority focuses on developing a healthy place-based innovation ecosystem that supports new business models and/or the delivery of solutions for the social good and/or with market potential that benefits society. The priority will help to create resilient and empowered communities at the local and regional levels, to create new jobs across the EU and to foster thriving urban, rural and coastal economies. Key to this is to stimulate co-creation processes uniting public authorities, the private sector, researchers and society.

Challenges to be addressed by R&I here include fostering governance innovation at all levels (local to global), underpinned by a strong SPI; empowering local authorities as agents of change and empowering citizens through social innovation; tackling food poverty and achieving sustainable and accessible food in cities, towns and regions; fostering citizen science, food system education and skills building; developing a true cost-sharing economy for food production and consumption; and implementing data-driven solutions. In addition to supporting the new farm-to-fork strategy, this priority also aims to contribute to the European Commission's digital single market strategy, the EU urban agenda and the Europe for citizens programme, among other policy priorities, and relevant targets of SDGs 2, 9, 11 and 16.

The European Commission's Reflection Paper – Towards a sustainable Europe by 2030³¹ highlights that Food 2030 is closely aligned with the EU's commitment to the UN SDGs. In this respect, Food 2030 endorses 'the wedding cake' approach to viewing the economic, social and ecological aspects of SDGs (see Figure 1.5).

Figure 1.5 SDG wedding cake approach



Source: Azote for Stockholm Resilience Centre, 'New way of viewing the Sustainable Development Goals and how they are all linked to food'.












This SDG vision implies that economies and societies are seen as embedded parts of the biosphere. This moves development away from the current sectoral approach where social, economic and ecological developments are seen as separate parts of an economy serving society within the safe operating space of the planet. Using this model, one can argue that all the SDGs are directly or indirectly connected to sustainable and healthy food systems.

³¹ European Commission (2019), [Reflection Paper – Towards a sustainable Europe by 2030, COM\(2019\)22](#), Brussels.

From vision to action and results

In 2020, the European Commission released its report Food 2030 Pathways for Action – Research and innovation policy as a driver for sustainable, healthy and inclusive food systems, which set out, according to the Food 2030 intervention logic, 10 thematic areas meriting further R&I investments. The report built on a 2016 staff working document and provided a structured basis for addressing food system R&I policy. The pathways represented key levers of change where R&I could have deep and multiple impacts on realising a sustainable food system vision.

Figure 1.6 Food 2030 pathway projects and contributions (2017–2022)

	FOOD 2030 Pathways	Projects	Investment (million EUR)
	PATHWAY 1 GOVERNANCE FOR FOOD SYSTEMS CHANGE	6	31
	PATHWAY 2 URBAN FOOD SYSTEMS TRANSFORMATION	7	71
	PATHWAY 3 FOOD FROM THE OCEAN & FRESHWATER RESOURCES	28	175
	PATHWAY 4 ALTERNATIVE PROTEINS FOR DIETARY SHIFT	8	77
	PATHWAY 5 FOOD WASTE & RESOURCE-EFFICIENT FOOD SYSTEMS	9	64.4
	PATHWAY 6 THE MICROBIOME WORLD	9	77
	PATHWAY 7 NUTRITION & SUSTAINABLE HEALTHY DIETS	11	96.3
	PATHWAY 8 FOOD SAFETY SYSTEMS OF THE FUTURE	9	42.8
	PATHWAY 9 FOOD SYSTEMS AFRICA	8	63.50
	PATHWAY 10 DATA & DIGITAL TRANSFORMATION	7	49.80
	PATHWAY 11 ZERO-POLLUTION FOOD SYSTEMS	NA	NA

NB: NA, not applicable. (a) The pathway ‘Zero pollution food systems’ was created in 2023. Therefore, no Food 2030-related project has yet been funded in the context of this pathway.

These 10 initial pathways, which take a mission-oriented, systemic and transdisciplinary approach to R&I, were built up in consultation with various European Commission services and with the support of a stakeholder engagement process. Their orientations were largely created as a result of the 2018 Food 2030 High-Level Event held in Plovdiv under the auspices of the Bulgarian Presidency. They were subsequently refined through an online stakeholder survey and a participatory expert workshop held on 4 March 2020 in Brussels.

Table 1.1 lists the 10 initial pathways (plus the 11th pathway, added in 2023) and provides a breakdown of the projects and the European Commission contributions to each of them. The projects are direct outcomes of Food 2030 topics, the first of which were launched as far back as 2017 during the last Horizon 2020 calls for proposals. So far 99 projects have been supported and a total of EUR 727.8 million have been invested in Food 2030 projects. The table excludes the potential projects that may be funded as a result of the 2023–2024 calls, which are likely to involve an additional investment of approximately EUR 230 million. It also portrays the multi-objective impact of each pathway in its potential to deliver co-benefits to each of the Food 2030 priorities (see Figure 1.1).

The rest of this report describes each of the 11 Food 2030 pathways, which will help the European Commission ideate the next phase of Horizon Europe for 2025–2027.

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PATHWAY 1

GOVERNANCE FOR FOOD SYSTEMS CHANGE³²



1. SYSTEMIC CHALLENGES

The main challenge for accelerating the transition towards sustainable food systems is addressing numerous urgent, complex, interconnected and global issues at various spatial and temporal scales. These include achieving the UN SDGs, the EU farm-to-fork strategy and its broader European Green Deal policy priorities³³.

These issues are influenced by several, partly interconnected, drivers, including change in governance structures and geopolitical stability, climate change, population growth and change in demography, increasing urbanisation, power disparities along the food supply chain, widening social inequalities, the influence of the media, and changes in individual and household dietary patterns. In addition, the direction of and the approach to food systems transformation are subject to debate, as is the need for reform itself. Other drivers, such as technological, institutional and social innovations, might help to address these issues.

There is considerable evidence in peer-reviewed literature that appropriate and effective governance³⁴, structures and institutions are key to food systems transformation³⁵. These must act at various levels³⁶ that effectively bridge local and global dimensions and put in place coherent and complementary policies, actions and development strategies. To be effective, food systems governance requires the engagement of policy actors across the food value chain (i.e. those that govern producing, distributing, transporting, trading, processing, marketing and consuming food); the major food security components (access, availability and utilisation); key socioeconomic and biophysical food system drivers; and thematic areas (including health, other socioeconomic issues and the environment). These all need to be considered at different spatial, temporal, cultural and jurisdictional scales. Good food systems governance requires governmental actors to drive the long-term change process towards sustainable and resilient outcomes and allow private consumers to express their preferences. Currently, policy issues related to these aspects are most often addressed in the individual thematic areas.

³² With acknowledgements to Agnieszka Grzegorzczak (European Commission, national expert in professional training), Ana Patricia Lopez Blanco (European Commission), Alice Pignacca (European Commission) and the following independent experts (listed in alphabetical order by surname) who provided ideas and comments during and after the 10 March 2023 Food 2030 workshop in Brussels: Thom Achterbosch, Megan Blake, Hugo de Vries, John Ingram, Carlo Mango, Jörn Schmidt, Roberta Sonnino and Henk Westhoek.

³³ IPCC (2023), [IPCC Climate Change 2023: Synthesis report](#), Geneva.

³⁴ Food system governance refers to the institutions, actors, rules and norms that shape how food is produced, distributed and consumed. It also includes the processes by which different food system actors and networks (including states, local and regional authorities, the private sector, research communities and civil society) are included in decision-making and policymaking at different levels.

³⁵ Dengerink, J. D., de Steenhuijsen Piters, C. B., Brouwer, J. H. and Guijt, W. J. (2022), [Food Systems Transformation: An introduction](#), Report No WCDI-22-201, Wageningen University and Research, Wageningen Centre for Development Innovation, Wageningen; Fonteijn, H. M. J., van Voon, G. A. K., de Steenhuijsen Piters, C. B. and Hengeveld, G. M. (2022), [The ABCD of Food Systems Resilience: An assessment framework](#), Wageningen University and Research, Wageningen; de Steenhuijsen Piters, B., Termeer, E., Bakker, D., Fonteijn, H., and Brouwer, H. (2021), [Food system resilience – towards a joint understanding and implications for policy](#), in Ribeiro-Barros, A. I., Tevera, D. S., Goulao, L. F. and Tivana, L. D. (eds), [Food Systems Resilience](#), IntechOpen; Clapp, J., Moseley, W. G., Burlingame, B. and Termine, P. (2022), [Viewpoint: the case for a six-dimensional food security framework](#), *Food Policy*, Vol. 106, 102164; Food Trails (2022), [The role of cities in shaping food environments, in the framework of the EU farm to fork strategy](#), policy brief; Wood, A., Queiroz, C., Deutsch, L., González-Mon, B., Jonell, M., Pereira, L., Sinare, H., Svendin, U. and Wassénius, E. (2023), [Reframing the local-global food systems debate through a resilience lens](#), *Nature Food*, Vol. 4, pp. 22–29.

³⁶ The European Commission's high-level expert group on strengthening the international SPIs for improved food systems concluded that global food system SPIs must be better supported and interconnected and can provide solutions to improve the resilience of our food systems. Singh, B. K., Fraser, E. D. G., Arnold, T., Biermayr-Jenzano, P., Broerse, J. E. W., Brunori, G., Caron, P., De Schutter, O., Fabbri, K., Fan, S., Fanzo, J., Gajdzinska, M., Gurinovic, M., Hugas, M., McGlade, J., Nellemann, C., Njuki, J., Tuomisto, H. L., Tutundjian, S., Wesseler, J., Sonnino, R. and Webb, P. (2022), [Food systems transformation requires science-policy-society interfaces that integrate existing global networks and new knowledge hubs](#), *Nature Food*, Vol. 4, pp. 1–3.

As a result, going beyond today's fragmented and sectoral approach is a necessity. Governmental actors play a key role in this. They need to act as conveners, facilitators and regulators of long-term transformation and provide directionality for changes and innovation. In addition, they need to focus investment on R&I, connect citizens, mitigate climate change impacts on the most vulnerable, support systemic education (from elementary to senior education, vocational education and life skill development), foster skills that consider gastronomic and culinary heritage and support innovation for sustainable and healthy diets³⁷. In this respect, there are several major ongoing policy developments where the issue of R&I governance will play a key role (EEA, 2022; IFPRI, 2022; IPCC, 2023; OECD 2021)^{38 39 40}.

As shown by the COVID-19 pandemic and Russia's invasion of Ukraine, catalysing food systems transformation also requires building adaptive capacity and resilience from farm to fork. Food system resilience has become a key objective of the food system agenda. Yet the relationship between good governance and resilience building remains largely unexamined. Multi-actor engagement, also involving young people⁴¹, is often encouraged as a better governance approach because it aims to foster decision-making through dialogue, consultation and joint analysis. Building resilient food systems is essential to avoid the impacts of catastrophic events. To achieve this, R&I is needed to identify and develop effective response mechanisms to mitigate the effects of shocks and stresses, and thus reduce vulnerability. Governance structures need to ensure the implementation and evaluation of these mechanisms, especially ensuring the inclusion of the most vulnerable population groups and reducing power imbalances. To this end, Food 2030 provides a framing and multi-actor engagement process within which citizens, national, urban and local governments and a diversity of stakeholders, including the private sector, can work together in a balanced way, thereby mitigating risks and vulnerabilities and building resilient food systems.

2. POLICY CONTEXT AND SYNERGIES

This pathway is relevant to EU policies such as the [common agricultural policy](#), the [common fisheries policy](#), the [European Green Deal](#), the [farm-to-fork](#) and [biodiversity](#) strategies, the [bioeconomy strategy](#) and Commission communication – Safeguarding food security and reinforcing the resilience of food systems⁴².

³⁷ On the governance of food systems R&I see: Sonnino, R., Callenius, C., Lähteenmäki, L., Breda, J., Cahill, J., Caron, P., Damianova, Z., Gurinovic, M. A., Lang, T., Laperriere, A., Mango, C., Ryder, J. Verburg G., Achterbosch, T., den Boer, A. C. L., Kok, K. P. W., Regeer, B. J., Broerse, J. E. W., Cesuroglu, T. and Gill, M. (2020), '[Research and innovation supporting the farm to fork strategy of the European Commission](#)', policy brief 3, Fit4Food2030; and Achterbosch, T. J., Getz Escudero, A., Dengerink, J. D. and van Berkum, S. (2019), '[Synthesis of existing food systems studies and research projects in Europe](#)', European Commission, Directorate-General for Research and Innovation, Brussels. On metrics and indicators for EU sustainable food systems reflecting varying world views see: Hebinck, A., Zurek, M., Achterbosch, T., Forkman, B., Kuijsten, A., Kuiper, M., Nørrung, B., van 't Veer, P. and Leip, A. (2021), '[A sustainability compass for policy navigation to sustainable food systems](#)', Global Food Security, Vol. 29, 100546; Fonteijn, H., van Vroom, G., Hengeveld, G. and de Steenhuisen Piters, B. (2022), '[Assessing the impact of interventions on food systems resilience](#)', Wageningen University and Research, Wageningen; Leeuwis, C., Boogaard, B. K. and Atta-Krah, K. (2021), '[How food systems change \(or not\): governance implications for system transformation processes](#)', Food Security, Vol. 13, No 4, pp. 761–80; and de Vries, H. (2023), '[The role of food science and technology in the future partnership sustainable food systems](#)', Trends in Food Science & Technology, Vol. 131, pp. 28–30.

³⁸ International Food Policy Research Institute (2022), [2022 Global Food Policy Report – Climate change and food systems](#), Washington, D.C.

³⁹ OECD (2021), [Making Better Policies for Food Systems](#), OECD Publishing, Paris

⁴⁰ European Environment Agency (2022), '[Reimagining the food system through social innovations](#)', briefing.

⁴¹ See, for instance, the [EU bioeconomy youth ambassadors initiative](#), involving 15 young ambassadors for 2022–2024.

⁴² European Commission (2022), [Commission communication – Safeguarding food security and reinforcing the resilience of food systems](#), COM(2022) 133 final

The very fragmented and sectoral policy landscape is characterised by 27 national governments and associated ministries responsible for agriculture, food, culture, energy, transport and the environment; numerous administrative subnational regions; and stakeholders from civil society, research, the private sector and international organisations. Withing this landscape, this pathway seeks to provide support for targeted action contributing to a way forward for future R&I policy in Europe and beyond. It is one of 11 Food 2030 pathways for action, which will help to underpin Horizon Europe, support evidence-based policymaking and implementation, adapt education programmes, skills and capacities, boost innovation and investment and encourage synergies and policy alignment.

The governance pathway should contribute to the development of sustainable European food systems and the bioeconomy, informed by food systems foresight and an exploration of alternative transition pathways towards sustainable futures. This will be done at the EU and Member State levels but also at the urban and regional levels.

The governance pathway has synergies with other EU R&I initiatives at the Member State level that promote greater cohesion, coordination and collaboration across the Member States' food systems and in the way national and European R&I policies are implemented. These include the [Sustainable Food Systems Partnership for People, Planet and Climate, SCAR](#) – which has established a strategic working group on food systems – and macroregional initiatives such as the [Central eastern European initiative for knowledge-based agriculture, aquaculture and forestry in the bioeconomy](#) (Bioeast)⁴³.

Synergies can also be found with the [EU mission 'A soil deal for Europe'](#) and [PRIMA](#), which targets the water–food nexus. For instance, the governance pathway could support the living labs in the Food 2030 urban projects to stimulate discussions and connections with the living labs that will be established under the EU mission 'A soil deal for Europe'⁴⁴ the food systems partnership⁴⁵ and PRIMA⁴⁶.

At the urban and regional levels, the pathway 'Governance for food systems change' will play a strong role in fostering living labs as places of co-creation and place-based solutions, in encouraging regional innovation governance and in helping stakeholders to align their education and R&I agendas in knowledge and innovation systems that are better oriented towards the barriers and opportunities of food systems transformation and thereby lower the risks associated with new technological developments.

The pathway will continue to leverage and align work along the new European innovation agenda with networks such as those of the European and national technology platforms,

⁴³ Through [Bioeast](#), a governmental initiative, the central and eastern European countries set the goal for 2030 of developing knowledge- and cooperation-based circular bioeconomies, which will help to enhance their inclusive growth, to create new value-added jobs and to strengthen environmental sustainability.

⁴⁴ The living labs will be launched in 2024, following the 2023 call for proposals, with the objective of reaching 100 living labs by 2030.

⁴⁵ The food systems partnership also has the general ambition to co-create with various actors in a diversity of living labs (e.g. policy labs, city labs, fab labs, field stations, experimental restaurants or supermarkets, logistics simulators) to develop sustainable food system concepts.

⁴⁶ [PRIMA identified four nexus ecosystem labs](#), one each in Egypt, Italy, Spain and Tunisia, where 12 major challenges will be used for the testing and validation of the project solutions.

[EIT Food](#)⁴⁷, cities and regions, philanthropic and international organisations, and other private sector and non-governmental organisation initiatives.

The past years' crises and the Russian war of aggression against Ukraine have had strong effects on the European food system. A sustainable European food system requires establishment of new international linkages and partnerships with the neighbouring countries Moldova, Ukraine and western Balkan countries. The related governance projects in the Horizon Europe programme envisage stepping up these efforts through robust and balanced research, innovation and knowledge transfer investments by mobilising pan-European public engagement and fostering science–policy discussions through concrete projects, while also building up and strengthening (regional) ecosystems of innovation and food valleys. This should bring together different stakeholders across Europe, following the quadruple and quintuple helix innovation models⁴⁸, to support the sustainable food system transition and appropriate governance and policymaking at all levels, from local to national, macroregional and European.

The governance pathway, moreover, has synergies with additional initiatives outside the sphere of Horizon Europe. In particular, these relate to the 2021 UNFSS process in which a high-level expert group established by the European Commission issued recommendations to the UNFSS Scientific Group to assess needs and options to strengthen the international SPI for food systems governance. Specifically, it recommended that the UNFSS should (i) explore practical options for improving SPIs related to and needed for transformative food systems actions, (ii) propose language that would entail a commitment to urgently establish enhanced SPI mechanisms post-summit and (iii) identify adequate funding targets and mechanisms to allow the long-term functionality of enhanced SPI activities⁴⁹.

The next two sections outline key barriers, lock-ins and enablers of change for the development and take-up of governance for food systems change.

3. BARRIERS AND LOCK-INS

- Substantial policy, regulatory, financial, technological, environmental, behavioural and cultural barriers to overcome, coupled with lack of political will (tension associated with electoral time frames and the impact of taking difficult decisions).

⁴⁷ Since EIT Food aims to foster collaboration across the entire food system to develop innovative technologies, products and services, synergies with the governance pathway could be built through joint online courses, education programmes and professional development opportunities and through engaging in participatory dialogue with the food industry (including start-ups, entrepreneurs and investors).

⁴⁸ The triple helix innovation model is widely recognised as a conceptual tool that promotes innovation and entrepreneurship through better understanding, cooperation and interaction between university, industry and government institutions. The quadruple helix adds a fourth helix on 'media-based and culture-based public' and 'civil society', whereas the quintuple helix also adds the helix of the 'natural environments of society'. Carayannis, E. G., Campbell, D. F. J. and Grigoroudis, E. (2022), '[Helix trilogy: the triple, quadruple, and quintuple innovation helices from a theory, policy, and practice set of perspectives](#)', *Journal of the Knowledge Economy*, Vol. 13, pp. 2272–2301.

⁴⁹ European Commission, High Level Expert Group to assess the needs, potential, feasibility and approach for International Platform for Food Systems Science (IPFSS) (2021), Recommendations to the United Nations' Food Systems Summit Scientific Group from the European Commission's High-Level Expert Group to assess needs and options to strengthen the international science–policy interface for food systems governance, Brussels. This resulted in a final report in 2022: European Commission, Directorate-General for Research and Innovation (2022), [Everyone at the Table – Transforming food systems by connecting science, policy and society](#), Publications Office of the European Union, Luxembourg.

- Priorities often being in competition (e.g. social, economic and environmental objectives).
- Current food systems governance and interventions being fragmented and sectoral.
- Current debates on food systems often focusing on two opposing views: favouring territorial development or global trade.
- Current initiatives being too small and short-lived to achieve impact at the scale needed to unlock funding for large-scale investments.
- Lack of knowledge sharing and coordinated efforts to address sustainability.
- Difficulties in agreeing on a common objective and combining contextually different objectives.
- Take single solution responses to address complex problems and isolated responses being used to address complex problems, ignoring the wider picture.
- Food standardisation ignoring culture as a crucial underlying factor influencing citizens' food choices.
- Policymakers and society at large not fully understanding and considering the need for transformations.

4. ENABLERS OF CHANGE

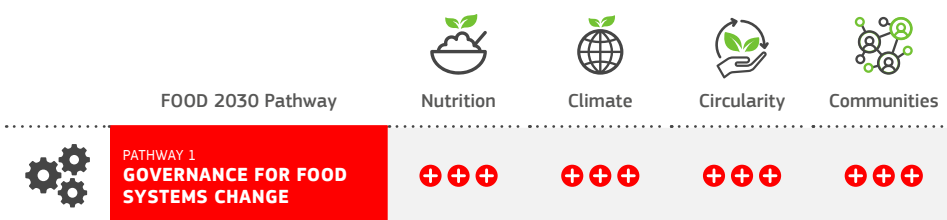
- Policy convergence and alignment.
- The proposal for a legislative framework for sustainable food systems, one of the flagship initiatives of the farm-to-fork strategy, and its planned monitoring system.
- Awareness that adequate and effective governance of structures and institutions, and long-lasting traditional ecological and newly developed skills and capacities, are needed to transform food systems.
- Cross-sectoral governance mechanisms to support innovative solutions in the food–energy–mobility nexus.
- Local food system transition (driven at local scales and upscaled by sustainable business solutions) globally supported by international bodies such as the UNFSS,

the Food and Agriculture Organization of the UN (FAO), the High-Level Panel of Experts on Food Security and Nutrition, the SPI of the UN Committee on World Food Security, the IPCC, the International Food Policy Research Institute, the International Panel of Experts on Sustainable Food Systems, the Organisation for Economic Co-operation and Development (OECD) and the EAT–Lancet Commission on Food, Planet, Health.

- Empowerment of local and regional actors to support the implementation of urban food policies and the development and implementation of innovative solutions (e.g. urban farms) through tailored financial and governance structures, and through funds to fairly compensate actors.
- Consideration and protection of the link between citizens and their food culture in order to promote sustainable food systems enabling healthy, culturally appropriate and culturally diverse diets.
- Stronger involvement of currently less represented countries to favour knowledge sharing, supported by initiatives such as Bioeast, to encourage EU-wide (and accepted) food system approaches.
- The need for a move towards sustainable food systems being more and more recognised by the private sector, for example with the EU Code of Conduct on Responsible Food Business and Marketing Practices⁵⁰.

5. FOOD 2030 CO-BENEFITS

The Food 2030 ambitions underpinning this pathway have the potential to address and deliver the following co-benefits⁵¹.



Nutrition and health

- Improving health and well-being.
- Fighting hunger and undernutrition.

⁵⁰ The [code of conduct](#) entered into force in 2021 and is a voluntary set of industry objectives launched by the European Commission under the EU farm-to-fork strategy. It currently has more than 100 signatories and aims to improve the sustainability performance mainly of the food processing, service and distribution industry.

⁵¹ The number of "+" signs used in the table below is representative of the number of impacts of the pathways towards each of the priorities. This is applicable for each chapter of this publication.

- Reducing diet-related diseases.
- Reducing the occurrence of zoonotic communicable and non-communicable diseases.
- Safeguarding food security for current and future generations with universal access to healthy, sustainable and affordable diet options.
- Ensuring food safety.
- Unlocking the potential of food systems for advancing planetary and human health.

Climate and sustainability

- Lowering emissions of greenhouse gases (GHGs) and pollutants by enabling a shift towards healthier diets through more sustainable food systems.
- Improving biodiversity through better management of land and ecosystem services, reduced application of harmful pesticides and fertilisers and less disruption of habitats.
- Improving soil health and restoring degraded soil by improving land fertility, reducing soil erosion and increasing carbon sequestration.
- Developing or reorienting financial incentives for food systems towards co-benefits for the climate, the natural environment and communities.

Circularity and resource efficiency

- Reducing food loss and waste across all parts of the food systems – from farm to fork.
- Increasing efficiency and food processing.
- Valorising unavoidable waste and co-products as new products and with new uses as part of a circular and sustainable bioeconomy.
- Reducing barriers to the redistribution of food surpluses.

Innovation and communities

- Combining organisational, social and technological innovations to overcome lock-ins into current unsustainable practices in food systems.
- Promoting food culture, democracy and citizen deliberation in food systems transformation.
- Embedding innovation through multi-actor and citizen engagement processes in knowledge structures that empower communities to co-create food systems solutions

that deliver co-benefits and to mitigate trade-offs.

- Encouraging place-based solutions with a strong community involvement and new ways of capacity development.
- Fostering inclusion and equity, thus ensuring a balanced, fair and just food system transition – economically, socially and environmentally – which addresses demands and trade-offs, and takes care of vulnerable populations.
- Tackling food insecurity and ensuring all have access to – and can afford to buy – healthy food from sustainable food systems.
- Increasing food knowledge and know-how.
- Strengthening governmental actors and R&I communities to facilitate system change and impact.

6. RESEARCH AND INNOVATION OUTCOMES AND FUTURE NEEDS

This section provides a snapshot of the R&I being carried out in relation to this pathway. It describes the R&I investments (European Commission financial contribution) supporting projects that have been funded as outcomes of relevant Food 2030 calls for proposals, in the context of societal challenge 2 of Horizon 2020 and cluster 6 of Horizon Europe. Furthermore, it describes the range of thematic issues covered, identifies future R&I needed and provides a summary of Food 2030 projects.

Investments

The total European Commission contribution to projects stemming from this pathway is EUR 51.5 million for 10 projects. Out of this, EUR 9 million was for two Horizon 2020 projects, EUR 22 million was for four projects in the Horizon Europe work programme for 2021–2022 and EUR 20.5 million has been provided for four projects planned for the Horizon Europe work programme for 2023–2024.

Issues addressed

The link with Food 2030 was very strong in the EU's R&I funding programme Horizon 2020, which resulted in several concluded projects. The Fit4Food2030 project developed a multi-stakeholder Food 2030 platform at the levels of cities and regions and created a set of policy labs, city labs and food labs to develop/pilot action-oriented training for students, households, researchers and professionals. The Susfans project built a set of metrics, models and foresight tools that can be used for navigating sustainable food systems and nutrition security.

Ongoing EU-funded Food 2030 projects in food systems governance predominantly address citizen engagement and multi-stakeholder platforms. For instance, the [FOSTER](#) project will develop a novel knowledge and innovation governance structure for Europe's food system with explicit roles for networks of citizens and change agents (action-oriented leaders). The [CLEVERFOOD](#) project will establish a structure of connected policy labs and living labs to pave the way for a more regenerative, resilient and plant-based food system. [FOODPathS](#) is developing a prototype sustainable food systems partnership. This includes its co-funding strategies, a governance model, a modus operandi, a sustainability charter, an SRIA and a showcase for examples of co-creation. It will also list potential trade-offs and will propose ways of communicating with other Horizon Europe partnerships.

Future calls and investments under Horizon Europe (2023–2024 work programme) are expected to contribute to impacts through topics such as fostering resilient European food systems, developing a pan-European academic network for food system science, increasing capacity for transformational change, strengthening and linking regional ecosystems of innovation to support food systems transformation and analysing the role of media in promoting healthy and sustainable consumption patterns.

Interconnections with the other pathways

Each of the other 10 Food 2030 pathways is closely interconnected with the governance pathway. For instance, the pathways 'Urban food systems transformation', 'Food waste and resource efficiency' and 'The microbiome world' contribute to developing innovative and inclusive governance mechanisms.

The 'Urban food systems transformation' pathway and projects funded under its umbrella (Horizon 2020 and Horizon Europe) include test beds of local food governance and recommendations to scale and replicate these. Hence, the urban pathway contributes to developing governance mechanisms by using local-level place-based solutions and engaging citizens.

The 'Food waste and resource efficiency' pathway seeks to provide a way forward for future R&I policy in Europe and beyond to reduce and prevent food waste and increase resource efficiency in line with the European Green Deal. Achieving several EU bioeconomy objectives (e.g. ensuring food and nutrition security, mitigating and adapting to climate change) will require combinations of targeted investments and policy measures⁵². A robust knowledge-based system is crucial for adaptive and effective governance, strengthened through the EU's Horizon 2020 and Horizon Europe programmes.

The 'The microbiome world' pathway and projects funded under its umbrella (Horizon 2020 and Horizon Europe) provide the scientific knowledge to use natural microbiomes for the sustainable production of new and healthier food applications. The pathway also

⁵² Philippidis, G., M'barek, R., Urban-Boysen, K. and Van Zeist, W.-J. (2023). [Exploring economy-wide sustainable conditions for EU bio-chemical activities](#), Ecological Economics, Vol. 210, 107857.

aims to contribute to the development of policies and strategies for the governance of microbiome-based technologies in the food sector, addressing issues such as safety, ethics and equity.

Future research and innovation needs

The R&I needs are divided into four mutually supportive actions or ‘question words’: what (prioritising themes), who (engaging actors), how (aligning activities) and where (exploring cases) questions.

- **What.** This covers governance priorities that require new knowledge (multiscale governing, legislative measures, ethics, political will, etc.), for example:
 - investing in the measurement of the impact of food system R&I in a changing context; assessment, analysis, modelling and decision support; mapping and monitoring food system performance; increasing evidence-based communication, dissemination and knowledge exchange; and strengthening the science–policy–society interface;
 - building systems thinking into governance and system innovation capacity for policymakers and other change agents across the EU;
 - fostering an integrated educational approach to learning that combines the arts (A) with science, technology, engineering and mathematics (STEM), that is, moving from STEM to STEAM;
 - understanding food culture and heritage and other drivers (e.g. education, media and digital marketing regarding fostering healthy and sustainable consumption patterns) that might shape sustainable consumer preferences and dietary behaviours;
 - improving governance of agri-food systems through digital technologies (e.g. applying them to better manage the impacts of climate change or to better nudge consumer behaviour);
 - better understanding the roles and behaviour of the various private actors in the various stages of the food supply chain, and how to change this behaviour to address systemic challenges, especially with regard to shaping the practices in supply chain management between actors upstream (food industry, retail and food service) and downstream (primary producers) and in shaping consumer choice (important with regard to healthy and sustainable consumption patterns);
 - better understanding how the financial world of private and public actors functions and influences these actors and how finance can create incentives and opportunities through financial regulations and reoriented investment practices;

- understanding the drivers of food insecurity in Europe (e.g. insufficient household income and inadequate minimum income policies, lack of food knowledge, local access barriers, insufficient support for people with physical and/or mental health problems that make the utilisation of healthy food difficult);
 - investing in better understanding of how different food contexts come together to form foodscapes that enable or disadvantage groups and individuals from being able to access and utilise healthy and sustainably produced food.
- **Who.** This covers governance priorities that relate to engaging mechanisms between diverse actors and actor networks to raise awareness of and foster more citizen involvement in science and R&I to enable food systems transformation, in line with the responsible R&I approach⁵³, for example:
 - convening multi-actor and public engagement to raise awareness of the transition towards sustainable food systems and get buy-in from all powerful actors – this asks for special attention to the role of (big) players in the agri-food system, but also involving disadvantaged communities, vulnerable people, women, youth and youth-led initiatives and organisations, and fostering food systems and bioeconomy education and training;
 - experimenting with new forms of food democracy, citizen assemblies, cross-sectoral and multi-stakeholder policy dialogue in the design of food policy and transition pathways with related agendas for future R&I;
 - developing a network of colleges and universities committed to stimulating student awareness of intangible gastronomic heritage and food traditions and systems through grassroots student advocacy and action campaigns, and an academic agenda, and to fostering innovation and experiment;
 - developing a network of food libraries and food museums as cultural institutions and tourist attractions.
 - **How.** This covers governance priorities where food system approaches (from a governance angle) are addressed, scenarios are developed and topics are aligned (bottom-up and top-down), for example:
 - at the international level, fostering science and cultural diplomacy by connecting with global leaders such as the Committee on World Food Security, the UN Educational, Scientific and Cultural Organization and the FAO as a follow-up to the UNFSS process and other relevant initiatives, and investing in continuous European and global foresight and scenario analysis on the transformation

⁵³ The [responsible R&I approach](#) is an approach rolled out in previous framework programmes for R&I and further defined in Horizon 2020. It guides researchers, innovators and organisations through more concrete normative orientations in the form of six policy keys: ethics, gender equality, governance, open access, public engagement and science education.

pathways for food systems to achieve the SDGs and other global policy goals (the UN Framework Convention on Climate Change, the World Health Assembly, the Convention on Biodiversity, etc.), which, in addition to fulfilling the need for better brokering of fragmented and sometimes conflicting knowledge (as recommended by the high-level expert group on international SPI for food systems governance), will help keep up the momentum of the UNFSS;

- at the national level, engaging with Member States through existing structures and initiatives such as SCAR that are helping to build an ERA for the food systems transition, including building up the Horizon Europe Sustainable Food Systems Partnership for People, Planet and Climate, which will also create a food systems observatory complementing the planned farm-to-fork monitoring framework;
 - at the local and regional levels, bringing together universities, cities and rural areas of different scales to take up food systems governance (also through city labs and food labs), bringing together policymakers, industries, researchers, educators and citizens to work on their visions of Food 2030, which includes supporting local/regional climate-neutral, healthy and sustainable food system strategies and could include supporting the delivery of provisions for multilevel governance in legislative action on sustainable food systems.
- **Where.** This covers governance priorities that consist of launching experiments with new instruments of food policy, place-based demonstrators and pilot projects across the EU, and fostering a culture of entrepreneurship for food systems transformation, for example:
 - launching demonstrations and thematic food labs that could also build on and complement the living labs (to be) established by the EU partnerships and missions, including the EU mission ‘A soil deal for Europe’;
 - developing and supporting a knowledge and innovation system in which networks of citizens and change agents – primary producers, food businesses, civil society, knowledge, finance, authorities and public sectors such as health, culture and education – deliver on mission-oriented innovation for food systems transformation;
 - fostering responsible innovation and investment, boosting skills and capacities and supporting cases for bioeconomy demonstration, testing and deployment, which also includes building a new European innovation agenda to boost the development of innovative solutions by helping create regional innovation food valleys to develop and test solutions;

- as a result, contributing to design and establishing an inclusive multilevel governance architecture and coherent policy frameworks to transform food systems, advance equitable livelihoods and achieve the Green Deal and the global ambitions set out by the UNFSS.

The governance pathway also needs to bring together a diversity of food systems stakeholders, including local communities and their intangible food heritage, and initiatives resulting from other pathways and intervention areas relevant to food systems.

Summary of relevant research and innovation projects and other actions

The Food 2030 projects relevant to this pathway include those presented in the following table.

PROJECT NAME & FUNDING INFORMATION	PROJECT AIM/OUTCOME
<p>FIT4FOOD2030 Fostering Integration and Transformation for FOOD 2030</p> <p>2017–2020, EUR 4.0 million (Horizon 2020), CSA, Food 2030</p>	<p>The project established a multi-stakeholder Food 2030 platform (the Sustainable Food Systems Network), at the levels of cities, regions, countries and Europe, through 11 policy labs to increase and align public/private R&I policies/programmes. Seven city labs and seven food labs were used to develop/pilot action-oriented training for students, consumers, researchers and professionals.</p>
<p>SUSFANS Metrics, Models and Foresight for European Sustainable Food and Nutrition Security</p> <p>2015–2019, EUR 5.0 million (Horizon 2020), RIA, Food 2030</p>	<p>The project delivered research on metrics, models and foresight to support evidence-based policies and innovation strategies for an EU with sustainable food and nutrition security.</p>
<p>FOSTER Fostering food system transformation by integrating heterogeneous perspectives in knowledge and innovation within the ERA</p> <p>2022–2026, EUR 5.0 million (Horizon 2020), RIA, Food 2030</p>	<p>FOSTER will build a platform including state-of-the-art knowledge on food systems, implement an academy for integrating food-system-related disciplines and initiate and assess a co-creation and co-learning process within six regional citizen-driven initiatives.</p>

<p><u>CLEVERFOOD</u> Connected Labs for Empowering Versatile Engagement in Radical Food system transformation</p> <p>2023–2026, EUR 8.0 million (Horizon Europe), CSA, Food 2030</p>	<p>CLEVERFOOD will establish a pan-European Food 2030 multi-actor and public engagement mechanism, support relevant citizen science projects emerging at the local level and develop and deploy innovative interactive food systems education materials.</p>
<p><u>FOODPaths</u> Co-creating the prototype ‘Sustainable FOOD Systems PARtnersHip’</p> <p>2022–2025, EUR 5.0 million (Horizon Europe), CSA, Food 2030</p>	<p>FOODPaths will develop a prototype of the European Sustainable Food Systems Partnership for People, Planet and Climate, with the goal of co-creating an inclusive governance model and system approaches.</p>
<p><u>RefreSCAR</u> Improved coordination of national and European bioeconomy research and innovation programmes in the ERA through strengthened SCAR working groups</p> <p>2023–2027, EUR 4.0 million (Horizon Europe), CSA, Food 2030</p>	<p>RefreSCAR will strengthen the strategic functioning and capacities of the SCAR working groups to improve coordination among R&I programmes. This will lead to enhanced R&I cooperation between Member States and associated countries and to synergies at the national and EU levels.</p>

NB: CSA, coordination and support action; RIA, research and innovation action.

In addition, the governance pathway also contributed to advancing research and policy analysis on Food 2030 priorities and other actions through expert reports, framework contracts and in-depth thematic assessments for a total European Commission contribution of EUR 1.64 million for four reports. The following table presents an overview of the reports and actions on food systems thinking and future R&I needs, on food system R&I investment levels in the EU, on the needs and options for strengthening the SPI for improved food systems governance and on specific SCAR support activities.

ACTION & FUNDING INFORMATION

OUTCOME

[Food 2030 Expert Group](#)
Expert report Recipe for Change: An agenda for a climate-smart and sustainable food system for a healthy Europe

2017–2018, EUR 0.15 million
Expert contracts, Food 2030

The expert group delivered a report and recommended orientations for food and nutrition security R&I in the years to come. Using food systems thinking, the experts have reworked and integrated Food 2030 priorities to develop a mission-type approach.

[Research and Innovation Tender](#)
Policy report Food Systems – Research and innovation investment gap study

2021–2022, EUR 0.19 million
Public procurement study, Food 2030

The investment gap study is a comparative study of food systems R&I investment levels in the EU, considering public and private R&I spent at the national and EU levels. The data were categorised according to the priorities, pathways and sectors identified in Food 2030. This work led to the publication of a policy brief and a full report with country-specific annexes.

[High-level expert group for strengthening the science–policy interface](#)
Independent expert report Everyone at the Table: Transforming food systems by connecting science, policy and society

2021–2022, EUR 0.3 million, 19 expert contracts, Food 2030

The high-level expert group assessed the needs and options for strengthening the SPI for improved food system governance. The experts delivered a report concluding that food system transformation must be better supported through more ambitious interlinked science–policy–society interfaces.

[SCAR framework contract](#)
Framework Contract RTD/2021/OP/0001 – Framework services contract for strategic analysis and support for enhanced research cooperation in agriculture and food

2022–2023, EUR 1 million,
Public procurement, Food 2030

The specific contract under this framework contract provided support to the SCAR working groups through the organisation of meetings (online and physical), workshops and conferences. The contractor's team also carried out portfolio analyses and supported the writing of mandate reports. In addition, the team provided newsletters and leaflets and supported the writing of policy briefs.



PATHWAY 2

URBAN FOOD SYSTEMS TRANSFORMATION⁵⁴



1. SYSTEMIC CHALLENGES

Nearly 80 % of all the food produced in the world is consumed in urban areas⁵⁵. In 2021, around 75 % of the EU population was living in cities, towns and suburbs⁵⁶. Cities and their inhabitants represent an essential leverage point for change, notably in terms of choices cities make regarding food procurement in schools and public canteens, the management of food loss and waste, the design of their food environments, urban food production, the fostering of local and peri-urban value chains, consumer behaviour, food culture and innovation, and people's relationships with food. Numerous novel practices for food system innovation are developed and tested at the local scale in cities and hold the potential to be disseminated or scaled up in new areas. The FAO recognised the importance of food systems in urban settings in the FAO framework for the urban food agenda, which emphasised the need for place-based innovations and solutions⁵⁷.

The concept of place-based solutions is one tool to provide local solutions to global problems and brings forth supportive urban–rural connections, contributing to sustainability and resilience. The concept harnesses the transformative potential of smaller unities that can also help to bridge urban and rural areas, that is, creating 'city regions' to produce desirable outcomes⁵⁸. Place-based approaches are socially constructed and multiscalar and can go beyond the confines of a city or community. Land use and urban planning are integral parts of this and can be drivers of urban food systems transformation, while also supporting biodiversity.

City governments and territorial communities are emerging as key actors in fostering more sustainable food systems and engaging citizens. The [Milan Urban Food Policy Pact](#) is a great example of an international agreement among cities committed to developing sustainable food systems. Cities still struggle to use a systemic approach to food due to fragmented responsibilities across ministries, but they have started to play a key role in enhancing participatory governance structures using a multi-actor approach⁵⁹.

Previous EU-funded Food 2030 projects brought forth three main lessons⁶⁰.

1. Place-based actions and solutions provide huge potential for facing our global challenges by using local and city region solutions.

⁵⁴ With acknowledgements to Paola Lepori and Isabelle van Borm (European Commission), and the following independent experts (listed in alphabetical order by surname) who provided ideas and comments during and after the 10 March 2023 Food 2030 workshop in Brussels: Barbara Archesso, Betina Bergmann Madsen, Peter Defranceschi, Andrea Magarini, Roberta Sonnino and Norbert Steinhaus.

⁵⁵ FAO (2022), 'Changing the urban landscape. Greening city living', 31 October 2022.

⁵⁶ Eurostat (2021), 'Urban–rural Europe'.

⁵⁷ FAO (2019), *FAO Framework for the Urban Food Agenda*, Rome.

⁵⁸ Sonnino, R. and Milbourne, P. (2002), 'Food system transformation: a progressive place-based approach', *Local Environment*, Vol. 27, No 7, pp. 915–926; Cities2030 workshop, 7 June 2022: a participatory workshop hosted by DG RTD and REA, with more than 25 EU funded projects who joined and shared their best practices.

⁵⁹ Mattioni, D., Milbourne, P. and Sonnino, R. (2022), 'Destabilizing the food regime "from within": tools and strategies used by urban food policy actors', *Environmental Innovation and Societal Transitions*, Vol. 44, pp. 48–59.

⁶⁰ Based on a survey of 22 urban food system transformation projects and a participatory online workshop (European Commission, Directorate-General for Research and Innovation (2023), [Urban food system transformation in the context of Food 2030](#), Publications Office of the European Union, Luxembourg).

2. Food needs to be seen in connection with health, climate, community and circularity (co-benefits) and treated in a systems approach for sustainable and resilient food systems and wider areas, such as the bioeconomy.
3. The diversity of activities showcased in previous projects on Urban food systems transformation provides plenty of options for local solutions to be replicated.

The need to strengthen the local resilience of food systems is more important than ever, especially for vulnerable groups facing food insecurity. Food systems' resilience is the ability of food systems to respond and adapt to disruptions, while maintaining their function, and can be enhanced by balancing long and short food supply chains with increased diversity and built-in redundancy and by developing robust local and regional food systems.

2. POLICY CONTEXT AND SYNERGIES

This pathway is relevant to EU policies, in particular the [European Green Deal](#) and the [farm-to-fork](#) and [biodiversity](#) strategies. In the farm-to-fork strategy, cities are named as an important governance level for a collective approach to food system transformation.

Furthermore, this pathway has synergies with other EU R&I funding initiatives connected to Horizon Europe. The dedicated Horizon Europe [Sustainable Food Systems Partnership for People, Planet and Climate](#) is closely linked to the vision of the pathway 'Urban food system transformation'. It is expected to be launched in 2024 and will provide a multi-actor R&I governance platform and process to deliver co-benefits in line with the European Green Deal and Food 2030. A cornerstone of the partnership is the exploitation of place-based solutions.

The pathway is fully in line with the goals of the Horizon Europe missions, in particular the [EU mission 'Climate-neutral and smart cities'](#), which aims to deliver 100 climate-neutral and smart cities by 2030 and ensure that these cities act as experimentation and innovation hubs to enable all European cities to follow suit by 2050. Urban food system transformation can be a key driver for urban regeneration, resilience and climate neutrality. Synergies are also planned with the New European Bauhaus candidate EU mission, for example on how to rethink the design of and create sustainable urban spaces that are more adapted to sustainable food provision and consumption and community empowerment. The EU mission '[A soil deal for Europe](#)' aims to establish 100 living labs and lighthouses to lead the transition towards healthy soil by 2030. There will be a mix of rural, forest and urban living labs.

The pathway has synergies with additional programmes outside the sphere of Horizon Europe. It is aligned with and contributes to the goals of the [urban agenda for the EU](#),

a multilevel working method promoting cooperation between Member States, cities, the European Commission and other stakeholders. The agenda stimulates growth, liveability and innovation in the cities of Europe, and contributes to enhancing the knowledge base on urban issues and exchanges of best practices and knowledge. A set of thematic partnerships contribute to climate adaptation, nature-based solutions and innovative public procurement. A new partnership on food is being set up to prioritise the role of cities in leading food system transformation.

Synergies are also to be found with [EIT Food](#) in several ways; for instance, EIT Food offers related courses, such as the 'Circular business models for sustainable urban food systems' course, and supports start-ups with a focus on urban food systems, such as Urban Crop Solutions.

At the global level, the importance of urban food systems is also underlined by the [Coalition on Sustainable and Inclusive Urban Food Systems](#), one of the commitments to action by the 2021 UNFSS, and takes inspiration from the [FAO framework for the urban food agenda](#).

3. BARRIERS AND LOCK-INS

- Lack of governance structures and coherence at different levels (local, regional and national) and coherence across those levels.
- Lack of frameworks and strategies fostering a systemic approach across disciplines and sectors.
- Competing resources (e.g. space for living and businesses versus urban gardens).
- Lack of capacities, skills, competencies and resources at the local level.
- Competing lifestyles (e.g. low cooking skills, fast-food lifestyle, little spare time).

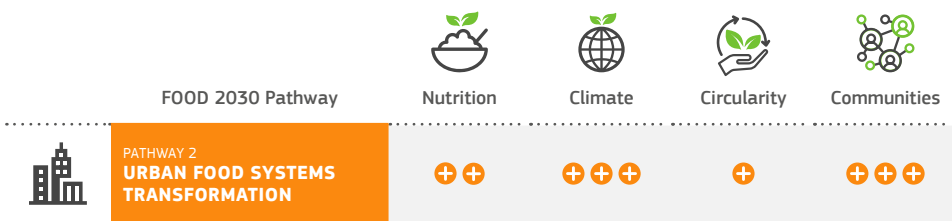
4. ENABLERS OF CHANGE

- Strengthened local SPI with data, monitoring and learning to inform policymakers and provide scientific evidence to back political commitment and financial sustainability.
- Political coherence and vertical multilevel governance, where the local level is empowered with the needed competencies and skills and supported by the regional and national levels, closely linked to activities of the governance pathway.

- Horizontal city-level governance, allowing collaboration and co-creation with other departments, the private sector, civil society and research organisations (quadruple helix model).
- Participatory policy processes engaging citizens and fostering citizen science, providing different perspectives, enabling co-learning, helping share ownership and promoting awareness raising and social innovation capacity.
- International initiatives and awareness raising through, for example, the UNFSS process stimulating action at the local level and creating a favourable context.

5. FOOD 2030 CO-BENEFITS

The R&I pathway ‘Urban food system transformation’ aims to support cities, towns and neighbourhoods in their transition towards sustainable food systems through improved local-level governance, strategic approaches and dedicated actions, multi-actor engagement and the empowerment of communities. The Food 2030 ambitions underpinning this pathway have the potential to address and deliver the following co-benefits.



Nutrition and health

- Enabling healthier urban food environments that can lead to healthy and sustainable diets and alter the trend of the increased accessibility of highly processed food with low nutritional value, and having universal access to healthy, sustainable food, thus contributing to the one health approach.
- Reducing obesity and diet-related non-communicable diseases (NCDs) by approaching urban citizens, especially children in schools, providing inclusive access to food, with awareness raising regarding healthy diets and capacity and skills building, and providing supportive procurement.

Climate and sustainability

- Enhancing resilience by using urban planning and community empowerment, for

example fostering dietary shifts for young people, while employing urban–rural linkages and synergies.

- Increasing climate change adaptation options, such as multi-purpose nature-based solutions, and also enhancing biodiversity (using local plants and trees) through joint food and climate strategies.
- Supporting climate targets through urban and vertical farms with strong community involvement for capacity building, and also supporting more short value chains to connect the urban–rural interface.

Circularity and resource efficiency

- Enhancing resource-efficient and community-driven food systems based on local solutions – enforced by local governments in cooperation with members of the private sector, such as retailers – thus addressing issues including food loss and waste, food packaging, water and energy usage, logistics, and adaptation of buildings and public spaces.

Innovation and communities

- Enabling people’s reconnection to (local) food, and thus with nature, connecting citizens from urban and rural areas to encourage knowledge sharing and synergy building, thus contributing to resilience.
- Providing innovation opportunities and sustainable urban development with a strong focus on improved social inclusion (including vulnerable communities) and community empowerment, for example through food policy councils and networks, and providing new approaches linked to nature-based solutions and urban planning and design.
- Improving education, awareness raising, skill building and community engagement to enhance evidence-based transformative change for sustainable food systems.

6. RESEARCH AND INNOVATION OUTCOMES AND FUTURE NEEDS

This section provides a snapshot of the R&I being carried out in relation to this pathway. It describes the R&I investments (European Commission financial contribution) supporting projects that have been funded as outcomes of relevant Food 2030 calls for proposals, in the context of societal challenge 2 of Horizon 2020 and cluster 6 of Horizon Europe. Furthermore, it describes the range of thematic issues covered, identifies future R&I needed and provides a summary of Food 2030 projects.

Investments

The total European Commission contribution to projects supported by this pathway is EUR 70.8 million for seven projects (EUR 50.6 million for five Horizon 2020 projects and EUR 20.2 million for two projects in the Horizon Europe work programme for 2021–2022) and a further EUR 18 million for five projects planned for the Horizon Europe work programme for 2023–2024.

There are other projects that take place in urban contexts but have a particular focus on individual issues such as food waste, healthy diets or international cooperation; therefore, these are covered in the sections on other Food 2030 pathways.

Issues addressed

Existing EU projects related to this pathway predominantly address the following aspects: policy creation and coherence, food waste, change in diets and, to a lesser extent, urban–rural governance and awareness raising. These elements are also covered in the ‘Food systems Africa’ pathway (pathway 9).

Most projects contributed to several Food 2030 co-benefits, partly through joint branding, which provided visibility and coherence. However, projects differed in their outcomes, with focus areas ranging from citizen engagement to local policy development and technology development and use. Many projects make strong use of place-based solutions through policy and living labs.

Further R&I projects are expected to be supported as an outcome of the 2023–2024 Horizon Europe work programme calls for proposals targeting topics supporting the planned farm-to-fork sustainability labelling framework by creating inclusive and smart ways to communicate regarding the sustainability of food, unlocking the potential of the New European Bauhaus initiative for urban food system transformation by placing a strong emphasis on food environments and nature-based solutions, and creating smart and attractive tools to enhance healthy and sustainable food provision and the eating and treatment of food at home.

Future research and innovation needs

Future R&I efforts should attempt to support the replication and scaling up and out of solutions by also capitalising on and synergising with other funding instruments, such as EIT Food and LIFE, and building connections to vertical government levels (regional, national). Key areas to focus on include:

- developing synergies and increasing connections across the rural–urban interface and city region interface to improve urban food system resilience and to contribute to transparency by using big data;

- ensuring that future R&I projects related to this pathway tackle all four Food 2030 priorities for a fully systemic approach and embed capacity-building actions to create Food 2030 cities;
- fostering more hands-on living labs and co-creation spaces with clear ownership, also addressing local food insecurity / food poverty issues, and using standardised metrics and impact assessments;
- drawing from and connecting all lessons learned from all relevant Horizon 2020 and Horizon Europe urban food systems projects by bringing stakeholders together, thus building on the outcome of the urban food system transformation report⁶¹, with a view to developing jointly designed ambitious guidance/roadmaps and providing support for cities on how to transform food systems from the perspective of key local-level actors as (i) citizens, (ii) city governments, (iii) regional governments, (iv) local businesses and (v) research organisations and education facilities⁶²;
- fostering local-level food system entrepreneurship and decentralised local capacities and solutions that are also relevant at the homestead and neighbourhood levels, such as living labs and accelerators;
- integrating knowledge and skill building to change food cultures and behaviours and to design opportunities for problem-based learning and the inclusion of citizens' knowledge and experience, thus enhancing resilience;
- creating opportunities to rethink and redesign urban spaces, buildings and flows that could foster sustainable urban food systems by integrating architecture, urban and spatial planning as tools for change, linking where possible to the EU missions 'A soil deal for Europe' and 'Climate-neutral and smart cities' and the New European Bauhaus initiative.

Summary of relevant research and innovation projects

The Food 2030 projects relevant to this pathway include those presented in the following table.

⁶¹ European Commission, Directorate-General for Research and Innovation, Lüth, D., Vandrich, J., Fabbri, K. (2023), [Urban food system transformation in the context of Food 2030 – Current practice & outlook towards 2030](#), Publications Office of the European Union, Luxembourg.

⁶² See, for example, the [Ganbatte](#) platform.

PROJECT NAME & FUNDING INFORMATION

PROJECT AIM/OUTCOME

<p><u>FoodE</u> Food Systems in European Cities</p> <p>2020–2024, EUR 7.2 million (Horizon 2020), IA, Food 2030</p>	<p>FoodE will accelerate the growth of citizen-led city region food systems by bringing together local initiatives across Europe and co-developing and disseminating new tools to promote and bolster citizen-driven food systems.</p>
<p><u>FoodSHIFT2030</u> Food System Hubs Innovating towards Fast Transition by 2030</p> <p>2020–2023, EUR 7.5 million (Horizon 2020), IA, Food 2030</p>	<p>FOODSHIFT2030 will launch an ambitious citizen-driven transition of the European food system towards a low-carbon, circular future, including a shift to less meat-based and more plant-based diets.</p>
<p><u>FOOD TRAILS</u> Building pathways towards Food 2030-led urban food policies</p> <p>2021–2024, EUR 11.9 million (Horizon 2020), IA, Food 2030</p>	<p>Food Trails will translate the Milan Urban Food Policy Pact’s vision and commitment into measurable and long-term progress towards sustainable food systems.</p>
<p><u>CITIES2030</u> Co-creating resilient and sustainable food systems towards FOOD2030</p> <p>2020–2024, EUR 11.8 million (Horizon 2020), IA, Food 2030</p>	<p>Cities2030 will create future-proof and effective urban food systems and ecosystems through a connected structure with citizens at the centre.</p>
<p><u>FUSILLI</u> Fostering the Urban food System Transformation through Innovative Living Labs implementation</p> <p>2021–2024, EUR 12.2 million (Horizon 2020), IA, Food 2030</p>	<p>FUSILLI will support the cooperation among European cities and their peri-urban areas for knowledge sharing and mutual learning.</p>

FoodCLIC

Integrated urban FOOD policies – developing sustainability co-benefits, spatial Linkages, social Inclusion and sectoral Connections to transform food systems in city-regions

2022–2027, EUR 11.2 million
(Horizon Europe), IA, Food 2030

FOODCLIC will create strong science–policy–practice interfaces across eight European city regions. The backbone of such interfaces will be provided by food policy networks, which will manage real-world experimental living labs to build a policy-relevant evidence base through learning in action.

CULTIVATE

Co-designing food sharing innovation for resilience

2023–2026, EUR 9.0 million
(Horizon Europe), IA, Food 2030

CULTIVATE will use a multi-actor approach to build sustainability and resilience in urban and peri-urban areas through a groundbreaking online social innovation support platform – the food sharing compass.

NB: IA, innovation action.



PATHWAY 3

FOOD FROM THE OCEAN AND FRESHWATER RESOURCES⁶³



1. SYSTEMIC CHALLENGES

Seafood production through fisheries and aquaculture is key for European and global food and nutrition security. Most seafood is low in carbohydrates but rich in proteins and polyunsaturated fatty acids, thus providing nutritional elements that are scarce in food produced on land. Europeans consume twice as much seafood as they produce, with most imports coming from Asian countries. As seafood is a highly traded commodity internationally, the environmental impact of transport and processing needs to be added to the impact of production.

While efforts to manage fisheries sustainably are starting to bear fruit in northern Europe, fisheries in southern Europe face depleted stocks. Particularly in the Mediterranean and the Black Sea, the collection of reliable data is challenging. This particularly affects the management of the plethora of small fishing vessels that are characteristic of the Mediterranean.

Well-managed sustainable aquaculture is necessary to increase seafood production, but, while booming globally, this sector is not yet sufficiently developed in Europe. Competition for space with other activities, lack of awareness and understanding of what aquaculture is, consumers' negative perceptions and a heavy administrative burden for investments are among the reasons for this slow development. Fish and shellfish farmed in the EU follow the highest environmental, food safety and social standards, and the potential for growth of the sector is massive, for example in southern Europe, where there is an acute need for economic growth and jobs.

Most of the seafood consumed in Europe consists of carnivorous species, and farming of such organisms depends largely on animal feed. Microalgae and macroalgae (seaweed) can produce a wide variety of edible substances of high nutritional value. They are popular food in Asia but their production and consumption are very low in Europe.

- Globally, 600 million people depend at least partially on fisheries and aquaculture. Per capita fish consumption rose from 10 kg per year in the 1960s to more than 20.2 kg in 2020⁶⁴.
- The state of commercial stocks is especially critical in the Mediterranean and the Black Sea, where most of the species assessed are at risk of collapse. The stocks of small pelagic fish (e.g. sardines and anchovies) are in better condition, but they are not always preferred by consumers.
- Aquaculture could cover close to two thirds of global seafood consumption by 2030⁶⁵. Aquaculture production for human consumption exceeded the production of capture fisheries in 2014⁶⁶.

⁶⁵ With acknowledgements to Rodrigo Ataíde Dias (European Commission) and the following independent experts (listed in alphabetical order by surname) who provided ideas and comments during and after the 10 March 2023 Food 2030 workshop in Brussels: Annelies Declercq, Michalis Pavlidis, Nina Peuhkuri and Joern Schmidt.

⁶⁴ FAO (2022), [The State of World Fisheries and Aquaculture 2022 – Towards blue transformation](#), Rome.

⁶⁶ World Bank (2013), [Fish to 2050 – Prospects for fisheries and aquaculture](#), World Bank report No 83177-GLB, Washington, D.C.

- With appropriate commercial development and marketing, European demand for seaweed could increase from around 0.27 million tonnes in 2019 to 8 million tonnes in 2030 and reach EUR 9 billion in value in 2030 across all sectors, with feed, food, plant biostimulants⁶⁷ and biomedical applications being the largest market segments. Such an increase in production, if realised in Europe, could create around 85 000 jobs, remove thousands of tonnes of phosphorus and nitrogen from the European seas annually and mitigate up to 5.4 million tonnes of CO₂ emissions a year, and it has the potential to relieve the pressure on land-based production.

The measures taken for the COVID-19 pandemic affected the resilience of seafood production, distribution and consumption, as many fishers and aquaculture farmers ceased working and restaurants were closed. Seafood proximity emerged as an important consideration for resilience. The sanctions on Russia as a reaction to its invasion of and war of aggression against Ukraine have led to an increase in energy prices. This specifically affected energy-intensive capture fisheries, but also seafood production as a whole.

2. POLICY CONTEXT AND SYNERGIES

The pathway 'Food from the ocean and freshwater resources' is directly relevant to EU policies, including the [common fisheries policy](#), the [marine strategy framework directive](#), the blue growth strategy, the [farm-to-fork](#) and [biodiversity](#) strategies and the [bioeconomy strategy](#). Other relevant Commission initiatives include the [strategic guidelines for a more sustainable and competitive EU aquaculture](#) and the [initiative towards a strong and sustainable EU algae sector](#). In addition, this pathway is also relevant to a package of measures to improve the sustainability and resilience of the EU's fisheries and aquaculture sector and the [pact for fisheries and oceans](#).

At the global level, this pathway is particularly relevant to UN SDG 14 on life below water. Furthermore, the 2021 UNFSS led to the creation of an [Aquatic Blue Food Coalition](#), of which the EU is a member.

This pathway builds synergies with the [EU mission 'Restore our ocean and waters'](#); the partnerships on sustainable blue economy, animal health and welfare, and sustainable food systems; and the smart specialisation strategy concerning the blue economy. In addition, it is related to the recent work of the [SCAR Fisheries and Aquaculture Research Strategic Working Group](#) on innovation in fishery monitoring science and on seafood-related nature-based solutions.

The next two sections outline key barriers, lock-ins and enablers of change for the development and take-up of food from the oceans and freshwater resources.

⁶⁶ FAO (2016), [The State of World Fisheries and Aquaculture 2016 – Contributing to food security and nutrition for all](#), Rome.

⁶⁷ Any substance or microorganism applied to plants with the aim of enhancing nutrition efficiency, abiotic stress tolerance and/or crop quality traits, regardless of its nutrient content.

3. BARRIERS AND LOCK-INS

- Complex global seafood supply chains, in some cases dominated by a few powerful actors.
- Gaps in biological and ecological knowledge of aquatic organisms and ecosystems.
- Lack of effective international collaboration for the management of shared fish stocks.
- Lack of infrastructure for technology uptake by the seafood sector in several areas in Europe.
- Poor environmental performance and the impact of some aquaculture practices, for example on surrounding water quality.
- Cumbersome and slow administrative procedures for authorising aquaculture investments.
- High insurance, installation and monitoring costs for mariculture (nearshore and offshore), discouraging small-scale investors.
- Lack of familiarity with seafood consisting of photosynthetic and low-trophic aquatic organisms; lack of know-how on how to cook, prepare and combine them; and, in general, negative consumer perceptions of farmed seafood.
- Limited consideration of seafood in the global food systems operating with a silo approach.

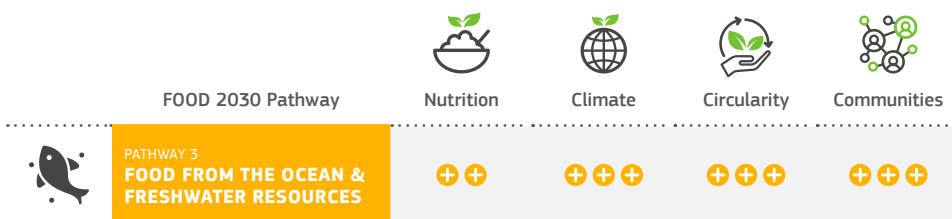
4. ENABLERS OF CHANGE

- Develop self-sustained training programmes to improve the professional skills and competences of those working and being trained to work within the blue economy and match them with needs of the industry. The programmes should continue beyond the lifespan of research projects and be in line with the EU bioeconomy strategy's commitment to addressing bioeconomy-related education and skills gaps.
- Encourage and promote the uptake of new technologies, particularly within the micro-, small and medium business sectors, possibly also through economic incentives (e.g. tax credits) or carbon credit offsetting.
- Encourage orchestrated research efforts across the EU and globally and promote coordinated management of seafood production in international contexts.
- Streamline policy on aquaculture practices across European countries to stimulate cross-border collaboration.

- Prioritise R&I on the most promising food production methods and their added values when it comes to small ecological footprints.
- Build on consumers’ trust with targeted campaigns on the benefits of seafood farmed in the EU, and enhance know-how on how to prepare farmed seafood, also taking advantage of public food procurement.

5. FOOD 2030 CO-BENEFITS

The R&I pathway ‘Food from the oceans and freshwater resources’ is intended to foster new knowledge and solutions in support of sustainable aquaculture and fisheries, and the production and consumption of seafood, which are key to sustainable and resilient food systems and food and nutrition security. The Food 2030 ambitions underpinning this pathway have the potential to address and deliver the following co-benefits.



Nutrition and health

- Achieving dietary shifts by providing nutritious proteins, essential amino acids, polyunsaturated fatty acids, minerals and vitamins and a variety of nutraceuticals from aquatic organisms.
- Ensuring the safety of fish, shellfish and algae through support from technologies such as blockchain technology and AI.

Climate and sustainability

- Contributing to carbon sequestration through algae and bivalve farming, and reducing GHG emissions through more energy-efficient fishing vessels and fishing techniques.
- Maintaining wild fish stocks within safe biological limits and safeguarding the integrity and functioning of marine ecosystems, while also relieving pressure on land resources and allowing for carbon reductions from terrestrial farming sources.

- Investigating where newly exploited areas for seafood production could combine, from the start, nature-based solutions such as habitat restoration with renewable energies.

Circularity and resource efficiency

- Minimising seafood waste by promoting maximum utilisation and valorisation of marine biomass (e.g. trimmings, viscera, algae) for food, feed, nutraceuticals and pharmaceuticals, including by unlocking the potential of the marine microbiome.
- Promoting the diversification of aquaculture through farming systems where organisms of different trophic levels are cultivated (integrated multi-trophic aquaculture and aquaponics, potentially in recirculating systems on land or in the sea).
- Developing metrics to determine the environmental impact of seafood production, including GHG emissions, water consumption, seabed degradation, the use of chemicals and biodiversity loss.

Innovation and communities

- Making aquaculture and fisheries smart by applying information and digital technologies, including AI, machine learning and cloud platforms used with the internet of things.
- Increasing the literacy of consumers on the nutritional, environmental and health benefits of aquatic species that require little or no animal-based feed.
- Triggering growth and job creation across the seafood value chain (including the supply of technology, equipment, services and feed) and in related sectors such as maritime ecotourism (recreational fisheries) and marine biotechnology, and developing lifelong learning programmes on innovation skills in the context of a knowledge-based economy and society.

6. RESEARCH AND INNOVATION OUTCOMES AND FUTURE NEEDS

This section provides a snapshot of the R&I being carried out in relation to this pathway. It describes the R&I investments (European Commission financial contribution) supporting projects that have been funded as outcomes of relevant Food 2030 calls for proposals, in the context of societal challenge 2 of Horizon 2020 and cluster 6 of Horizon Europe. Furthermore, it describes the range of thematic issues covered, identifies future R&I needed and provides a summary of Food 2030 projects.

Investments

From 2018 onwards, under Horizon 2020 societal challenge 2, the EU has invested more than EUR 100 million in this area by supporting 15 projects. In the first 2 years of Horizon Europe, more than EUR 75 million were invested in seafood research under cluster 6, including under the EU mission 'Restore our ocean and waters by 2030', supporting 13 projects. An additional amount of approximately EUR 56 million is also expected as result of the 2023 and 2024 Horizon Europe topics related to this pathway.

Issues addressed

In the first 4 years of Horizon Europe, there was a strong focus on the interaction between seafood production (both fisheries and aquaculture) and climate.

Projects also focused on technological aspects for the meaningful and efficient implementation of the fisheries control system in Europe and globally. However, as technology is evolving by leaps and bounds, and considering the importance of controlling fisheries, more support may be needed to keep up with new technological developments. More emphasis might also be needed on addressing important scientific and policy issues concerning species of particular economic and political importance.

The external dimension of the EU common fisheries policy (sustainable fisheries partnership agreements and fishing in international waters) has not been explicitly supported, even though it concerns around 20 % of the yield of EU vessels. There were attempts in Horizon 2020 to work with non-EU countries (in the Atlantic and in Asia) on aquaculture development, but a more holistic and coordinated approach is needed to build win-win relationships with countries rich in seafood and in aquaculture development potential. This is important, as there is often a lack of overlap between aquaculture knowledge centres and available space to implement this knowledge.

There was also a focus on fish health and fish welfare in aquaculture, with two dedicated projects that started in 2022 working on welfare indicators, diagnostics and vaccines. Together with the partnership on animal health and welfare, which also covers aquaculture, considerable R&I support will be provided to the sector.

Wider issues of innovation in seafood production and better engagement of citizens in the production and consumption of seafood were also supported by projects.

Freshwater aquaculture, and freshwater bioeconomy in general, were also supported in the first years of Horizon Europe.

The EU mission ‘Restore our ocean and waters by 2030’ strongly supports low-trophic aquaculture (algae and molluscs), but the focus is mainly on large farms, while small family-run farms, such as oyster farms, need tailor-made support. This is particularly pertinent given that 80 % of EU aquaculture production businesses are identified as micro-production businesses.

Future research and innovation needs

To fully realise the potential of fish, shellfish and algae for sustainable and healthier food systems, it is important to address issues of basic science and applied technology and also governance and social issues.

- Science and technology:
 - advancing basic knowledge (e.g. on early life cycles, biological life cycles in captivity, growth conditions in relation to climate change, spawning grounds of wild stocks, ecological tipping points), and developing tools for sustainable management of fish and shellfish stocks;
 - advancing technology and innovation for more efficient environmentally friendly production systems and for monitoring aquaculture fish growth, health, welfare and quality;
 - advancing know-how for resource-efficient and sustainable farming of fish, shellfish and algae, including underlying economic impact assessments, market analysis and cost/production studies;
 - advancing technological knowledge and social innovations to decrease the negative impact of fishing, including creating innovative fishing techniques and reducing vessel emissions;
 - revolutionising fisheries and aquaculture monitoring by introducing new technologies for efficient, effective and remote monitoring and data collection, supporting the ecosystem-based approach;
 - advancing the application of nature-based solutions for sustainable use of aquatic resources;
 - advancing the valorisation of aquatic biomasses to value-added food and feed products and ingredients;
 - advancing knowledge of cross-sectoral production chains and value networks, strengthening the blue–green (ocean–land) link and the energy–food–mobility nexus.

- Governance:
 - smartly managing small-scale sustainable seafood production and consumption;
 - promoting light-touch regulation of aquaculture businesses operating to best practice standards and optimal efficiencies;
 - working in the international arena to create a level playing field for seafood in the global market so that European seafood competes on fair terms, and developing appropriate market strategies;
 - bridging the distance between the generation of knowledge (mainly in urban centres in developed countries) and seafood production (mainly in rural areas and in developing countries), and promoting sustainable seafood production outside Europe;
 - co-creating optimal maritime spatial plans, including for aquaculture and fisheries, with all actors to promote local production and short food supply chains;
 - increasing the connection of food systems across oceans, freshwaters and land.
- Social innovation:
 - improving the perception and public acceptance of seafood that is farmed in the EU to the highest environmental and social standards;
 - promoting the consumption of less known seafood, particularly photosynthetic and low-trophic aquatic species;
 - fairly pricing seafood, taking into account the impact of its production and ensuring the right to healthy food for all;
 - empowering vulnerable people and small actors in the food chain.

Summary of relevant research and innovation projects

The Food 2030 projects relevant to this pathway include those presented in the following table.

PROJECT NAME & FUNDING INFORMATION	PROJECT AIM/OUTCOME
<p><u>SMARTFISH</u> Smart fisheries technologies for an efficient, compliant and environmentally friendly fishing sector</p> <p>2018–2022, EUR 6 million (Horizon 2020), Food 2030</p>	<p>This project used machine vision, camera technology, data processing, machine learning, AI, big data analysis, smartphones/tablets, light-emitting diode technology, acoustics and remotely operated vehicle technology to build systems for monitoring, analysing and improving processes for all facets of the fishing sector.</p>
<p><u>PANDORA</u> Paradigm for Novel Dynamic Oceanic Resource Assessments</p> <p>2018–2022, EUR 5.6 million (Horizon 2020), Food 2030</p>	<p>PANDORA created more realistic assessments and projections of changes in fisheries resources by utilising new biological knowledge.</p>
<p><u>SUMMER</u> Sustainable management of mesopelagic resources</p> <p>2019–2024, EUR 6.5 million (Horizon 2020), Food 2030</p>	<p>This project is exploring the role of mesopelagic fish, understood in terms of the ecosystem and establishing tools to accurately estimate their biomass and the interspecies impact.</p>
<p><u>MEESO</u> Ecologically and economically sustainable mesopelagic fisheries</p> <p>2019–2024, EUR 6.4 million (Horizon 2020), Food 2030</p>	<p>MEESO is quantifying the spatio-temporal distributions of the biomass, the production and the ecosystem role of mesopelagic resources, and assessing options to sustainably exploit them.</p>
<p><u>EcoScope</u> Eco-centric management for sustainable fisheries and healthy marine ecosystems</p> <p>2021–2025, EUR 8 million (Horizon Europe), Food 2030</p>	<p>This project is developing an interoperable platform and a decision-making toolbox, available to decision-makers and end users through a public portal, to promote ecosystem-based fishery management.</p>
<p><u>SEAWISE</u> Shaping ecosystem based fisheries management</p> <p>2021–2025, EUR 8 million (Horizon Europe), Food 2030</p>	<p>SEAWISE is improving stock productivity predictions using environmental metrics, density dependence, predation, stock health indicators and habitat extent, and multispecies–multi-fleet models that provide ecosystem forecasts of the effect of fisheries management measures.</p>

<p><u>BLUEBIO</u> ERA-NET Cofund on Blue Bioeconomy – Unlocking the potential of aquatic bioresources</p> <p>2018–2024, EUR 8 million (ERA-NET), Food 2030</p>	<p>The BLUEBIO project is unlocking the potential of aquatic bioresources to create jobs and economic growth and provide food, nutrition and bio-based products and services.</p>
<p><u>AQUAIMPACT</u> Genomic and nutritional innovations for genetically superior farmed fish to improve efficiency in European aquaculture</p> <p>2019–2023, EUR 6.1 million (Horizon 2020), Food 2030</p>	<p>This project is integrating the fields of fish breeding and nutrition to increase the competitiveness of the EU's aquaculture of Atlantic salmon, rainbow trout, gilthead sea bream and European sea bass, to ensure food and nutrition security and to satisfy consumer demands.</p>
<p><u>ASTRAL</u> All Atlantic Ocean Sustainable, Profitable and Resilient Aquaculture</p> <p>2020–2024, EUR 7.9 million (Horizon 2020), Food 2030</p>	<p>ASTRAL is developing integrated multitrophic aquaculture production chains for the Atlantic markets.</p>
<p><u>AQUAVITAE</u> New species, processes and products contributing to increased production and improved sustainability in emerging low trophic, and existing low and high trophic aquaculture value chains in the Atlantic</p> <p>2019–2023, EUR 8 million (Horizon 2020), Food 2030</p>	<p>AquaVitae will work towards sustainable aquaculture production and the development of new low-trophic species in aquaculture value chains, including macroalgae, integrated multitrophic aquaculture, shellfish, echinoderms and finfish.</p>
<p><u>IFISHIENCI</u> Intelligent Fish feeding through Integration of ENabling technologies and Circular principle</p> <p>2018–2023, EUR 6 million (Horizon 2020), Food 2030</p>	<p>The project delivered breakthrough innovations supporting sustainable aquaculture based on enabling technologies and circular principles.</p>

<p><u>FUTUREEUQUA</u> Future growth in sustainable, resilient and climate friendly organic and conventional European aquaculture</p> <p>2018–2023, EUR 6 million (Horizon 2020), Food 2030</p>	<p>This project promoted the sustainable growth of environmentally friendly organic and conventional aquaculture that is resilient to climate change.</p>
<p><u>NewTechAqua</u> New Technologies, Tools and Strategies for a Sustainable, Resilient and Innovative European Aquaculture</p> <p>2020–2023, EUR 6 million (Horizon 2020), Food 2030</p>	<p>This project is advancing resilient and sustainable new solutions to expand and diversify EU production of finfish, molluscs and microalgae, including working on genetics, new species and new products.</p>
<p><u>AQUA-FAANG</u> Advancing European Aquaculture by Genome Functional Annotation</p> <p>2019–2023, EUR 6 million (Horizon 2020), Food 2030</p>	<p>AQUA-FAANG is improving the understanding of genome function and of the usage of genotype-to-phenotype prediction in the six most important fish species in European aquaculture.</p>
<p><u>NEOGIANT</u> The power of grape extracts: antimicrobial and antioxidant properties to prevent the use of antibiotics in farmed animals</p> <p>2021–2025, EUR 8.4 million (Horizon 2020), Food 2030</p>	<p>NEOGIANT is developing animal feed, treatment products and sperm extenders based on natural extracts that can decrease the use of antibiotics in farm animals, substitute synthetic preservatives and provide antimicrobial and antioxidant protection to livestock, poultry and fish.</p>
<p><u>CURE4AQUA</u> Curing EU aquaculture by co-creating health and welfare innovations</p> <p>2022–2027, EUR 4.8 million (Horizon Europe), Food 2030</p>	<p>This project is improving aquatic animal health and welfare and supporting the environmentally friendly, inclusive, safe and healthy production of seafood.</p>
<p><u>IGNITION</u> Improving Green Innovation for the blue revolution: new tools and opportunities for a more sustainable animal farming</p> <p>2022–2026, EUR 5.1 million (Horizon Europe), Food 2030</p>	<p>IGNITION is unveiling new knowledge regarding animal welfare in the context of climate change and proposing new tools to mitigate the adverse effects of stress.</p>

<p><u>SAFE</u> SmartAqua4Future</p> <p>2022–2026, EUR 4.5 million (Horizon Europe), Food 2030</p>	<p>SAFE is applying circular economy approaches to the valorisation of solid and liquid wastes from recirculating aquaculture systems and integrated multi-trophic aquaculture systems.</p>
<p><u>AWARE</u> Aquaponics from WAstewater Reclamation</p> <p>2022–2026, EUR 4.7 million (Horizon Europe), Food 2030</p>	<p>AWARE is locally producing fish for human consumption with no impact on natural habitats, no dependence on natural freshwater availability and high resiliency to climate change.</p>
<p><u>FISH-X</u> Providing a European Fisheries Dataspace Through a Consultative Approach</p> <p>2022–2025, EUR 4.5 million (Horizon Europe), Food 2030</p>	<p>FISH-X is developing a fisheries dataspace and insight platform – based on smart orchestrated architecture and open interoperable technology via Gaia-X – that will improve fishing methods, increase yields and protect endangered fishery stocks.</p>
<p><u>EVERYFISH</u> Digital transition of catch monitoring in European fisheries</p> <p>2022–2026, EUR 3.9 million (Horizon Europe), Food 2030</p>	<p>This project is optimising automatic data collection of fish size, weight and species, providing verifiable catch information and ensuring correct reporting and compliance by design with fisheries regulations.</p>
<p><u>FishEUtrust</u> European integration of new technologies and social-economic solutions for increasing consumer trust and engagement in seafood products</p> <p>2022–2026, EUR 4.6 million (Horizon Europe), Food 2030</p>	<p>This project is integrating different actors into a digital platform that links technology providers, supply chain stakeholders, regulators/policymakers and consumers.</p>
<p><u>SEA2SEE</u> Innovative blockchain traceability technology and Stakeholders' Engagement strAtegy for boosting Sustainable sEafood visibility, social acceptance and consumption in Europe</p> <p>2022–2026, EUR 4.4 million (Horizon Europe), Food 2030</p>	<p>SEA2SEE is developing a novel end-to-end blockchain model and professional and consumer applications that will fill in existing seafood traceability gaps.</p>

CIRCALGAE

CIRCular valorisation of industrial ALGAE waste streams into high-value products to foster future sustainable blue biorefineries in Europe

2022–2026, EUR 8.5 million
(Horizon Europe), Food 2030

CIRCALGAE is introducing an integrated biorefinery concept and delivering novel macroalgae and microalgae ingredients to the food, feed and cosmetic sector.



PATHWAY 4

ALTERNATIVE PROTEINS FOR DIETARY SHIFT⁶⁸



1. SYSTEMIC CHALLENGES

Diversifying our dietary habits by including more meat and dairy alternatives based on alternative protein sources (e.g. plants, fungi, microbes, meat from cell cultures, insects, algae (macroalgae and microalgae)) can be an effective way to tackle global challenges such as climate change, natural resource scarcity, food security and malnutrition.

A dietary shift towards alternative sources of proteins can contribute to one fifth of the mitigation needed to ensure global warming does not exceed 2 °C above pre-industrial levels⁶⁹. The sixth assessment of the IPCC showed that 23–42 % of global GHG emissions come from food systems. These emissions could decrease if diets high in plant-rich protein content and low in meat and dairy products are adopted⁷⁰. An OECD study also showed that ‘products differ greatly in their GHG emissions intensity, with beef derived from pure beef herds showing a considerably higher GHG emissions intensity than other products’, mainly due to land use change⁷¹. The livestock sector produces 14.5 % of the global anthropogenic GHG emissions⁷². Crop or livestock production uses about one third of the land surface and three quarters of freshwater resources globally⁷³. Some imported animal-based products do not always follow the same production-related sustainability standards as those defined in the EU, which can lead to deforestation or unsustainable land use change outside EU borders. The overconsumption of red and processed meat also has significant negative effects on human health and can lead to diet-related diseases, in particular NCDs, such as certain types of cancer, cardiovascular diseases, obesity and diabetes⁷⁴.

As diets are deeply ingrained in cultural heritages, they can be difficult to change. Moreover, consumers expect these products to be safe and healthy, tasty, visually appealing, affordable to all and clearly labelled. Prices, taste, food purchasing habits, product availability, perceived personal benefits and policies should therefore be taken into consideration, since a shift towards alternative protein sources depends on European citizens’ engagement and willingness to change their diets, for which all of these aspects are important. Consumer choices also depend on both marketing signals and the food environment; the food environment ensures the availability and access to food, links food supply and diets and is one of the determinants

⁶⁸ With acknowledgements to the following independent experts (listed in alphabetical order by surname) who provided ideas and comments during and after the 10 March 2023 Food 2030 workshop in Brussels: Ondina Afonso, Bruno Menne, Camille Perrin, Acacia Smith, Wim Verbeke and Emanuele Zannini.

⁶⁹ de Coninck, H., Revi, A., Babiker, M., Bertoldi, P., Buckering, M., Cartwright, A., Dong, W., Ford, J., Fuss, S., Hourcade, J. C., Ley, D., Mechler, R., Newman, P., Revokatova, A., Schultz, S., Steg, L. and Sugiyama, T. (2018), ‘[Strengthening and implementing the global response](#)’, in Masson-Delmotte, V., Zhai, P., Pörtner, H.-O., Roberts, D., Skea, J., Shukla, P. R., Pirani, A., Moufouma-Okia, W., Péan, C., Pidcock, R., Connors, S., Matthews, J. B. R., Chen, Y., Zhou, X., Gomis, M. I., Lonnoy, E., Maycock, T., Tignor, M. and Waterfield, T. (eds), *Global Warming of 1.5 °C*. An IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty, IPCC, Geneva, pp. 313–443.

⁷⁰ IPCC, Pathak, M., Slade, R., Pichs-Madruga, R., Ürge-Vorsatz, D., Shukla, P. R. and Skea, J. (2022), ‘Technical summary’, in Shukla, P. R., Skea, J., Slade, R., Al Khourdajie, A., van Diemen, R., McCollum, D., Pathak, M., Some, S., Vyas, P., Fradera, R., Belkacemi, M., Hasija, A., Lisboa, G., Luz, S. and Malley, J. (eds), *Climate Change 2022 – Mitigation of climate change: Contribution of Working Group III to the sixth assessment report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, UK, and New York, NY, doi:10.1017/9781009157926.002.

⁷¹ Deconinck, K. and Toyama, L. (2022), *Environmental Impacts along Food Supply Chains: Methods, findings, and evidence gaps*, OECD Food, Agriculture and Fisheries Papers, No 185, OECD Publishing, Paris.

⁷² Gerber, P. J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falucci, A. and Tempio, G. (2013), *Tackling Climate Change through Livestock – A global assessment of emissions and mitigation opportunities*, FAO, Rome.

⁷³ IPBES (2019), *The global assessment report on biodiversity and ecosystem services – Summary for policymakers*, IPBES Secretariat, Bonn.

⁷⁴ Bouvard, V., Loomis, D., Guyton, K. Z., Grosse, Y., El Ghissassi, F., Benbrahim-Tallaa, L., Guha, N., Mattock, H. and Staif, K. (2015), ‘[Carcinogenicity of consumption of red and processed meat](#)’, *Lancet Oncology*, Vol. 16, No 16, pp. 1599–1600.

of food production⁷⁵. Furthermore, shifting demand will create new business opportunities, but will also unavoidably be a challenge for some other businesses, which need to be supported in the transition to new jobs and opportunities in order to leave nobody behind.

Many alternative protein sources already exist, and R&I efforts are needed to boost their uptake, while ensuring acceptability to consumers. More can also be done to identify other alternative protein sources and introduce them into the human diet. This entails health (e.g. food safety and allergenicity issues), societal (e.g. behavioural changes and acceptance by consumers) and regulatory considerations. Alternative protein sources may or may not be considered novel foods in the EU. [If they qualify as novel foods](#), they require pre-market authorisation for their consumption based on the European Food Safety Authority (EFSA) assessment of the health risks. Finally, a dietary shift towards sustainably sourced alternative proteins can contribute to building food system resilience. If the proteins are sourced locally, this can also reduce dependency on protein imports.

2. POLICY CONTEXT AND SYNERGIES

The pathway ‘Alternative proteins for dietary shift’ is relevant to EU policies such as the [common agricultural policy](#), the [common fisheries policy](#), the [European Green Deal](#), the [farm-to-fork strategy](#) and the [biodiversity strategy](#), [Europe’s beating cancer plan](#), the [EU regulation on novel foods](#), the [updated bioeconomy strategy](#), the [sustainable blue economy communication](#), the [algae initiative](#), the [protein plan](#), the upcoming Commission report on plant proteins for a sustainable food system, Commission communication – [A clean planet for all: A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy](#) and Commission communication – [Safeguarding food security and reinforcing the resilience of food systems](#).

This pathway has synergies with other EU R&I funding initiatives connected to Horizon Europe. It is closely related to the activities of SCAR, which has established a task force on proteins to support new paradigms for producing, managing and consuming proteins. Synergies can also be found with [EIT Food](#), the EIT [Climate-KIC](#), the food systems partnership and [PRIMA](#), which is targeting the water–food nexus.

The pathway, moreover, has synergies with additional programmes outside the sphere of Horizon Europe. These include the LIFE programme, which funds several projects on the impact of food production on the environment. Another is the Desira initiative, which aims to contribute to the climate-relevant, productive and sustainable transformation of agriculture and food systems in low- and middle-income countries, and also develops projects closely related to this pathway under its pillar 1 (R&I in agricultural and food systems). The last related programme is the European Maritime, Fisheries and Aquaculture Fund, which funded projects on seafood alternatives, among others.

⁷⁵ European Commission, Directorate-General for Research and Innovation, Group of Chief Scientific Advisors (2020), [Towards a Sustainable Food System – Moving from food as a commodity to food as more of a common good: Independent expert report](#), Publications Office of the European Union, Luxembourg.

The next two sections outline key barriers, lock-ins and enablers of change for the development and take-up of alternative proteins for a dietary shift.

3. BARRIERS AND LOCK-INS

- Disruption of the whole farming sector, especially the livestock sector, but also the arable crop sector, whose production is mainly used as feed.
- Difficult and expensive scale-up of the production of alternative proteins.
- Policy inconsistencies, with a non-negligible share of public funds directed towards unsustainable and unhealthy foods, despite Green Deal and farm-to-fork objectives.
- Regulatory issues limiting market uptake (administrative burdens, legal texts that are difficult to understand and to apply, high costs of complying with regulations, inconsistencies among Member States).
- Difficulty bringing about positive behavioural changes as a result of consumer preferences/demands that are shaped by a mix of unhealthy food environments, sociocultural and ideological forces, confusing communication, etc.
- Lack of consumer trust in novel products.
- Lack of knowledge of the sustainability and health-related impacts of some sources of alternative proteins (e.g. cultured meat, insects, fungi, microbial-based proteins, plants).
- International uncertainties (market developments, conflicts, trade issues).

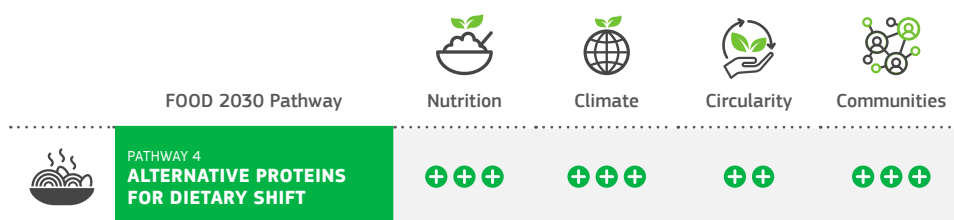
4. ENABLERS OF CHANGE

- New job opportunities and business models for food producers, processors, food services and retailers.
- More direct and indirect subsidies and other incentives, and differentiated tax regimes.
- More EU political commitment through the implementation of the European Green Deal and the farm-to-fork strategy.
- More investment in research at the European and national levels, and in communication for filling knowledge gaps and raising consumers' and food services actors' awareness.

- Empowerment of citizens to change their diets and make informed choices regarding healthier and more sustainable food.
- Enhanced connection between social/consumer science and food innovation.
- Increased awareness of the key role of the private sector and its role in rethinking/reshaping food environments.
- More support for farmers who change production habits and farming systems to focus on more sustainable and more plant-rich protein sources.
- More public food procurement to support the dietary transition through reshaping the food value chain and the food environment.

5. FOOD 2030 CO-BENEFITS

The R&I pathway ‘Alternative proteins for dietary shift’ aims to advance knowledge and solutions that foster the development of improved or new foods that incorporate or are based on alternative protein sources. Furthermore, it supports R&I that can bring about the promotion and take-up of these foods to support the shift towards predominantly plant-rich diets, and in doing so is highly connected to the Food 2030 pathway ‘Nutrition and sustainable healthy diets’. The Food 2030 ambitions underpinning this pathway have the potential to address and deliver the following co-benefits.



Nutrition and health

- Promoting healthier and more sustainable diets that reduce diet-related NCDs.
- Diversifying the offer of proteins sourced from existing and new ingredients.
- Meeting diverse, cultural and specific needs through a place-based dietary shift.

Climate and sustainability

- Reducing GHG emissions and biodiversity loss.
- Improving air and water quality.
- Reducing dependence on imports (leading to less deforestation) and external inputs (e.g. less use of chemical fertilisers), which will have positive impacts on the climate.

Circularity and resource efficiency

- Reducing land and water use and decreasing the resource footprint across all sectors.
- Reducing food waste through the potential reintroduction of by-products into the food chain as alternative protein sources (e.g. by efficiently growing microorganisms or fungi on food waste).

Innovation and communities

- Triggering innovation, new jobs, business models, value-added products and services.
- Meeting the needs, values and expectations of society, especially vulnerable groups, in a responsible and ethical way.
- Improving the resilience and performance of farming methods (e.g. soil and biodiversity protection, water management).

6. RESEARCH AND INNOVATION OUTCOMES AND FUTURE NEEDS

This section provides a snapshot of the R&I being carried out in relation to this pathway. It describes the R&I investments (European Commission financial contribution) supporting projects that have been funded as outcomes of relevant Food 2030 calls for proposals, in the context of societal challenge 2 of Horizon 2020 and cluster 6 of Horizon Europe. Furthermore, it describes the range of thematic issues covered, identifies future R&I needed and provides a summary of Food 2030 projects.

Investments

In Horizon 2020 and Horizon Europe, it is estimated that the European Commission financial contributions in this area have exceeded EUR 175 million. Out of the projects contributed to, eight projects were direct outcomes of this Food 2030 pathway, representing an investment of EUR 77 million. An additional amount of approximately EUR 16 million is also expected as a result of the 2023 and 2024 Horizon Europe topics related to this pathway.

Issues addressed

Existing EU-funded projects predominantly address the following R&I needs: filling knowledge gaps on alternative sources of protein, improving the food environment to ensure more affordable and accessible sustainable and healthy foods, understanding the drivers of consumption choices and acceptance by consumers before introducing a type of alternative protein to the market, increasing the production of alternative sources of proteins (especially plant-rich ones) and developing cultured-meat-related production.

These projects contributed to improving and increasing the production of mainly plant-rich proteins, while paying attention to environmental and nutritional impacts. A few projects focused on other types of protein sources for food, such as insects or microalgae. The level of R&I activities differs according to the source of proteins considered. Overall, alternative proteins have been studied more than dietary shifts. The projects focus mainly on production, and much less on food environment and consumer behaviour. Finally, most of the projects aim to develop knowledge. There is therefore a need to use the outcomes of research projects to (i) foster more downstream innovation and the technological scale-up and scale-out of promising results already obtained and (ii) incorporate consumers' views into new product development and innovation processes to better respond to consumer needs.

Further R&I projects are expected to be supported – as an outcome of the 2023–2024 Horizon Europe work programme calls for proposals – that target topics related to the potential impact of novel foods (including alternative protein sources) on food systems in terms of sustainability, and on the potential impacts of cultured meat and cultured seafood on environmental, economic and health-related aspects and the challenges and opportunities for the farming sector.

Future research and innovation needs

Within the context of this pathway, more efforts should be deployed on innovation and on gathering knowledge on how to foster dietary shifts towards more plant-rich diets. More specifically, there is a need to:

- develop a platform for the collection and collation of food consumption data (dietary data hub) to get a better understanding of changing dietary habits;
- develop technologies, formulation techniques and processes to foster the acceptability, affordability, availability and sustainability of products based on alternative proteins, paying attention to food composition and the processing of raw materials;
- improve the sustainable use of side stream inputs in the processing of alternative proteins, thus promoting circularity;

- study allergenicity and food intolerance related to several diets, including various sources of proteins, in different regions of the EU;
- study the nutritional adequacy, digestibility and sensory quality of alternative proteins, specifically considering the needs of the most vulnerable groups;
- explore the impact of media (including social media) and education on a shift towards diets based on alternative protein sources, especially plant-rich ones;
- strengthen education, communication, awareness and access to information (e.g. clear labelling) regarding food systems and dietary shifts;
- reduce energy and water dependency when it comes to the production and processing of alternative proteins.

Summary of relevant research and innovation projects

The Food 2030 projects relevant to this pathway include those presented in the following table.

PROJECT NAME & FUNDING INFORMATION	PROJECT AIM/OUTCOME
<p><u>NEXTGENPROTEINS</u> Bioconversion of underutilized resources into next generation proteins for food and feed</p> <p>2019–2023, EUR 8 million (Horizon 2020), IA, Food 2030</p>	<p>The project addressed key barriers that limit the use of microalgae, single-cell proteins and insects in food/feed. It plans to find means to improve acceptability to and trust on the part of consumers.</p>
<p><u>SUSINCHAIN</u> SUSustainable INsect CHAIN</p> <p>2020–2023, EUR 8 million (Horizon 2020), IA, Food 2030</p>	<p>The project contributed to novel protein provision for feed/food in Europe by overcoming the barriers to increasing the economic viability of the insect value chain and opening markets.</p>
<p><u>PROFUTURE</u> Microalgae protein ingredients for the food and feed of the future</p> <p>2021–2023, EUR 7.8 million (Horizon 2020), IA, Food 2030</p>	<p>The project focused on the market uptake of innovative, healthy and sustainable food/feed products with protein-rich microalgae ingredients.</p>

<p><u>SMART PROTEIN</u> Smart Protein for a Changing World. Future-proof alternative terrestrial protein sources for human nutrition encouraging environment regeneration, processing feasibility and consumer trust and acceptability.</p> <p>2020–2024, EUR 8.2 million (Horizon 2020), IA, Food 2030</p>	<p>The project aims to industrially validate and demonstrate innovative, cost-effective, resource-efficient, EU-produced, nutritious plant and microbial biomass proteins from edible fungi by upcycling side streams from the pasta, bakery and beer industries (bread crusts and other residues).</p>
<p><u>GIANT LEAPS</u> Gap resolution in safety, Nutritional, allergenicity and Environmental assessments to promote Alternative Protein utilization and the dietary Shift</p> <p>2022–2026, EUR 10.3 million (Horizon Europe), RIA, Food 2030</p>	<p>The project will address knowledge gaps and undertake proactive engagement to arrive at optimised future diets based on alternative proteins that are broadly accepted across stakeholder groups.</p>
<p><u>LIKE-A-PRO</u> From niche to mainstream – alternative proteins for everybody and everywhere</p> <p>2022–2026, EUR 12 million (Horizon Europe), RIA, Food 2030</p>	<p>The project aims to mainstream alternative proteins, making them accessible, available and acceptable. Key representatives along the alternative protein value chain will work together. Eleven living labs in four real-life food environments will be co-designed with citizens; 16 new alternative protein products will be developed.</p>

NB: IA, innovation action; RIA, research and innovation action.



PATHWAY 5

**FOOD WASTE AND RESOURCE-
EFFICIENT FOOD SYSTEMS⁷⁶**



1. SYSTEMIC CHALLENGES

In the roadmap to a resource-efficient Europe⁷⁷, ‘resource efficiency’ was identified as a means to improve economic performance while reducing pressure on natural resources. Food systems crucially depend on the use of natural resources and are embedded in the limits of our planet. For instance, agriculture accounts for 70 % of global surface and groundwater withdrawals, mainly for irrigation⁷⁸. The food production and supply chain accounts for about 30 % of total global energy consumption⁷⁹. Evidence shows losses of resources throughout food systems.

- Of the total global input of nitrogen and phosphorus, only 15–20 % is embedded in the food that reaches consumers, which implies large nutrient losses to the environment⁸⁰.
- Food waste⁸¹ is a fundamental issue, as the resources used to produce food that is eventually wasted are also lost. The FAO estimates that ‘around 14 percent of food produced is lost from the post-harvest stage up to, but excluding, the retail stage’⁸². The United Nations Environment Programme (UNEP) estimates that 17 % of food produced worldwide was wasted in 2019, in retail and consumption⁸³. In 2020, food waste accounted for 10 % of food supplied to EU consumers in the supply and consumption sectors⁸⁴. Food that is wasted is eventually discarded with packaging (plastic being the most common packaging material).

Those losses have negative impacts on society and the environment. In particular, losses in the ecosystems trigger air, soil and water pollution⁸⁵. In addition to its carbon footprint, the food that is harvested but ultimately lost or wasted worldwide puts pressure on resources; for example, it requires a cropland area greater than the size of China⁸⁶, and consumes about one quarter of all water used by agriculture each year⁸⁷. Those negative impacts are expected to increase globally due to population growth, the expansion of cities and dietary shifts towards more resource-intensive products (meat, dairy products, etc.).

Resource-efficient and zero-waste food systems can only be achieved through strategies decreasing (primary) resource demand by reducing overall production and

⁷⁶ With acknowledgements to Linda Salamé (European Commission) and the following independent experts (listed in alphabetical order by surname) who provided ideas and comments during and after the 10 March 2023 Food 2030 workshop in Brussels: Thomas Candéal, Céline Giner, Luis Lassaletta, Tomasz Szuba and Toine Timmermans.

⁷⁷ European Commission (2011), *Commission communication – Roadmap to a resource efficient Europe*, COM(2011) 571 final.

⁷⁸ FAO (2021), *The state of the world's land and water resources for food and agriculture – Systems at breaking point: Synthesis report 2021*, Rome.

⁷⁹ FAO (2011), *‘Energy-smart’ food for people and climate*, issue paper, Rome.

⁸⁰ UNEP (United Nations environment programme) (2016), *Food Systems and Natural Resources – A report of the Working Group on Food Systems of the International Resource Panel*, Nairobi.

⁸¹ Food waste is defined in the waste framework directive ([Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain directives](#) (OJ L 312, 22.11.2008, p. 3), amended by [Directive \(EU\) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste](#) (OJ L 150, 14.6.2018, p. 109): “food waste” means all food as defined in Article 2 of Regulation (EC) No 178/2002 of the European Parliament and of the Council that has become waste’.

⁸² FAO (2019), *The State of Food and Agriculture 2019 – Moving forward on food loss and waste reduction*, Rome.

⁸³ UNEP (2021), *Food Waste Index Report 2021*, Nairobi.

⁸⁴ In 2022, EU Member States reported the amount of food waste for all stages of the food supply chain generated in 2020 using a common methodology developed by the European Commission: Eurostat (n.d.), *‘Food waste and food waste prevention – estimates’*.

⁸⁵ UNEP (2016), *Food Systems and Natural Resources – A report of the Working Group on Food Systems of the International Resource Panel*, Nairobi.

⁸⁶ World Resources Institute (2015), *‘Climate Watch (CAIT): Country greenhouse gas emissions data’*.

⁸⁷ FAO (2013), *Food Wastage Footprint – Impacts on natural resources: Summary report*, Rome.

consumption of food while delivering the same function or benefit. This can be done through better use and valorisation of food throughout its life cycle, and through new models of service provision⁸⁸.

In this pathway, the term ‘resources’ refers to natural resources, which can be renewable or non-renewable in nature. Resource-efficient and zero-waste food systems are expected to yield the highest benefits in some specific areas of intervention, such as food waste prevention/reduction/valorisation. A shift towards reducing food losses and food waste is needed globally, as research shows that there are leakage effects of global trade that may offset all benefits of food waste reduction in the EU⁸⁹.

Dietary shifts also play an important role in achieving resource-efficient and zero-waste food systems by reorienting consumption away from resource-intensive products and from overconsumption. Dietary shift, however, is covered in the pathway ‘Alternative proteins for dietary shift’, whereas issues concerning food-system-related environmental pollution are dealt with in the zero pollution pathway.

Better resource efficiency and prevention/reduction of food losses and food waste can strengthen food systems’ resilience; for example, it can contribute to reducing the dependency on imports of food products, fertilisers and other inputs.

2. POLICY CONTEXT AND SYNERGIES

This pathway is relevant to EU policies supporting the [European Green Deal](#), in particular the [farm-to-fork strategy](#), the [biodiversity strategy](#), the [bioeconomy strategy](#), the [circular economy action plan](#), the European Climate Law, the zero pollution action plan, the [common fisheries policy](#), the [common agricultural policy](#), the [industrial strategy](#), the [internal market and tax policy](#), and environment, food safety and health policies (e.g. the [waste framework directive](#)). It is also particularly relevant to SDG 12 ‘Ensure sustainable consumption and production patterns’. To accelerate the EU’s progress towards SDG target 12.3, the Commission proposed⁹⁰ to set legally binding food waste reduction targets to be achieved by Member States by 2030: reducing waste by 10 % in processing and manufacturing, and by 30 % (per capita) at the retail and consumption stages combined (restaurants, food services and households).

This pathway has synergies with other EU R&I funding initiatives connected to Horizon Europe, such as the [Circular Bio-Based Europe joint undertaking](#), [EIT Food](#) and the [EIT Climate-KIC](#).

The pathway has synergies with additional programmes outside the sphere of Horizon Europe. These include the LIFE programme, which funds several projects on food waste prevention (e.g. awareness-raising campaigns, product specific supply chain); however,

⁸⁸ International Resource Panel, Potočník, J. and Teixeira, I. (2022), [Making Climate Targets Achievable – Improving wellbeing through reduced absolute resource use](#), co-chair opinion piece, Paris.

⁸⁹ Jafari, Y., Britz, W., Dudu, H., Roson, R. and Sartori, M. (2020), ‘[Can food waste reduction in Europe help to increase food availability and reduce pressure on natural resources globally?](#)’, German Journal of Agricultural Economics, Vol. 69, No 2, pp. 143–168.

⁹⁰ As part of the proposal for a targeted [revision of the waste framework directive](#), adopted by the Commission on 5 July 2023.

those focused more on deployment of resources to help mobilise the capacities of stakeholders and to bring new technological solutions across the 'valley of death'⁹¹ and to the market. The European Regional Development Fund and the NextGenerationEU instrument should also be considered.

The next two sections outline key barriers, lock-ins and enablers of change for increasing the resource efficiency of food systems.

3. BARRIERS AND LOCK-INS

- Bounded rationality of food stakeholders and misalignment between private gains and life cycle impacts (environmental impacts occur throughout the life cycle of food products and services, but the entire life cycle is not visible to food stakeholders, which leads to decisions with restricted or counterproductive impacts).
- Imperfect information given to food stakeholders (the consumer is unable to tell which products are resource-efficient and hence cannot make fully informed decisions).
- Embedded cultural and working practices of food stakeholders (e.g. consumers fear not having enough food on the table).
- Lack of capacity for actors in the food systems to create networks across different industries.
- Externalised costs (the environmental impacts generated by food systems have a cost but are not valued within the economy system).
- Split incentives, which happen when the actor required to make the resource efficiency investment does not receive the benefit of this investment (e.g. manufacturers do not have a direct incentive to produce food with a longer shelf life, which would benefit the consumer, as the manufacturer would potentially lose future revenue if less food were wasted (and bought)).
- At the farm level, lack of access to capital, financial constraints or slow payback times.
- Lack of awareness and of empowerment of food operators regarding the link between their choices, inefficient food systems and their environmental and socioeconomic impact.
- Trade-off considerations (e.g. food waste and dietary shifts, availability of food waste biomass for different purposes).
- Lack of global cooperation.

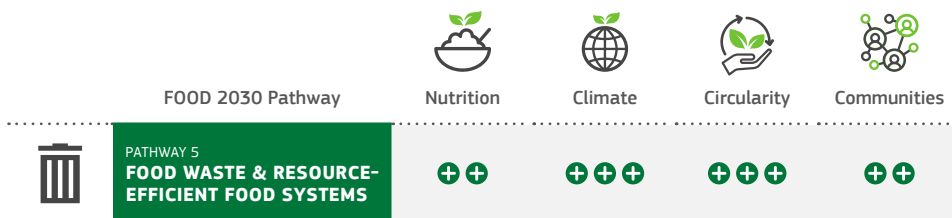
⁹¹ The 'valley of death' is a phase evident in the early stages of science-based innovation when a technology's continued development is hindered through a lack of funding and support.

4. ENABLERS OF CHANGE

- EU and national strategies, implementation plans and (voluntary) agreements.
- EU Member States' cooperation.
- Multi-stakeholder involvement.
- Sound, harmonised and transparent data and monitoring systems, and toolboxes for decision-makers.
- Improved technologies that make better use of the potential of the digital food environment to provide information to consumers⁹².
- Education, training and awareness.
- Economic, fiscal and regulatory incentives so that it is more economically viable to be resource efficient.
- Financial support to incorporate innovations into business processes.

5. FOOD 2030 CO-BENEFITS

The R&I pathway on resource-efficient food systems aims to foster new knowledge and solutions to tackle food losses and food waste and reduce the consumption of resources more generally, across food-system-related sectors and at the consumer level. The Food 2030 ambitions underpinning this pathway have the potential to address and deliver the following co-benefits.



⁹² European Commission, Directorate-General for Research and Innovation, Group of Chief Scientific Advisors (2023), [Towards Sustainable Food Consumption – Promoting healthy, affordable and sustainable food consumption choices](#), scientific opinion No 14, Publications Office of the European Union, Luxembourg.

Nutrition and health

- Healthier food from more efficient, and hence less polluted, food production systems.
- Increased food security through food waste reduction, including food recovery and redistribution programmes.

Climate and sustainability

- Reduced pressure on natural resources and ecosystems, in particular water, soil and energy.
- Climate change mitigation fostered through the reduction of GHG emissions.
- Increased availability and better use of natural resources for climate change adaptation/mitigation and biodiversity strategies.

Circularity and resource efficiency

- More efficient use of energy, water, land and soil in all food-system-related sectors.
- More circular food and bioeconomy systems, in line with the waste hierarchy and the cascading principle.
- Food surplus valorised or redistributed to people in need.

Innovation and communities

- Communities' needs (e.g. food security, health, climate adaptation, financial security) addressed in a more integrated and inclusive manner, fostering increased awareness regarding the benefits of natural resources and the need to preserve them or use them wisely in food systems.
- Technological and social innovation increased to enable sustainable use and valorisation of resources used for food production, distribution and consumption.

6. RESEARCH AND INNOVATION OUTCOMES AND FUTURE NEEDS

This section provides a snapshot of the R&I being carried out in relation to this pathway. It describes the R&I investments (European Commission financial contribution) supporting projects that have been funded as outcomes of relevant Food 2030 calls for proposals, in the context of societal challenge 2 of Horizon 2020 and cluster 6 of Horizon Europe. Furthermore, it describes the range of thematic issues covered, identifies future R&I needed and provides a summary of Food 2030 projects.

Investments

Between Horizon 2020 and Horizon Europe, it is estimated that the European Commission financial contributions in this area have exceeded EUR 170 million. Out of the projects that received contribution, nine projects were direct outcomes of this Food 2030 pathway, representing an investment of EUR 64 million. An additional amount of approximately EUR 19 million is also expected as a result of the 2023 and 2024 Horizon Europe topics related to this pathway.

Issues addressed

During the first part of Horizon Europe (2021–2024) the calls for proposals stemming from this pathway contributed mainly to the prevention and reduction of food losses and food waste by covering:

- measurement and reporting of food loss and waste (by collecting data, developing measurement/estimation methodologies and tools and providing tailored training);
- social norms (by providing evidence on the role of existing social norms in actors' food loss and waste behaviours and by fostering behavioural changes);
- effectiveness of food loss and food waste prevention interventions (by inspiring actors to use science- and evidence-based assessment tools and data to make better decisions);
- microbiomes and their potential to provide solutions in food processing, packaging and shelf-life;
- environmental impacts of food loss and waste (by assessing those impacts and better integrating food waste prevention/reduction actions into climate strategies);
- the impact of marketing standards on food waste.

Future research and innovation needs

- Insights into the relationship between changes in the efficiency and circularity of food systems, the behaviour of food systems and the availability of food waste and food surplus biomass for valorisation, including the link with trade, are essential.
- Data (scope, quality, availability, coverage, harmonisation, validation, transparency), analysis and monitoring systems (including impact assessments) must be strengthened to support stakeholders' decisions, policy developments and evaluations. We need to understand the enabling factors that facilitate frugality and unwasteful behaviour⁹³.

⁹³ Science Advice for Policy by European Academies (2023), [Towards Sustainable Food Consumption](#), Berlin.

- Tailored innovations, including social innovations, and resource-smart technologies need to be developed and/or scaled up to increase the resource efficiency and circularity of food systems on both the supply and the demand sides. This could include optimising the shelf life of food while preserving food quality and safety, ecodesigning food packaging, improving energy efficiency of processing and preserving facilities, improving monitoring systems and information flows regarding the use of natural resources in food systems, improving information knowledge and technology dissemination systems to increase the rationality of stakeholders and enable them to create symbiosis links with stakeholders, or demonstrating business cases (e.g. in living labs). In particular, the potential of microorganisms, algae, insects, seaweed and other alternative sources, but also digital technologies to fight food waste and develop alternative food products, could be unlocked.
- Actions to address the various stakeholders' lack of awareness and empowerment (e.g. consumers, chefs, farmers) regarding the link between food choices (e.g. food waste amounts), the efficiency and circularity of food systems and the smart use of natural resources are also important. For example, they could consider alternative date labels in the regulation of food information to consumers, including smart technologies⁹⁴.
- The design and implementation/enforcement of resource efficiency and circularity policies and markets should be supported/improved, guided by a systemic assessment of costs and benefits and based on positive communication (the less-is-more paradigm). This should consider the aggregate life cycle impacts of food systems and include currently externalised costs (e.g. through incentives, regulatory and/or fiscal measures).
- Member States should be supported regarding the implementation of EU-level targets for food waste reduction (e.g. through tailor-made strategies and impact evaluation).
- Effective combinations of different interventions (e.g. sequentially) should be determined⁹⁵.
- Strategies related to the resource efficiency of food systems should be better connected to climate and environmental strategies. The coordination of strategies at the global level would enable the minimisation of leakage effects linked to trade.
- International cooperation (e.g. EU–AU cooperation), including capacity building, knowledge transfer, technology transfer, investments in infrastructure and legislation, should also be enhanced.

⁹⁴ European Commission, Joint Research Centre, Candéal, T., Brüggemann, N., Bruns, H., Casonato, C., Diercxsens, C., García-Herrero, L., Gil, J. M., Haglund, Y., Kaptan, G., Kasza, G., Mikkelsen, B. E., Obersteiner, G., Pires, I. M., Swannell, R., Vainioranta, J., van Herpen, E., Vittuari, M., Watanabe, K. and Sala, S. (2023), [Tools, best practices and recommendations to reduce consumer food waste – A compendium](#), Publications Office of the European Union, Luxembourg.

⁹⁵ European Commission, Joint Research Centre, Candéal, T., Brüggemann, N., Bruns, H., Casonato, C., Diercxsens, C., García-Herrero, L., Gil, J. M., Haglund, Y., Kaptan, G., Kasza, G., Mikkelsen, B. E., Obersteiner, G., Pires, I. M., Swannell, R., Vainioranta, J., van Herpen, E., Vittuari, M., Watanabe, K. and Sala, S. (2023), [Tools, best practices and recommendations to reduce consumer food waste – A compendium](#), Publications Office of the European Union, Luxembourg.

Summary of relevant research and innovation projects

The Food 2030 projects relevant to this pathway include those presented in the following table.

PROJECT NAME & FUNDING INFORMATION	PROJECT AIM/OUTCOME
<p><u>FOLOU</u> Bringing knowledge and consensus to prevent and reduce Food Loss at the primary production stage.</p> <p>2023–2026, EUR 6.5 million (Horizon Europe), RIA, Food 2030</p>	<p>The project will use a forceful, coherent, multidisciplinary approach to set up a mechanism allowing a change based on monitoring and measuring. The action plan includes knowledge transfer to primary producers, retailers, consumers, policymakers and researchers that will enable the implementation of proposed recommendations leading to a reduction of food loss.</p>
<p><u>WASTELESS</u> Waste quantification solutions to limit environmental stress</p> <p>2023–2025, EUR 5.5 million (Horizon Europe), RIA, Food 2030</p>	<p>The project will develop and test a mix of innovative tools and methodologies for measuring and monitoring food loss and waste. The project is carrying out research activities on innovative processes and streams to valorise unavoidable food loss and waste.</p>
<p><u>ToNoWaste</u> Towards a new zero food waste mindset based on holistic assessment</p> <p>2022–2026, EUR 6.0 million (Horizon Europe), RIA, Food 2030</p>	<p>The project is conducting research and using past findings to identify social, technical, environmental, economic, political, legal, ethical and demographic drivers and hindrances. It will inspire market actors to use science- and evidence-based assessment tools and data to make better decisions.</p>
<p><u>CHORIZO</u> Changing practices and Habits through Open, Responsible, and social Innovation towards ZerO food waste</p> <p>2022–2025, EUR 6.1 million (Horizon Europe), RIA, Food 2030</p>	<p>The project will improve knowledge of how social norms (perceived rules or expectations) determine behaviour related to food loss and waste. This information will be useful for decision-makers and food chain stakeholders.</p>
<p><u>ZeroW</u> Systemic Innovations Towards a Zero Food Waste Supply Chain</p> <p>2022–2025, EUR 12.0 million (Horizon 2020), IA, Food 2030</p>	<p>The project is demonstrating diverse innovations in nine real-life food chains, employing a systemic innovation approach to effectively address the multidimensional issue of food waste.</p>

SISTERS

Systemic Innovations for a Sustainable reduction of the European food waste

2021–2026, EUR 8.3 million
(Horizon 2020), IA, Food 2030

The project will propose a set of systemic innovations aiming to reduce food loss and waste generated in every stage of the food value chain in Europe. The innovations will solve main existing challenges in production, processing, marketing (retailing/wholesaling), consumption and logistics, among other stages. It will also design the first European short-chain platform for farmers to sell their discarded produce.

NB: IA, innovation action; RIA, research and innovation action.



PATHWAY 6

THE MICROBIOME WORLD⁹⁶



1. SYSTEMIC CHALLENGES

'Microbiomes' refers to the complex communities of microorganisms – including bacteria, archaea, lower and higher eukaryotes – and viruses, along with their genetic material (i.e. genomes), and the environmental conditions that support them. They are found in, on and all around us, and are defined by the characteristic microbial community in a particular habitat⁹⁷. Microbiomes are omnipresent within the food systems and play a critical role in driving the productivity and health of soil, plants, animals (both terrestrial and aquatic) and humans. For example, in humans, a dysfunctional microbiome is linked to obesity and to some NCDs, such as certain types of cancer and diabetes. Similarly, the plant and soil microbiomes are essential for the resilience of the ecosystem. Recently, microbiome discoveries and innovations have shown important potential to transform our food systems, including improving plant nutrition uptake, promoting soil remediation, enhancing the health of livestock and opening up new avenues to ensure food safety and quality through new processing and preservation techniques. However, a major challenge for the emerging field of microbiome research is its fragmentation throughout the scientific disciplines, with cross linkages that should be improved to collectively embody a holistic approach that accurately mirrors the interconnectedness between ecosystems. Therefore, unravelling the complexity of the microbiome through interdisciplinary and holistic approaches to the relationship between a host and its microbe (holobiont) could be a game changer in advancing the transition towards sustainable and healthy food systems⁹⁸.

The study of microbiomes can revolutionise the way we approach sustainability and resilience in the food system. From the smallest microbes to the most complex ecosystems, the microbiome offers a world of possibilities for innovative solutions that support our goal of creating a healthier and more sustainable future.

The human microbiome, for instance, influences the digestion and absorption of nutrients, while the soil microbiome affects crop growth and soil health. In the ocean, the marine microbiome forms the basis of primary production on which all other biota directly or indirectly subsist. In food systems, the microbiome is relevant to food processing, preservation and safety, for example through the use of beneficial microbes in fermentation or the detection of harmful bacterial growth. Furthermore, the microbiome also affects food waste, as the microbiome influences the rate of food breakdown, and the compost microbiome contributes to the decomposition of organic matter. Finally, microbiomes can positively affect food sustainability by improving agricultural and aquaculture practices through decreased use of antibiotics or pesticides and by affecting the balance of the ecosystem.

⁹⁶ With acknowledgements to the following independent experts (listed in alphabetical order by surname) who provided ideas and comments during and after the 10 March 2023 Food 2030 workshop in Brussels: Catherine Bessy, Magdalena Fraç, Marta Hugas, Emmanuelle Maguin, Yolanda Sanz and Amine Zorgani.

⁹⁷ Marchesi, J. R. and Ravel, J. (2015), 'The vocabulary of microbiome research: a proposal', *Microbiome*, Vol. 3, 31.

⁹⁸ Meisner, A., Wepner, B., Kostic, T., van Overbeek, L. S., Bunthof, C. J., de Souza, R. S. C., Olivares, M., Sanz, Y., Lange, L., Fischer, D., Sessitsch, A. and Smidt, H. (2022), 'Calling for a systems approach in microbiome research and innovation', *Current Opinion in Biotechnology*, Vol. 73, pp. 171–178.

One of the major challenges in incorporating microbiome research into well-established regulations is the lack of a robust pool of data or evidence. While significant progress has been made in understanding microbiomes' role in human health and various industries, there is still much to learn about the complex and dynamic interactions within microbial communities. The lack of comprehensive and standardised data poses a challenge to establishing clear and evidence-based regulations. Efforts are under way to fill this gap, such as the creation of microbiome research consortia, databases and analytical tools. However, it is important to continue to prioritise research and data collection to ensure evidence-based decision-making.

Recent advances in genomics, bioinformatics and biotechnology have opened new avenues of exploration and discovery, providing researchers with the tools they need to unlock the secrets of the microbiome. By delving deeper into the inner workings of this complex world, we can gain a better understanding of the intricate relationships between microorganisms and their environment and hosts, and how they can be harnessed to support a more sustainable food system and, thereby, improve human health.

With the right investment and collaboration, the microbiome has the power to transform the food system into a healthier, more sustainable and more resilient one for the generations to come.

2. POLICY CONTEXT AND SYNERGIES

Owing to difficulties in communicating its importance, microbiome research is generally not given high priority on the political agenda. Nevertheless, various initiatives are taking place and political decisions are being taken that include or are relevant to microbiomes. These include the policy objectives of the [Green Deal](#), the [farm-to-fork strategy](#), the [biodiversity strategy](#), the [bioeconomy strategy](#) and the SDGs; the update of four implementing regulations (in November 2022) amending the [current rules on plant protection products relevant to micro-organisms](#); the proposal for a [regulation on substances of human origin](#), which will include other substances such as human microbiomes; the inclusion of the [one health](#) approach in the work of [various EU agencies and research institutes](#); the microbiome working group of the [International Bioeconomy Forum](#), which guides cooperation at the global level; and the [human microbiome action](#) coordinating and maximising the impact of European microbiome R&I.

This pathway is also building various synergies and relates to the activities of Desira, which aims to contribute to the climate-relevant, productive and sustainable transformation of agriculture and food systems in low- and middle-income countries. European Cooperation in Science and Technology actions, the LIFE programme, Horizon Europe's missions (e.g. 'A soil deal for Europe', 'Restore our ocean and waters') and PRIMA have also funded several projects on microbiomes, metagenomics and holobiont.

The next two sections outline key barriers, lock-ins and enablers of change for the development and take-up of holistic microbiome approaches for sustainable food systems.

3. BARRIERS AND LOCK-INS

- Microbiome research is still separated and fragmented to concentrate on separate scientific fields instead of interconnections between fields and ecosystems, which hinders the implementation and scale-up of innovations.
- Microbiome research cuts across traditional domains, technical disciplines and economic sectors, which adds to the complexity of potential innovations and also of policies or EU legislation⁹⁹.
- EU legislation often focuses on individual microorganisms instead of complex communities and ecosystem effects.
- Microbial-based products can fall under several regulatory regimes in the food and medical areas: there is no direct transition from the food safety and health claims perspective to the therapeutic and drug development perspective.
- The weight of evidence is still limited regarding fully incorporating the human gut microbiome as an end point in risk and safety assessments of compounds entering the food chain, and therefore to be reflected adequately in specific EU regulations.
- There is limited availability of and access to high-quality microbiome data, which can be costly and time-consuming to generate, therefore hindering the development of new microbiome-based therapies and applications.
- There is a confounding complexity to microbial communities and a lack of standard analysis methods. The microbiome is a complex system that consists of diverse microbial species, which interact with each other and with the host organism in a dynamic and multifaceted manner. This complexity can make it difficult to develop standardised methods for data collection, analysis and interpretation.
- There is limited understanding of the functional roles of specific microorganisms and microbial networks in the gut and other ecosystems, which can make it difficult to identify targets for preventive or therapeutic interventions.
- There are complex interactions between host genetics, environmental factors and the microbiome, which pose a significant challenge to the development of personalised microbiome-based predictive, preventive or therapeutic solutions.

⁹⁹ FAO (2019), [Microbiome: The missing link? Science and innovation for health, climate and sustainable food systems](#), Rome.

- The field of microbiome research is relatively new, and the necessary expertise in bioinformatics and data science is still developing. Development of analytical tools and pipelines for data flow is necessary to extract meaningful insights from complex microbiome data.
- There are currently disparities in access to microbiome research and applications across different populations, such as those in low-income or rural areas. Addressing these disparities and ensuring equitable access to microbiome research and applications is an important systemic challenge to consider.
- When developing microbiome-related innovations, it is crucial to take a holistic approach and weigh the risks and benefits. While the microbiome holds great promise for improving human health, food and the environment, there are potential risks associated with microbiome interventions that must be carefully considered. For example, the use of antibiotics and other antimicrobial agents in humans, animals and the environment can disrupt the balance of the host microbiome and lead to the development of antibiotic-resistant strains of bacteria. Similarly, the introduction of non-native microbial species into an ecosystem can have unintended consequences and affect the natural balance of microbial communities.

4. ENABLERS OF CHANGE

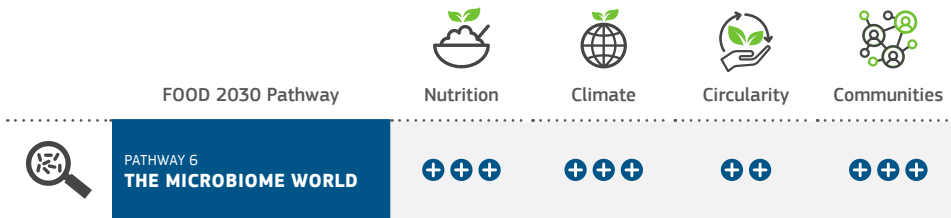
- Understanding potential challenges when using microbiomes in food-related applications enables us to calculate risks and benefits for environmental, agricultural, animal and human health, and to make informed decisions and raise awareness.
- Investigating the exact role of microbiomes in human health and the food system and fostering an interdisciplinary holobiont approach will enable safe and reliable microbiome innovations.
- Investigating the gaps in the infrastructure (informatics, databases, biobanks) for long-term storage of results from microbiome research to share knowledge and data will be key, as will establishing biobanks across disciplines.
- Funding and support for the development of new technologies and methodologies can improve the efficiency and accuracy of microbiome data collection and analysis.
- Designing reliable and clear regulatory frameworks for microbiome-based products will enable faster introduction of new innovations to the market. Similarly, clear regulatory frameworks for evaluating the effects of new products such as new

proteins, novel foods and cell-based products on the healthy microbiome will allow the assessment of any dysfunctionality.

- Facilitating communication and collaboration between regulatory bodies can streamline the regulatory process for microbiome-based food and feed products.
- Support should be provided for a holistic approach towards microbiome research that enables actions on integrated research connecting different ecosystems, and the health of their hosts and environments.
- Fostering collaborations with international research institutions can broaden the scope of research and include underrepresented populations, especially African countries, in microbiome studies.
- Furthering holobiont-based research to understand the host and its associated microbiota as one unit will help to better understand complex interactions and co-evolution processes.
- Understanding the role, origin and diversity of microbiomes will increase knowledge within several fields for industrial applications and the circular economy.
- Political visibility of and commitment to fostering microbiome-based solutions for sustainable food systems and the bioeconomy should be increased at the EU and global levels.
- Microbiome-based products that are based on diverse microbial communities, have minimal ecological impact and promote the use of natural microbiome-based products that are sustainable and environmentally friendly should be promoted.
- Collaborations between researchers and the public should be fostered to promote knowledge sharing and address misunderstandings and miscommunications regarding microbiome-based products and interventions.
- Increasing public awareness and understanding of the microbiome's role in food safety, nutrition and sustainability, and its potential to generate economic benefits, is important.

5. FOOD 2030 CO-BENEFITS

The Food 2030 ambitions underpinning this pathway have the potential to address and deliver the following co-benefits.



Nutrition and health

- Steering our health trajectory. The food we ingest carries microbiomes that in turn influence our human gut microbiome and determine our health status and well-being. The resulting microbiome intersections can modify the healthy properties of the nutrients we eat and enhance or impair the functioning of our metabolic, neuroendocrine and immune systems.
- **Regulating the immune response, protecting us from harmful pathogens or chronic inflammation, facilitating digestion, regulating fat storage and synthesising vital vitamins.** When our microbiome is out of balance, it can be a precursor to altered stress responses and disease, including depression, cancer, obesity and type 2 diabetes.
- **Understanding the link between antimicrobials and other drugs and microbiomes.** This is critical to fighting antimicrobial resistance. By developing new ways to protect and restore the microbiome and measuring its impact on our health risks, we can take important steps towards safeguarding our health and well-being.

Climate and sustainability

- Establishing and maintaining healthy microbial communities in the soil to support the productivity of our agricultural systems; break down organic matter from, for example, food waste; cycle nutrients; and support plant health, growth and development.
- Using microbiomes as biopesticides to protect crops from harmful pests and diseases, thus reducing our reliance on harmful chemical pesticides and moving towards more sustainable and environmentally friendly agriculture.
- Combating climate change, as these omnipresent communities of microorganisms

are responsible for producing and consuming the three most important GHGs: CO₂, CH₄ and N₂O.

Circularity and resource efficiency

- Breaking down food waste, creating new materials and generating renewable energy, thus playing a key role in circular bioeconomy.
- Breaking down plastics, absorbing CO₂ from the atmosphere and treating complex pollutants in wastewater.

Innovation and communities

- Fostering innovation and creating new entrepreneurship opportunities by using microbiome applications to drive the creation of new jobs and business models.
- Adapting and deploying microbiome applications at local and regional scales, thereby providing opportunities for place-based innovation, enabling these localised efforts to enhance economic development and creating a ripple effect throughout the broader economy.
- Using microbiome applications for the creation of new markets, especially in areas such as biotechnology, agriculture, aquaculture, nutrition and healthcare.

6. RESEARCH AND INNOVATION OUTCOMES AND FUTURE NEEDS

This section provides a snapshot of the R&I being carried out in relation to this pathway. It describes the R&I investments (European Commission financial contribution) supporting projects that have been funded as outcomes of relevant Food 2030 calls for proposals, in the context of societal challenge 2 of Horizon 2020 and cluster 6 of Horizon Europe. Furthermore, it describes the range of thematic issues covered, identifies future R&I needed and provides a summary of Food 2030 projects.

Investments

Microbiome R&I existed prior to Food 2030 and was relevant to various thematic areas, including those beyond food systems, such as health and the environment. Between Horizon 2020 and Horizon Europe, it is estimated that the European Commission financial contributions in this area have exceeded EUR 600 million. Out of the projects contributed to, nine projects were direct outcomes of this Food 2030 pathway, representing an investment of EUR 77 million. An additional amount of approximately EUR 19 million is also expected as a result of the 2023 and 2024 Horizon Europe topics related to this pathway.

Issues addressed

The EU has been actively funding projects aimed at addressing various aspects of microbiome research and development. Notably, a significant portion of these have focused on the development of novel and improved microbiome products, services and processes for use in food and animal feed. These projects are geared towards promoting sustainable food systems and the one health approach, which highlights the interconnectivity between human, animal and environmental health. Furthermore, they are geared towards harnessing the potential of hologenomic or multi-omic approaches, which aim to understand the interactions between the host and its associated microbiome by getting a more complete picture of how a biological system works.

Horizon 2020 projects address the development of microbiome innovations for sustainable food and healthy and sustainable diets and unravel the interactions between microorganisms. Moreover, Horizon Europe topics in the 2023–2024 work programme focus on food waste through innovative microbiome-based packaging, microbiomes as indicators of food safety and usage of microbiomes for new tastes and flavours to encourage a dietary shift. Most of the projects deriving from these topics will be innovation actions (IAs) fostering the biotechnological scale-up and scale-out of various microbiome-based applications.

Future research and innovation needs

To fully realise the potential of microbiome solutions for sustainable and healthier food systems, it is crucial to focus on scaling up these solutions and embracing holobiont and 'one microbiome' approaches, following the principles of the one health approach, which can support adaptative climate change, energy savings and resilience, along with healthier and nutritious food systems. To this end, several areas warrant more attention and investment.

- Microbiome solutions have the potential to address a range of environmental challenges, including plastic pollution, wastewater management and rising CO₂ levels.
 - **Breaking down plastic waste and converting it into useful by-products such as biofuels or biodegradable materials.** This approach has the potential to not only reduce plastic pollution, but also create new sources of sustainable materials and energy. It can be addressed through the work of the Circular Bio-Based Europe joint undertaking.
 - **Treating and purifying wastewater, removing contaminants and pollutants and producing clean water for reuse.** This approach can help to conserve water resources and reduce the impact of wastewater on the environment.
 - **Capturing and storing CO₂, either through biological processes or by engineering microbes to produce useful products from CO₂.** This has the

potential to not only reduce GHG emissions, but also create new sources of sustainable food and non-food products and materials.

- Omics technologies have revolutionised our understanding of the microbiome and enabled the study of complex microbial communities at an unprecedented scale. However, there are several important factors to consider when using these technologies to study the holobiome. Exploring omics technologies for studying the holobiome requires careful consideration of microbial and non-microbial interactions, their impact on the host and the quality of the data generated.
- The development of microbiome biobanks and the promotion of data sharing require a range of measures for ensuring that the data generated from different sources are consistent and reliable. They can also be used for providing standard protocols and quality control measures. Similarly, the improvement of the infrastructure and the data-sharing platforms can facilitate the exchange of data and promote collaboration among researchers and stakeholders. This work could be aligned with the work performed by the European Strategy Forum on Research Infrastructures.
- The impact of media and education for communicating the importance of microbiome and holobiont R&I should be reinforced.
- Advances are also needed in understanding the microbiome's role in environmental health, such as in air and water quality. Developing a better understanding of the interactions between the microbiome and the environment could have important implications for public health and policy and could be addressed through the zero pollution pathway.

Summary of relevant research and innovation projects

The Food 2030 projects relevant to this pathway include those presented in the following table.

PROJECT NAME & FUNDING INFORMATION

PROJECT AIM/OUTCOME

CIRCLES

Controlling mIcRobiomes CircuLations for bEtter food Systems

2018–2024, EUR 10.0 million
(Horizon 2020), IA, Food 2030

CIRCLES aims to discover and translate innovative, microbiome-tailored circular actions into concrete applications that will ultimately enhance EU food systems' performances and their overall sustainability. The set-up of real-world labs in six food systems relevant to the EU market – tomatoes, spinach, poultry, pigs, Atlantic salmon and sea bream aquacultures – will enable CIRCLES to increase knowledge of the importance of food system microbiomes as determinants of productivity, quality, safety and sustainability.

<p><u>MASTER</u> Microbiome Applications for Sustainable food systems through Technologies and EnteRprise</p> <p>2019–2023, EUR 11.0 million (Horizon 2020), RIA, Food 2030</p>	<p>MASTER took a global approach to the development of concrete microbiome products, foods/feeds, services or processes with high commercial potential, which will benefit society through improving the quantity, quality and safety of food, across multiple food chains. The project developed marine, plant, soil, rumen, meat, brewing, vegetable waste and fermented food microbiome outputs, among others. It did so by mining microbiome data related to the food chain, developing big data management tools to identify interrelations between microbiomes across food chains, and generating applications that promote sustainability and circularity and contribute to waste management and climate change mitigation.</p>
<p><u>SIMBA</u> Sustainable innovation of microbiome applications in food system</p> <p>2018–2023, EUR 10.0 million (Horizon 2020), IA, Food 2030</p>	<p>SIMBA will first launch an in silico phase in order to analyse the pre-existing microbiome databases and earlier studies to identify the best microbiome layout capable of supporting food chain quality and productivity. Microbiome-tailored interventions will be specifically developed, including soil, plant, fish, aquaculture and food/feed processing, for optimal layout, as defined in the modelling step.</p>
<p><u>HoloFood</u> Holistic solution to improve animal food production through deconstructing the biomolecular interactions between feed, gut microorganisms and animals in relation to performance parameters</p> <p>2019–2022, EUR 9.9 million (Horizon 2020), IA, Food 2030), IA, Food 2030</p>	<p>The project focused on salmon and chicken, two critically important farmed animal systems. It characterised not only their associated microorganisms' genomes, transcriptomes and metabolomes but also how the microbiome interacts with animals' genomes and transcriptomes within the new holo-omic framework in relation to key performance indices and animal welfare issues to optimise feed additives.</p>
<p><u>MicrobiomeSupport</u> Towards coordinated microbiome R&I activities in the food system to support (EU and) international bioeconomy goals</p> <p>2018–2022, EUR 3.5 million (Horizon 2020), CSA, Food 2030</p>	<p>MICROBIOMESUPPORT was one of the key drivers of implementing Food 2030 strategies by coordinating the activities, meetings, workshops and results of the International Bioeconomy Forum Food Systems Microbiome Working Group. The main concept behind MICROBIOMESUPPORT was to boost the bioeconomy and the Food 2030 strategy by focusing on the new avenues generated by microbiome R&I efforts.</p>

<p><u>HealthFerm</u> Innovative pulse and cereal-based food fermentations for human health and sustainable diets</p> <p>2022–2026, EUR 11.3 million (Horizon Europe), IA, Food 2030</p>	<p>HealthFerm will disentangle the interaction of food fermentation microbiomes, grain-based foods and the human gut microbiome with health. It will use microbial resources and fermentation technology to develop healthy pulse- and cereal-based food and diets that cater to the desires and needs of EU citizens.</p>
<p><u>DOMINO</u> Harnessing the microbial potential of fermented foods for healthy and sustainable food systems</p> <p>2023–2028, EUR 10.8 million (Horizon Europe), IA, Food 2030</p>	<p>DOMINO will investigate the health impacts of a fermented-food-based diet on a healthy population and a cohort suffering from metabolic syndrome to better focus on health biomarkers. The project will provide tailor-made microbial solutions using an integrated omics strategy and computational biology modelling to address the challenges associated with sustainable food production and healthy nutrition.</p>
<p><u>WHEATBIOME</u> Unravelling the potential of the wheat microbiome for the development of healthier, more sustainable and resilient wheat-derived food & feed products</p> <p>2023–2026, EUR 5.1 million (Horizon Europe), IA, Food 2030</p>	<p>The WHEATBIOME project will contribute to the understanding of the role of the wheat microbiome in sustainable development by undertaking cutting-edge research with strong collaboration between academia, industry, food system actors and governmental authorities distributed across six EU countries. It will explore the role of microbiomes in wheat production systems in a broad approach from soil to plate.</p>
<p><u>TRIBIOME</u> Advanced tools for integration and synergistic inTeRconnection of microBIOMes in resilient food systems</p> <p>2023–2026, EUR 4.9 million (Horizon Europe), IA, Food 2030</p>	<p>TRIBIOME aims to advance alignment with the Green Deal and the farm-to-fork strategy by deepening the knowledge of soil/plant/animal and human microbiomes, and their interrelationships and interconnections, so that they can play a leading role in the resilience of food production systems in the near future. TRIBIOME will address the main challenges, such as the need to minimise resources, reduce the environmental impact and promote a healthy and plant-based food chain while feeding a constantly growing world population under the paradigm of climate change.</p>

NB: CSA, coordination and support action; RIA, research and innovation action; IA, innovation action



PATHWAY 7

NUTRITION AND SUSTAINABLE HEALTHY DIETS¹⁰⁰



1. SYSTEMIC CHALLENGES

The provision of healthy, culturally adapted food and diets is central to healthy lives and well-being. A healthy diet, however, may not be enough as we strive towards living within planetary boundaries. This pathway thus fosters a dietary shift towards sustainable healthy diets and nutrition, where both sustainability and health aspects are intricately linked. What people eat is very much linked to cultural preferences and geographical circumstances. In recent years, however, globalisation has brought about a greater uniformization of diets, at times at the expense of local diet diversity, health and environmental sustainability concerns. Diets and nutrition represent a field where there is fragmented policy action and much misinformation and hence they would benefit from building a stronger science–policy–society interface.

Unhealthy diets lead to malnutrition, which comes in many forms: under-nutrition, over-nutrition and nutrient deficiencies, often referred to as the ‘triple burden of disease’. Malnutrition affects all regions of the world, all ages, all socioeconomic groups and both sexes. No country is untouched by it, with all experiencing at least one form of malnutrition, which can lead to stunting, wasting, overweight and obesity, among other physical impacts on human health. This pathway focuses on nutrition and dietary shifts within the context of Europe and its cultural diet diversity.

Facts and figures

- **Stunting.** Worldwide, this affects 149 million children under 5 years of age.
- **Overweight and obesity.** These affect nearly 39 million children and over 2.2 billion people (women have a higher prevalence of obesity than men: 16.2 % compared with 12.3 %) ¹⁰¹.
- **Unhealthy diets.** In total, 3 billion people cannot afford a healthy diet.
- **Hunger.** Between 720 million and 811 million people in the world faced hunger in 2020, and close to 193 million people are acutely affected by food insecurity and in need of urgent assistance across 53 countries/territories ¹⁰².

Unhealthy diets – usually combining several factors such as an excess of fats, salt, sugars, animal-based products, and calorie-dense, nutrient-poor and (hyper-)processed foods – have been associated with a negative impact on health, and with leading to obesity and the risk of NCDs. Common NCDs include cardiovascular illnesses, stroke, cancer and diabetes, which are causes of human suffering and premature deaths. Risk of NCDs can be reduced through effective education and interventions that tackle risk factors such as unhealthy diets, physical inactivity, harmful alcohol consumption and smoking.

¹⁰⁰ With acknowledgements to Zuleika Saz Parkinson (European Research Executive Agency) and Ariane Vander Stappen (European Commission) and the following independent experts (listed in alphabetical order by surname) who provided ideas and comments during and after the 10 March 2023 Food 2030 workshop in Brussels: Carsten Carlberg, Laura Fernandez Celemin, Carlos González Navarro, Gert Meijer, and Jasmina van Driel.

¹⁰¹ European Commission (n.d.), ‘[Knowledge Centre for Global Food and Nutrition Security](#)’.

¹⁰² European Commission, Knowledge Centre for Global Food and Nutrition Security (2023), ‘[Brief me on “Nutrition”](#)’.

Other diet-related illnesses – such as inflammatory bowel disease, food allergies and food intolerances – are also increasing worldwide. Furthermore, according to the EFSA the micronutrient deficiencies of vitamins and minerals (e.g. vitamin D, iodine) associated with unhealthy dietary patterns, combined with a growing elderly population, are also part of the systemic challenges to be addressed. In addition to affecting people's physical health, malnutrition affects people's mental health, well-being and ability to work. Elderly people with chronic diseases, more vulnerable population groups or those who are socially isolated are particularly at risk. Many communities, especially those in low-income groups, do not have access to a variety of healthy food options, making it difficult for individuals to make nutritious choices and lead healthy lives¹⁰³. Moreover, healthy food options tend to be more expensive than less healthy alternatives, making them less accessible to low-income individuals and families¹⁰⁴.

The healthcare burden of diet-related diseases has a large influence on European public health. Burden-of-disease studies provide the means to measure the impact of morbidity and mortality on populations. The most comprehensive study of this kind, the Global Burden of Disease study, has been undertaken by the World Health Organization (WHO) and the Institute for Health, Metrics and Evaluation. The 2017 Global Burden of Disease study estimates that over 91 % of deaths and almost 87 % of disability-adjusted life years (a measure of the years of healthy life lost) in the EU in 2017 were the result of NCDs¹⁰⁵.

Importantly, most of these diet-related diseases and deaths are preventable. However, progress in tackling all forms of malnutrition remains slow, and it is expected that the number of malnourished people has increased, particularly in low- and middle-income countries, because of the COVID-19 pandemic, the multiplication of conflicts and extreme climate events.

To match the ambition and needs of sustainable healthy diets for all, there also needs to be a reciprocal change in terms of what we grow, what food we process and how, how food environments are designed, and our overall relationship to food and food systems. Fostering healthy diets, however, may not be enough, as we must also strive towards living within planetary boundaries. This pathway thus fosters a dietary shift towards sustainable healthy diets and nutrition, where both sustainability and health aspects are intricately linked. To also meet planetary boundaries and reduce the carbon and environmental footprint of what we eat, a dietary shift towards more plant-rich diets that are sourced from sustainable, healthy and tasty food, accessible to all, is an important way forward.

¹⁰³ Evans, A., Banks, K., Jennings, R., Nehme, E., Nemeč, C., Sharma, S., Hussaini, A. and Yaroch, A. (2015), '[Increasing access to healthful foods: a qualitative study with residents of low-income communities](#)', International Journal of Behavioural Nutrition and Physical Activity, Vol. 12 (Suppl. 1), S5.

¹⁰⁴ Daniel, C. (2020), '[Is healthy eating too expensive?: How low-income parents evaluate the cost of food](#)', Social Science & Medicine, Vol. 248, 112823.

¹⁰⁵ European Commission, Health Promotion and Disease Prevention Knowledge Gateway (2021), '[EU burden from non-communicable diseases and key risk factors](#)'.

The transformation to healthy diets by 2050 will require substantial dietary shifts. This includes more than doubling the consumption of healthy foods such as fruits, vegetables, legumes, seeds and nuts, and a reduction of more than 50 % in the global consumption of less healthy foods, such as added sugars and red meat¹⁰⁶.

If sustainable healthy diets are not accessible, affordable and appetising, however, they will not be easily adopted. Given that dietary behaviours and food preferences are established early in life, it is important to ensure that healthy habits are established in this period of life. However, food environments, which include all forms of marketing, labelling, markets and retail spaces and restaurants, have an overwhelming influence on our food and dietary choices even as we age, so rethinking and redesigning these is an important leverage point for fostering positive behavioural changes and responsible consumer and personal choices.

Achieving sustainable healthy diets and nutrition requires a systemic approach involving all the main actors – from primary producers to food processors, retailers, food service providers, healthcare professionals, educators, consumers and policymakers. R&I in this area will play an important role in providing the necessary knowledge for effective changes.

In particular, this pathway will foster advances for the development of sustainable and healthy functional foods and food reformulation, and advances to support a dietary shift towards plant-rich diets in the post-farm sectors and with a view to strengthening the cooperation with health sectors, thus improving health promotion and public health overall.

2. POLICY CONTEXT AND SYNERGIES

This pathway is relevant to EU policies such as the [common agricultural policy](#), the [common fisheries policy](#), the [European Green Deal](#), the [farm-to-fork strategy](#), the [EU White Paper on a strategy for Europe on nutrition, overweight and obesity-related issues](#), [Europe's beating cancer plan](#) and the [EU mission 'Cancer'](#).

As a follow-up of the 2021 UNFSS, international coalitions for actions have emerged to support the transformation of food systems. Among them, two specifically relate to nutrition: the [School Meals Coalition](#) and the [Coalition of Action on Healthy Diets from Sustainable Food Systems for Children and All](#). The European Commission is a member of these two coalitions.

This pathway has synergies with other EU R&I funding initiatives connected to Horizon Europe, in particular those linked to health and disease prevention addressed

¹⁰⁶ EAT–Lancet Commission (2019), [Healthy Diets from Sustainable Food Systems – Food planet health](#), summary report of the EAT–Lancet Commission.

predominantly in cluster 1 of Horizon Europe, including the EU mission ‘Cancer’. It also has synergies with EIT Food through its EIT Food mission programme on healthier lives through food.

Moreover, the pathway has synergies with additional programmes and work streams outside the sphere of Horizon Europe such as those implemented by the European Health and Digital Executive Agency. The agency implements [EU4Health](#), the largest programme to boost health around the EU, and implements the single market programme on food. The Joint Research Centre has also developed the [Health Promotion and Disease Prevention Knowledge Gateway](#), which provides numerous briefs on nutrition and diet-related topics.

This pathway focuses on nutrition and the shift towards sustainable healthy diets. Its focus is predominantly on the European context, taking account of its geographic and cultural diversity. Nutrition and diets outside Europe are addressed by the ‘Food systems Africa’ pathway. This pathway is closely connected to the pathway ‘Alternative proteins for dietary shift’, which aims to increase the availability and take-up of alternative proteins, given their potential to positively impact health and environmental sustainability.

The next two sections outline key barriers, lock-ins and enablers of change for the development and take-up of sustainable and healthy diets and nutrition.

3. BARRIERS AND LOCK-INS

- There is a lack of education on the link between lifestyle (including diet), nutrition, health and sustainability. The health literacy of the general population in Europe needs to be drastically increased. Moreover, people are not aware of the true cost of food and of aspects such as environmental impacts, the public health burden, climate change, sustainability, biodiversity, production and socially fair trading.
- The lack of affordable healthy food options makes it difficult for individuals to make nutritious choices and to improve their diets.
- There is a lack of interdisciplinary, multidisciplinary and transdisciplinary R&I for healthy and nutritious diets.
- The lack of interdisciplinarity and transdisciplinarity among healthcare professionals leads to missing out on benefits of food and diets for health, well-being and disease prevention. In this context, training healthcare professionals more intensely on nutrition is essential to change mindsets about healthy and sustainable diets.

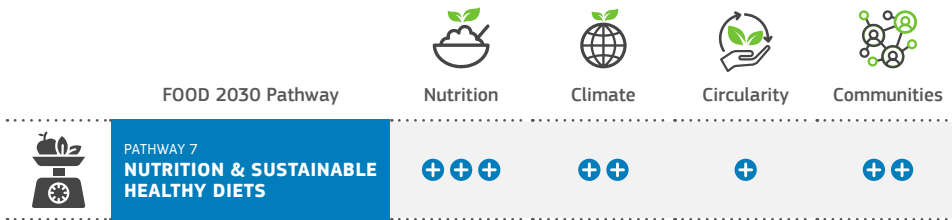
- There is a lack of appropriate research infrastructure, standardised methodologies and monitoring systems to collect, connect, compare and share data in relation to nutrition and diets.
- Regarding legal and intellectual property rights procedures in Europe, there is a need to speed up innovation and reduce the time to market of relevant food products (reformulation, functional foods, etc.).

4. ENABLERS OF CHANGE

- Political commitment and development of a common policy on sustainable healthy diets that are accessible and affordable for all.
- Exploration of healthy and sustainable alternatives to current animal meat protein sources.
- Drastic improvements of education and communication throughout food systems, schools and healthcare services and centres.
- Common mandatory front-of-pack nutrition and sustainability labelling schemes at the EU level.
- Nutrient profiles under the EU claims regulation to prevent misleading nutritional and health claims, and flexible and quick processes for approval through clearer guidelines.
- EU and national food-based dietary guidelines for healthy and sustainable diets, considering the specificities of vulnerable groups.
- More action on factors influencing consumer choices to educate and empower them to make conscious and responsible choices and to make the healthy choice the easy choice, starting with children and offering education on food.
- Provision of food that is affordable, appetising, convenient and adapted for older people.
- Open science, exchange of data, and research infrastructure to collect, connect, compare and share data on food and nutrition.

5. FOOD 2030 CO-BENEFITS

The Food 2030 ambitions underpinning this pathway have the potential to address and deliver the following co-benefits.



Nutrition and health

- Education on and raising awareness of food choices and the impact of diets and nutrition on preventing diseases, rethinking food supply, leading to more responsible and sustainable food consumption patterns, and also triggering innovation for new products, markets and business models.
- Promotion of good health and synchronising well-balanced diets and healthy eating behaviours with sustainable habits to ensure that the healthy option is also the easy option.
- Reformulation of food products towards nutritious, safe and healthy food products by including ingredients that are naturally rich in fibre – such as wholegrains, legumes, nuts and seeds, fruit and vegetables and alternative protein sources based on, for example, microorganisms, insects or plant-based raw materials rich in protein, such as legumes – to improve the availability of food choices and, at the same time, ensure optimal nutrition in the long term.
- Deeper knowledge of fermented foods in terms of both health and sustainability.

Climate and sustainability

- Diets and nutritional considerations linked to environmental sustainability and climate contributing to lower green house gas emissions.
- Development of food chains with environment-friendly food processing and local and seasonal practices, thus improving the sustainability and diversity of options.

Circularity and resource efficiency

- More responsible food consumption overall, fostering demand-driven sustainable diets.

Innovation and communities

- Improved synergies connecting food and health systems in local communities, resulting in more innovative and culturally adapted products and services.
- Healthy and affordable food for all, leading to improved social inclusion and equity, especially for the most vulnerable groups.

6. RESEARCH AND INNOVATION OUTCOMES AND FUTURE NEEDS

This section provides a snapshot of the R&I being carried out in relation to this pathway. It describes the R&I investments (European Commission financial contribution) supporting projects that have been funded as outcomes of relevant Food 2030 calls for proposals, in the context of societal challenge 2 of Horizon 2020 and cluster 6 of Horizon Europe. Furthermore, it describes the range of thematic issues covered, identifies future R&I needed and provides a summary of Food 2030 projects.

Investments

In Horizon 2020 and the initial calls of Horizon Europe, the EU invested about EUR 116 million in the areas related to this pathway by supporting more than 13 projects (including both Food 2030 and non-Food 2030-related projects).

Issues addressed

Existing EU-funded projects predominantly address the following R&I needs: malnutrition in elderly people, childhood obesity, personalised nutrition, the use of sweeteners, sustainable food choices in schools and dietary behaviour.

These R&I projects contribute to improving knowledge of nutrition and its relationship with health, improving knowledge of the risk and benefits of alternative products to sugar, improving the healthy choices at schools and developing smart personalised nutrition systems tailored to different types of population.

Further R&I projects are expected to be supported as an outcome of the 2023–2024 Horizon Europe work programme calls for proposals targeting topics including R&I activities to eradicate micronutrient deficiencies in the EU and the development of new healthy and sustainable food products and processes.

This pathway has strong scientific links with the ‘The microbiome world’, ‘Alternative proteins for dietary shift’ and ‘Food safety systems of the future’ pathways.

Future research and innovation needs

There is a need for a stronger R&I focus on co-benefits between diets, food nutrition and health and sustainable food production and processing.

R&I should further invest in developing knowledge and solutions for healthy, affordable, appetising, sustainable and nutritious food and diets for all, leaving no one behind. It should deepen our knowledge of how foods and diets can contribute to good health and prevent chronic metabolic diseases and how such foods and diets can also reduce the environmental impact of foods systems. It should also foster behavioural changes to help citizens lead healthy lives and make well-informed positive dietary choices.

Further R&I is also needed to study and better understand the impact of new dietary patterns (e.g. veganism, eating proteins from cell cultures) on health and disease prevention from a holistic point of view.

The development of healthy, sustainable dietary habits and food and taste preferences can be better supported for infants and young children (including those still breastfeeding).

Harmful alcohol consumption is an area of concern and there is a need to find ways to improve the situation.

The need to develop new fermented products in relation to sustainable healthy diets is also an important area of innovation.

Future R&I needs to support research on the human (gut) microbiome (see the Food 2030 microbiome pathway), individual postprandial responses to different food items, the crucial impact of a functional immune system, and mental illnesses and NCDs. The utilisation of big data and the development of digital tools in nutrition bears the potential to facilitate this need.

Sustainable, healthy and more nutritious diets in the future will have to include new food products, services (e.g. smartphone apps) and processes to overcome current unsustainable practices.

Summary of relevant research and innovation projects

The Food 2030 projects relevant to this pathway include those presented in the following table.

PROJECT NAME & FUNDING INFORMATION

PROJECT AIM/OUTCOME

<p><u>STOP</u> Science and Technology in childhood Obesity Policy</p> <p>2018–2022, EUR 9.6 million (Horizon 2020), RIA, Food 2030</p>	<p>STOP generated timely, comprehensive and policy-relevant measures of childhood obesity in all European countries; it generated new transdisciplinary evidence of the role of key determinants of childhood obesity, emphasising the role of different environments surrounding children..</p>
<p><u>COCREATE</u> Confronting Obesity: Co-creating policy with youth</p> <p>2018–2023, EUR 9.7 million (Horizon 2020), RIA, Food 2030</p>	<p>The project intends to generate knowledge and innovative tools for assessing policy implementation, strategies for empowering adolescents and strategies for identifying, implementing and monitoring relevant policy programmes that are applicable to stakeholders involved in the European efforts to tackle childhood obesity.</p>
<p><u>NUTRISHIELD</u> Fact-based personalised nutrition for the young</p> <p>2018–2023, EUR 7.2 million (Horizon 2020), IA, Food 2030</p>	<p>The project developed an innovative framework that assists people to implement better nutrition choices. The platform is based on information collected from clinical trials on young people with obesity and/or diabetes, studies of preterm infants and information on the role of nutrition on cognitive development.</p>
<p><u>PREVENTOMICS</u> Empowering consumers to PREVENT diet-related diseases through OMICS sciences</p> <p>2018–2022, EUR 7.0 million (Horizon 2020), IA, Food 2030</p>	<p>The project objectives included the integration of genetic, nutritional and psychological data with metabolomic technologies and computational modelling to evaluate the incidence of disease-inducing factors on the organism.</p>
<p><u>STANCE4HEALTH</u> Smart Technologies for personAlised Nutrition and Consumer Engagement</p> <p>2018–2023, EUR 6.3 million (Horizon 2020), IA, Food 2030</p>	<p>The project worked on the development of a smart personalised nutrition system tailored to different target groups, from healthy adults to overweight children and individuals suffering from coeliac disease or allergies.</p>
<p><u>PROTEIN</u> Personalized nutriTion for hEalthy livINg</p> <p>2018–2022, EUR 7.0 million (Horizon 2020), IA, Food 2030</p>	<p>The objective was to create a system based on internet communication technology for personalised nutrition using analysis of dietary behavioural patterns, physical activity and individual parameters.</p>

<p><u>SWEET</u> Sweeteners and sweetness enhancers: Impact on health, obesity, safety and sustainability</p> <p>2018–2023, EUR 9.0 million (Horizon 2020), RIA, Food 2030</p>	<p>The SWEET project was designed to (i) identify and address the barriers to and facilitators of the use of sweeteners and sweetness enhancers and (ii) examine the risks and benefits of using them to replace sugar in the diet in the contexts of health, obesity, safety and sustainability.</p>
<p><u>PLANEAT</u> Food systems transformation towards healthy and sustainable dietary behaviour</p> <p>2022–2026, EUR 11.4 million (Horizon Europe), RIA, Food 2030</p>	<p>PLANEAT will enable 58 500 consumers to transition to healthier and sustainable dietary patterns by 2032, reducing premature mortality by 20 % and GHG emissions of local food supply chains by 23 % in 39 areas.</p>
<p><u>FEAST</u> Food systems that support transitions to hEalthy And Sustainable dieTs</p> <p>2022–2027, EUR 11.7 million (Horizon Europe), RIA, Food 2030</p>	<p>FEAST aims to support the EU's just transition to healthy diets produced by sustainable food systems.</p>
<p><u>SWITCH</u> Switching European food systems for a just, healthy and sustainable dietary transition through knowledge and innovation</p> <p>2023–2026, EUR 10.4 million (Horizon Europe), RIA, Food 2030</p>	<p>The overarching goal of the SWITCH proposal is to improve understanding of knowledge, accessibility and facilitation gaps that limit present large-scale adoption of sustainable and healthy diets among European citizens and to develop and demonstrate appropriate innovative solutions and tools to facilitate a just transition towards healthy and sustainable dietary behaviour at all levels of the multi-actor food system in the EU.</p>
<p><u>CoDiet</u> Combatting diet related non-communicable disease through enhanced surveillance</p> <p>2023–2026, EUR 7.3 million (Horizon Europe), RIA, Food 2030</p>	<p>The overarching aim of CoDiet is to develop a series of tools that will address the current gaps in our knowledge and lead to the development of a tool that will assess dietary-induced NCD risks.</p>

NB: RIA, research and innovation action; IA, innovation action.



PATHWAY 8

FOOD SAFETY SYSTEMS OF THE FUTURE¹⁰⁷



1. SYSTEMIC CHALLENGES

Ensuring food safety throughout the food chain in the context of food systems is crucial. The EU has one of the world's safest food systems, assuring a high level of food safety, animal health and welfare, and plant health. The foundation for this is the General Food Law and related legislation. Moreover, the EFSA, which is responsible for risk assessment, scientific advice and support, is also constantly developing its methodologies for the risk assessment of new technologies and potentially emerging hazards in the food system.

Consumers must have confidence that the food they buy is safe, wholesome and nutritious. Guaranteeing that food sold in the EU remains safe is at the centre of a Europe that protects. EU food safety rules empower citizens, businesses and policymakers to ensure a safe, prosperous and sustainable Europe. Transparent, continuous and inclusive risk communication is required, involving risk assessors and risk managers, to support and maintain European citizens' confidence in agri-food products and in the food system. The global population growth will require the EU to also address potential food safety and food security challenges by developing and ensuring more sustainable and resilient food systems. Safe food is the basis for healthy diets and sustainable food systems, yet in the EU alone 40 000 cases of food-borne outbreaks are reported each year¹⁰⁸.

The traceability of food and feed throughout the food chain underpins food safety and is paramount for the protection of consumers, particularly when food and feed are found to be faulty. The incorporation of new technologies (e.g. blockchain) to manage food system traceability is still promising from the point of view of food chain transparency and integrity. Intentional infringements of EU agri-food chain legislation may hinder the functioning of the EU single market and may also constitute a risk to human, animal or plant health, to animal welfare or to the environment. In addition, fraud affects businesses and consumers. The consequences are often financial, but food fraud is a complex issue that can have other potential implications (e.g. a loss of consumer trust, as they are being misled).

While major efforts are continuously made in terms of EU food safety and traceability, food safety remains a global concern, with related social and economic costs being unacceptably high. According to EFSA reports, the number of reported food-borne outbreaks in the EU in 2021 was 4 005, with 32 543 related (human) cases of illness, 2 495 hospitalisations and 31 deaths¹⁰⁹.

According to the annual report from the Alert and Cooperation Network for 2022, the number of notifications exchanged by the Agri-food Fraud Network related to suspicions of fraud reached a total of 600 cases, a significant increase from 2021 (407). Honey and royal jelly (representing 15.7 % of the total cases) was the most reported category.

¹⁰⁷ With acknowledgements to Valerio Abbadessa (European Commission), Alice Pignacca (European Commission) and the following independent experts (listed in alphabetical order by surname) who provided ideas and comments during and after the 10 March 2023 Food 2030 workshop in Brussels: Stephan Bronzwaer, Pamela Byrne, Veronica Lattanzio, Begoña Ruiz, Felix Sancho and Bernd-Alois Tenhagen.

¹⁰⁸ Average number of cases for 2017–2021, data calculated from the EFSA dashboard: EFSA (n.d.), 'Foodborne outbreaks – dashboard'.

¹⁰⁹ EFSA (n.d.), 'Foodborne outbreaks – dashboard'.

Suspicious regarding meat and meat products (other than poultry) and fish and fish products each represented 7.7 % of the notifications. Concerning the origin of the products reported in the system, 72.7 % concerned goods coming from the EU and 26.7 % from outside the EU¹¹⁰.

Food safety issues are pertinent to all food system sectors, from farm to fork. Each actor in the system has a responsibility to ensure that stringent safety standards are met so that the final product is healthy. Unsafe food can result from contamination by bacteria, viruses, fungi, parasites, chemicals and prion contamination, which can lead to issues ranging from spoilage to global health threats.

In the context of ensuring safe food for sustainable food systems, it is also important to consider the impact of climate change on food production and processing, logistics and storage, food handling and food waste. By taking a holistic approach to food safety, it is possible to address issues such as food and nutrition security and environmental sustainability throughout the bioeconomy lens, while ensuring that the food we consume is safe and healthy, and production processes become sustainable. Therefore, food safety is closely interlinked with food security, that is, alternative protein sources can also raise food safety issues (i.e. allergenicity).

The one health approach, which stands for an integrated and systemic approach to health, provides a new way of working to connect and integrate knowledge, data and expertise across a wide range of disciplines, sectors and actors. To best protect human, animal, plant and environmental health, food risk assessment needs to keep up with the latest developments in science and technology (capitalising on data), invest in future preparedness, support the transition towards sustainable food systems, increase the importance of risk assessments in society, team up with food safety actors across the EU and beyond and apply the one health approach¹¹¹.

The food safety systems of the future can contribute to building resilience by reducing, monitoring and preventing the number of food-borne infectious outbreaks.

2. POLICY CONTEXT AND SYNERGIES

In a policy context, the 'Food safety systems of the future' pathway is relevant to health, food and nutrition security policies, the policy objectives of the [EU Green Deal](#), the [farm-to-fork strategy](#), the [bioeconomy strategy](#), the [chemical strategy for sustainability](#) and the [communication on food security](#), among others.

¹¹⁰ European Commission (n.d.), [The EU Agri-Food Fraud Network](#).

¹¹¹ Devos, Y., Bray, E., Bronzwaer, S., Gallani, G. and Urt, B. (2022), [Advancing food safety: strategic recommendations from the "ONE – Health, Environment & Society – Conference 2022"](#), EFSA Journal, Vol. 20, No 11, e2011101.

At the global level, this pathway is relevant to the [FAO–WHO Codex Alimentarius committees](#)’ activities and SDGs 2, 3, 12, 13, 14 and 15.

This pathway has synergies with other EU R&I funding initiatives connected to Horizon Europe and the EU missions ‘[A soil deal for Europe](#)’ and ‘[Adaptation to climate change](#)’. It is also an issue integrated into various Horizon Europe partnerships, including the [European Partnership for the Assessment of Risks from Chemicals](#), the European Partnership for Animal Health and Welfare, the [European Partnership on Metrology](#) and the [Sustainable Food Systems Partnership for People, Planet and Climate](#).

The food safety pathway also has synergies with additional programmes and work streams outside the sphere of Horizon Europe and relevant to the activities of the European Commission Joint Research Centre and EU agencies such as the EFSA, which are key partners contributing to a robust SPI in this area.

With respect to synergies across Food 2030 pathways, food safety is also partly addressed in the ‘Food systems Africa’ and ‘Food from the oceans and freshwater resources’ pathways.

The next two sections outline key barriers, lock-ins and enablers of change for the further development and improvement of food safety.

3. BARRIERS AND LOCK-INS

- Limited investment in R&I to advance regulatory science and technological innovation in food safety and risk assessment and therefore a lack of harmonised and holistic methods to properly monitor and conduct research.
- Lack of data or lack of accessibility, comparability and interoperability of data collected under different frameworks (e.g. by authorities and food business operators), especially in various areas of risk assessment.
- Data gaps between data producers and data handlers, sometimes working in silos, and lack of transdisciplinary competences to facilitate communication.
- Lack of incentives, benefits or gains regarding sharing data and making data available, for example for risk assessment purposes.
- Complexity of production and trade systems involving a multitude of actors within and outside the EU.

4. ENABLERS OF CHANGE

- **Constant political commitment to fostering safe and sustainable food systems.** This includes the EU Green Deal, in particular the farm-to-fork strategy, the chemicals strategy for sustainability, the biodiversity strategy, the communication on food security and the communication on the new European innovation agenda.
- **Enhanced transparency of and engagement in EU food safety risk assessment data and processes, and enhanced risk communication.** This includes the transparency regulation amending the General Food Law, and the harmonisation of risk assessment frameworks.
- **Digital innovation.** This will allow progress in areas such as traceability, transparency, process control, risk prediction and assessment, and risk communication and may support reducing the administrative burden on small and medium-sized enterprises (SMEs). It will also be important to develop the SMEs' technological progress through, for example, the European digital innovation hubs.
- **Novel technologies.** This covers the use of technologies that will help to improve the safety, authenticity and traceability of food systems (e.g. blockchain, digital twins, smart sensor systems and data visualisation), and the use of photonics for improved and rapid detection systems, biosensors, omics techniques (metabolomics, proteomics, lipidomics, metagenomics, etc.), AI, biotechnology and synthetic biology, surface and material science, hygienic design of food processing equipment and facilities, new preservation technologies, innovative packaging technologies, etc.
- **Education and training.** This includes the transdisciplinary education and mobility of experts to build a generation of experts who can use evidence from different disciplines, and the achievement of food safety literacy for the consumer and in society.
- **Creativity and systems thinking.** This includes the wider adoption of a systems thinking approach to design processes able to find solutions to address societal, organisational and human challenges. It involves enhancing a creativity culture around the food safety systems of the future.
- **A more holistic and strengthened science–policy–society interface.** This will support food safety and fight food fraud.

5. FOOD 2030 CO-BENEFITS

The Food 2030 ambitions underpinning this pathway have the potential to address and deliver the following co-benefits.



Nutrition and health

- Contributing to public health through the supply of healthy and nutritious food that is not subject to accidental contamination across the entire food supply chain.
- Avoiding and fighting food fraud, thereby ensuring the integrity of food authenticity.
- Fostering public trust in food system operators.

Climate and sustainability

- Ensuring food remains safe under changing climate conditions that can affect cold storage and cause a shortage of water, potential power failures, flooding or supply chain interruptions.
- Ensuring harmful pathogens and chemicals do not enter and propagate in the natural environment.
- Increasing food systems' resilience to climate with novel food safety technologies.

Circularity and resource efficiency

- Valorising safe food waste side streams for edible and non-edible ingredients or by-products, thus contributing to a circular bioeconomy.
- Incorporating risk–benefit analysis in socioeconomic analysis of more efficient, circular and sustainable production and food-processing technologies.

Innovation and communities

- Raising consumers' and citizens' awareness of how to avoid food safety risks at home.

- Contributing to new advances in regulatory science and risk assessment to support policymaking and testing strategies that enable hazard and risk assessments that are reliable and animal-free.
- Developing and deploying innovative technologies and practices, including digital solutions to improve process control, thus helping industries and communities to foster improved food safety.

6. RESEARCH AND INNOVATION OUTCOMES AND FUTURE NEEDS

This section provides a snapshot of the R&I being carried out in relation to this pathway. It describes the R&I investments (European Commission financial contribution) supporting projects that have been funded as outcomes of relevant Food 2030 calls for proposals, in the context of societal challenge 2 of Horizon 2020 and cluster 6 of Horizon Europe. Furthermore, it describes the range of thematic issues covered, identifies future R&I needed and provides a summary of Food 2030 projects.

Investments

Food safety R&I has a long tradition in EU R&I funding and has benefited from considerable investments. In Horizon 2020 and the initial calls of Horizon Europe, the EU invested about EUR 160 million in this area by supporting more than 20 projects (including both Food 2030 and non-Food 2030 related projects).

Issues addressed

Existing EU-funded projects predominantly address the following R&I needs: technologies for food chain control and transparency, consumers and food safety, risk management, food and authenticity fraud, and food safety stakeholder platforms.

These projects contribute to improving the transparency of food systems, improving knowledge of food safety hazards and increasing knowledge of risk management.

Further R&I projects are expected to be supported as an outcome of the 2023–2024 Horizon Europe work programme calls for proposals targeting topics including new genomic techniques, technology transfer for food safety and food fraud, and the influence of climate change on food safety.

Future research and innovation needs

- Focused research is needed on food safety regulatory science for the future, including risk assessment methodologies and decision-supporting process, optimisation and modelling tools.

- R&I is needed on prediction through modelling, identification, assessment and management of existing and emerging food safety issues across food systems and their interconnectedness, including food safety and food security links with the effects of climate change. This will involve embedding the idea of preparedness, that is, how to be anticipatory and how to be flexible and reactive.
- There is a need for a stronger focus on co-benefits between food safety, nutrition, health, microbiome and sustainable food production and processing. The one health approach¹¹² can prevent outbreaks of zoonotic diseases in animals and people, improving food safety and security, and so contributing to co-benefits and systems thinking. R&I is needed to support the implementation of a one health approach; to integrate knowledge, data and expertise across a wide range of disciplines, sectors and actors; and to attain optimal health outcomes that account for the inextricable link between the health of humans, animals, plants and their shared environment. This will enable assessments that support the necessary transition to sustainable food systems.
- Research is needed that supports the resilience of food systems in the areas of food safety and food fraud (i.e. early detection and fast and efficient response to food-borne outbreaks, and the application of digital modelling and optimisation tools).
- Improved systems are needed for the prevention of food contamination with foreign materials, chemicals or pathogens. This will include the use of AI-based models and advanced in-line detection systems (i.e. taking advantage of new photonic technologies).
- There is a need for alternatives to antimicrobials to be used in farming, food processing, production or packaging. They must be safe, effective and precise in their action so that they do not affect the beneficial microbiome that may be present.
- Sustainable packaging systems and materials that can extend shelf-life while maintaining food quality and safety should be developed, with a specific focus on new alternatives to plastic, including waste-derived materials.
- Improved systems are needed for the determination of safety, authenticity and traceability in the food system. So are systems assuring the accessibility and interoperability of data. This will involve applying big data science, AI and blockchain technologies to food safety, food fraud and traceability.
- There is a need for live monitoring of food safety in the food chain, for example through digital twins and smart sensors in bioreactors for cultured meat, which indicate the nutritional content, efficiency and other quality metrics.

¹¹² Devos, Y., Bray, E., Bronzwaer, S., Gallani, G. and Url, B. (2022), [Advancing food safety: strategic recommendations from the "ONE – Health, Environment & Society – Conference 2022"](#), EFSA Journal, Vol. 20, No 11, e201101.

- The concept of real-time release testing should be imported from the pharmaceutical manufacturing domain to create new data streams and technologies and speed up our application process by providing bilateral and auditable communication on quality control, even during the production process.
- There is a need to understand food safety issues related to new food sources (novel foods, insects, alternative proteins, cultivated meat, seafood, reuse of side stream products, etc.), while supporting food security and sustainability.
- Better understanding is needed of the impact of microplastics on public health throughout food systems.
- There is a need to foster targeted education and capacity building for future food safety experts, risk assessors, food value chain operators and consumers in collaboration with Member States.

Summary of relevant research and innovation projects

The Food 2030 projects relevant to this pathway include those presented in the following table.

PROJECT NAME & FUNDING INFORMATION	PROJECT AIM/OUTCOME
<p><u>FoodSafety4EU</u> Multi-stakeholder platform for food safety in Europe</p> <p>2021–2023, EUR 3.0 million (Horizon 2020), CSA, Food 2030</p>	<p>Among other objectives, this project aims to create a platform for stakeholder engagement on food safety.</p>
<p><u>SAFFI</u> Safe food for infants in the EU and China</p> <p>2020–2024, EUR 4.0 million (Horizon 2020), RIA, Food 2030</p>	<p>This project plans to improve risk-based food safety management of biohazards through omics and predictive microbiology.</p>
<p><u>DITECT</u> Digital technologies as an enabler for a continuous transformation of food safety system</p> <p>2020–2023, EUR 4.1 million (Horizon 2020), RIA, Food 2030</p>	<p>This project aims to develop a standard-based, modular, big-data-enabled platform capable of predicting the food safety parameters of food products based on data collected in real time using cost-efficient sensors and incorporating blockchain processes.</p>

<p><u>HOLIFOOD</u> Holistic approach for tackling food systems risks in a changing global environment</p> <p>2022–2026, EUR 6.1 million (Horizon Europe), RIA, Food 2030</p>	<p>The project will apply a systems approach, which takes the whole environment in which food is being produced into account, including its economic, environmental and social aspects.</p>
<p><u>FOODSAFER</u> A joined-up approach to the identification, assessment and management of emerging food safety hazards and associated risks</p> <p>2022–2026, EUR 5.3 million (Horizon Europe), RIA, Food 2030</p>	<p>This project will develop an open and accessible digital hub as a one-stop-shop vehicle targeted at risk managers and assessors, food safety authorities, and relevant actors and stakeholders.</p>
<p><u>TRUSTyFOOD</u> Stakeholders-driven Pathways for blockchain implementation in the agri-food sector</p> <p>2022–2025, EUR 3.0 million (Horizon Europe), CSA, Food 2030</p>	<p>The project will investigate and discuss technical aspects and non-technical barriers to blockchain technologies deployment, standardisation and regulatory issues. It will develop a white paper.</p>
<p><u>THEROS</u> An integrated toolbox for improved verification and prevention of adulterations and non-compliances in organic and geographical indications food supply chain</p> <p>2023–2025, EUR 4.0 million (Horizon Europe), IA, Food 2030</p>	<p>This project will develop low-cost, digital and scalable solutions that rely on Earth observation, photonics, the internet of things and DNA authenticity methods in order to ensure efficient detection of food fraud and ensure product quality and sustainability.</p>
<p><u>ALLIANCE</u> A holistic framework in the quality Labelled food supply chain systems' management towards enhanced data Integrity and verAcity, interoperability, traNsparenCy, and tracEability</p> <p>2022–2025, EUR 3.8 million (Horizon Europe), IA, Food 2030</p>	<p>This project aims to develop innovative technology solutions (e.g. internet-of-things sensing devices, in situ portable rapid testing devices to detect adulteration and verify food origin and authenticity) and to foster evidence-based decision-making tools through AI.</p>

Watson

A holistic framework with anticounterfeit and intelligence-based technologies that will assist food chain stakeholders in rapidly identifying and preventing the spread of fraudulent practices

2023–2026, EUR 9.7 million
(Horizon Europe), IA, Food 2030

The project plans to demonstrate, in six use cases, the following objectives: (i) the prevention of counterfeit alcoholic beverages, (ii) preserving the authenticity of honey that has protected geographical identification status, (iii) introduction of on-site authenticity checks and proof of the traceability of olive oil, (iv) the identification of possible manipulations at all stages of the meat chain, (v) the improved traceability of high-value products in the cereal and dairy chain and (vi) combating salmon counterfeiting.

NB: CSA, coordination support action; RIA, research and innovation action; IA, innovation action.



PATHWAY 9

FOOD SYSTEMS AFRICA¹¹³



1. SYSTEMIC CHALLENGES

Africa has the world's fastest growing population, which has more than doubled from 477 million in the 1980s to over 1.3 billion today¹¹⁴. While birth rates have started declining, it is expected that the population will nearly double to over 2.5 billion by 2050¹¹⁵. Africa also has the youngest population in the world, with 400 million people between 15 and 35 years¹¹⁶. This high population growth is connected with rapid urbanisation. It is estimated that 59 % of people will live in cities by 2050¹¹⁷. These combined trends have resulted in a number of opportunities and challenges in relation to food and nutrition security and sustainable food systems.

On the positive side, the market for food in Africa is expanding rapidly, largely fuelled by an increasing middle class¹¹⁸. By 2030, food demand is projected to increase, bringing the size of Africa's food and agribusiness to EUR 0.94 trillion¹¹⁹ and opening up employment opportunities all across food systems. Local African supply chains dominate the domestic food markets, with an estimated 90 % of all consumed food supplied by local producers, a substantial number of them being small-scale producers, which explains why 50 % of (sub-Saharan) Africa's working population is still engaged in agriculture¹²⁰. Female labour input into crop production ranges from 56 % in Uganda to 24 % in Niger, with an average of 40 % across the six countries where data are available¹²¹. Nevertheless, the African Development Bank estimates that Africa's annual import bill of food will triple from EUR 35 billion in 2017 to about EUR 110 billion in 2025¹²².

On the negative side, Africa's food systems are increasingly affected by soil degradation and climate change, which imply difficult conditions for agriculture, biodiversity and food security. Africa was and still is faced with disrupted supply chains resulting from the COVID-19 pandemic and Russia's war of aggression against Ukraine, which have added further pressure on Africa's sustainability and food security ambitions. The need to strengthen the resilience of African food systems and actors is more important than ever in order to reduce the dependency on imports and increase food security by strengthening local production systems. This is linked to the necessity for diversification of cultivation through the promotion of agroecological or nature-based solutions to keep soil healthy in the absence of costly bulk artificial fertiliser supply, diversification that could come from innovation and new markets, through the development of circular economies and the creation of new value chains that would directly reduce the food system's vulnerability to

¹¹³ With acknowledgements to the following independent experts (listed in alphabetical order by surname) who provided ideas and comments during and after the 10 March 2023 Food 2030 workshop in Brussels: Irene Annor-Frempong, Aida Bakri, Gertrud Buchenrieder, Gabriela Quiroga and Genna Tesdall.

¹¹⁴ UN, Department of Economic and Social Affairs, Population Division (2019), [World Population Prospects 2019 – Highlights](#), New York.

¹¹⁵ UN, Department of Economic and Social Affairs, Population Division (2022), [World Population Prospects 2022 – Summary of results](#), New York.

¹¹⁶ [Data refer to the AU](#).

¹¹⁷ UN, Department of Economic and Social Affairs, Population Division (2019), [World Urbanization Prospects: The 2018 revision](#), New York.

¹¹⁸ African Development Bank (2011), ['Africa's middle class triples to more than 310 m over past 30 years due to economic growth and rising job culture, reports AfDB'](#), 10 May 2011.

¹¹⁹ Beegle, K. G., Hentschel, J. S. and Rama, M. G. (2012), [World Development Report 2013 – Jobs](#), World Bank Group, Washington, D.C.

¹²⁰ World Bank (n.d.), ['Employment in agriculture \(% of total employment\) \(modeled ILO estimate\) – sub-Saharan Africa'](#), based on International Labour Organization, Ilostat (n.d.), 'ILO modelled estimates database'.

¹²¹ World Bank (2018), ['Women, agriculture and work in Africa'](#).

¹²² Africanews (2017), ['Why is Africa importing \\$ 35 bn in food annually? – AfDB boss asks'](#), 21 April 2017.

disruptions¹²³. Furthermore, African women are still disproportionately affected by poverty, and the COVID-19 pandemic has exacerbated gender inequalities¹²⁴.

Malnutrition, in all its forms, remains a big challenge and constitutes one of the greatest obstacles to equitable economic and social development. For instance, malnutrition is responsible for a 10 % loss in gross domestic product every year¹²⁵. No single African country is on track to achieve all the global nutrition targets by 2030. Africa remains the worst-affected region, with one in five people facing hunger on the continent, more than twice the global average¹²⁶. Different forms of malnutrition (stunting, micronutrient deficiency, overweight and obesity) can coexist within the same country, and sometimes within the same household or individual, and thus they must all be addressed together. Food and nutrition security is a matter of not only quantity but also access to food, food safety and nutritional quality. In 2020, about 46 million more people in Africa were undernourished than in 2019, bringing the total number of people affected by hunger in Africa to 282 million¹²⁷. Furthermore, the FAO estimates that one third of food is lost or wasted across the whole supply chain, and in Africa this food loss mostly occurs at the farm level¹²⁸. Climate change could also lead to an increase in migration. The World Bank estimates that by 2050 sub-Saharan Africa could see as many as 86 million internal climate migrants¹²⁹.

2. POLICY CONTEXT AND SYNERGIES

The pathway ‘Food systems Africa’ is relevant to EU policies such as the [EU Green Deal](#) and, in particular, the [farm-to-fork](#), [biodiversity](#) and [bioeconomy](#) strategies.

It is also part of the European Commission priority for a stronger Europe in the world, and its [global gateway strategy](#). Strengthening R&I cooperation between the AU and the EU is a key priority, as R&I contributes to sustainable and inclusive development, economic growth and job generation, thereby reducing poverty and inequalities. This is also set out in important policy decisions, such as the establishment of the [African continental free trade area](#); the [AU agenda 2063](#), the [2024 science, technology and innovation strategy for Africa](#); and the [EU communication on the comprehensive strategy with Africa](#).

At the global level, the pathway is relevant to the SDGs included in the UN 2030 agenda, namely SDGs 2, 3, 12, 14 and 15.

This pathway is part of the EU–AU R&I partnership on [FNSSA](#), which was identified as the first priority of the [AU–EU HLPD on Science, Technology and Innovation](#). It is pursuing

¹²³ Karoliina, R., Jyrki, A., Kalle, A. and Pasi, R. (2023), ‘[The elements of resilience in the food system and means to enhance the stability of the food supply](#)’, Environment Systems and Decisions, Vol. 43, pp. 143–160.

¹²⁴ According to new African country gender profiles developed by the African Development Bank.

¹²⁵ High Level Panel of Experts on Food Security and Nutrition (2017), [Nutrition and Food Systems – A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security](#), Rome.

¹²⁶ UN World Food Programme (2023), [The State of Food Security and Nutrition in the World \(SOFI\) Report – 2023](#).

¹²⁷ FAO, International Fund for Agricultural Development, United Nations Children’s Fund, World Food Programme and WHO (2021), [The State of Food Security and Nutrition in the World 2021 – Transforming food systems for food security, improved nutrition and affordable healthy diets for all](#), Rome, FAO.

¹²⁸ FAO (2011), [Global Food Losses and Food Waste – Extent, causes and prevention](#), Rome.

¹²⁹ World Bank (2021), ‘[Millions on the move in their own countries: the human face of climate change](#)’, 13 September 2021.

a 10-year roadmap (2016–2026)¹³⁰ with four priorities: (i) sustainable intensification, (ii) agriculture and food systems for nutrition, (iii) expansion and improvement of agricultural trade and markets and (iv) a group of cross-cutting topics. The [Leap4FNSSA project](#) supported the coordination and policy development of the FNSSA priority. It developed the concept of an international research consortium on FNSSA. The AU–EU International Research Consortium was launched in September 2022 and will provide a mid- to long-term partnership platform for African and European institutions to eliminate fragmentation. It will address knowledge management and communication, provide mechanisms for continuous dialogue and action among actors in food systems at different geographical levels and improve coordination structures.

The pathway is also closely related to the activities of SCAR, in particular the SCAR strategic working group on European agricultural research towards greater impact on global challenges. Synergies can also be found with the co-funded ERA-NETs (A long term EU–Africa research and innovation partnership on food and nutrition security and sustainable agriculture ([LEAP-AGRI](#)); and Food system and climate (FOSC): assessing the impact of climate change on food and nutrition security and designing more sustainable and resilient food systems in Europe and beyond ([FOSC](#))), the Horizon Europe Sustainable Food Systems Partnership for People, Planet and Climate, the Horizon Europe missions (e.g. ‘A soil deal for Europe’) and the PRIMA targeting the water–food nexus.

Moreover, the pathway has synergies with additional programmes outside the sphere of Horizon Europe. These include the AU research grants programme and the EU’s Desira initiative, which aims to contribute to the climate-relevant, productive and sustainable transformation of agriculture and food systems in low- and middle-income countries. Desira also develops projects closely related to this pathway under its pillar 1 (R&I in agricultural and food systems).

The next two sections outline key barriers, lock-ins and enablers of change for fostering sustainable, healthy and inclusive food systems and nutrition in Africa.

3. BARRIERS AND LOCK-INS

- Lack of linkages between research platforms/initiatives and food system actors/innovators.
- Poor dialogues on the research–policy–business–society interfaces.
- Lack of linkages between EU Member States’ and AU member states’ initiatives on different food policies.

¹³⁰ Africa–EU Partnership (2016), [Roadmap towards a jointly funded EU–Africa research & innovation partnership on food and nutrition security and sustainable agriculture](#), Addis Ababa.

- Difficulty finding the right balance between place-based solutions and scaling-up opportunities through regionalisation and globalisation.
- Insufficient regional approaches on strategic topics and themes to deal with.
- Lack of integrated regional food system policies addressing conflicts of pastoral and arable systems and their access to resources and markets.
- Poorly developed, not climate-resilient, food value chains.
- Inefficient essential infrastructure, including transportation, electricity, water and sanitation, which are treated as urban and rural development projects separate from food system interventions, but are the essential foundation of many food system interventions.
- Lack of rural advisory agents and organisations, which is holding back progress in food systems; rural advisory services also often focus specifically on the farm level, but food systems have an increasing need for rural advice covering all parts of the food value chain.
- Lack of capacity and political will of existing governance structures.

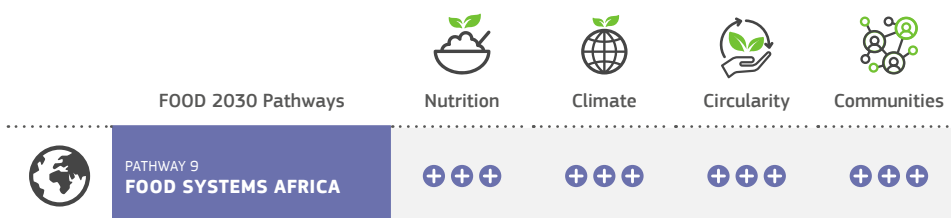
4. ENABLERS OF CHANGE

- New and revitalised jobs and food system leadership opportunities, including revitalised rural–urban food connections, and provision of attractive jobs (livelihoods) and income for farmers and other actors in the rural/urban food system.
- R&I cooperation in the FNSSA priority of the EU–AU collaboration.
- Innovation accelerators integrated into R&I projects and programmes.
- Recent political commitments to positive changes at the EU and global levels, including in the EU Green Deal, the farm-to-fork strategy, the UNFSS follow-up and the African continental free trade area.
- Integration and consistency of agricultural and health policies in nutrition-sensitive food policies.
- Continuous research on sustainable food environments, food cultures and household food choices, supporting healthy nutrition and sustainable lifestyles.

- Development of food processing value chains, including in rural areas, within reach of farming settings and pastoral communities.
- Development of collaboration models and technical support of food system actors.
- Integrated regional food policies addressing the needs and opportunities of pastoral and arable systems and alleviating conflicts and security risks through innovative solutions for resource and market access.
- Public–private partnerships to encourage women and youth entrepreneurs through blended finance mechanisms, with public funding as a de-risking mechanism to encourage private investments in food systems.
- Science diplomacy as a vehicle for transformation that facilitates cross-border collaborations and partnerships to address global challenges.
- A large and increasingly educated youth population generally open to change and enthusiastic about creating positive changes in food systems.
- Youth empowerment and engagement in the food system transition and their roles as agents of positive changes.
- Food system scenario mapping and foresight studies enabling transitions to long-term actionable outcomes.
- The African continental free trade area, with the associated easing of administrative burdens within the free trade zone.

5. FOOD 2030 CO-BENEFITS

This pathway has the potential to address and deliver the following Food 2030 co-benefits.



Nutrition and health

- Fewer food contaminants, in particular pesticide residues and mycotoxins, implying greater food safety and fewer zoonotic and food-borne diseases.
- Improved nutrition through nutrition-sensitive agriculture, including agro-silvo-pastoral practices and the use of overlooked types of foods, legumes and vegetables/fruits.
- Promotion of good health and healthy lifestyles and reduction of risk factors for diet-related NCDs.

Climate and sustainability

- Better environmental footprint in the food systems through leveraging agroecology and nature-based solutions, promoting R&I on chemical-pesticide-free solutions, and achieving lower GHG emissions through improved agroecological practices.
- Responsible and sustainable consumption and production, while ensuring economic and sociocultural sustainability.
- Savings in fossil energy resources through promoting renewable energy and improving transport, processing and logistics through strengthened local food systems.

Circularity and resource efficiency

- Use of traditional preservation techniques such as drying and fermentation to prolong the shelf life of food.
- Responsible and more efficient use of resource inputs (water, energy, etc.).
- Less food loss and waste throughout food systems, implying that more food is consumed and waste is valorised in support of a circular economy.

Innovation and communities

- Co-design of best-fit business models, value-added products, and goods and services aligned with sustainable food systems, thus ensuring inclusion and reduced food poverty.
- Collective actions to foster responsible innovation and community food system leadership, including sociocultural and socioeconomic innovations to improve the work-life balance of women.
- Providing new and renewed inclusive jobs that are safe, dignified, attractive and empowering and that facilitate community agency, in particular for women and young people.

6. RESEARCH AND INNOVATION OUTCOMES AND FUTURE NEEDS

This section provides a snapshot of the R&I being carried out in relation to this pathway. It describes the R&I investments (European Commission financial contribution) supporting projects that have been funded as outcomes of relevant Food 2030 calls for proposals, in the context of societal challenge 2 of Horizon 2020 and cluster 6 of Horizon Europe. Furthermore, it describes the range of thematic issues covered, identifies future R&I needed and provides a summary of Food 2030 projects.

Investments

African food system R&I existed prior to Food 2030. Between Horizon 2020 and Horizon Europe, it is estimated that the European Commission financial contributions in this area have exceeded EUR 420 million. Out of the projects contributed to, eight projects were direct outcomes of this Food 2030 pathway, representing an investment of EUR 63.5 million. An additional amount of approximately EUR 19 million is also expected as a result of the 2023 and 2024 Horizon Europe topics related to this pathway.

Issues addressed

The EU has contributed to sustainable food system transformation in Africa through directly supporting R&I initiatives, strengthening regional R&I organisations and engaging in HLPDs through various funding instruments¹³¹. The projects contributed to innovative food systems in Africa by linking rural and urban food systems, particularly contributing to the resilience of food systems and the fight against malnutrition, particularly in women and children. Two ERA-NET co-funding mechanisms (FOSC and LEAP-AGRI) are the precursors of the AU–EU International Research Consortium in line with the co-ownership and co-funding of the FNSSA priority. Horizon Europe projects funded through the 2022 work programme have specifically targeted African food cities and malnutrition, whereas 2023–2024 Horizon Europe projects are to target food safety and trade aspects.

The dedicated mapping exercise¹³² performed on AU–EU FNSSA R&I projects in relation to their innovation and business potential is also important, providing recommendations on how projects could be transformed into tangible business and development outcomes.

Further R&I projects are expected to be supported as an outcome of the 2023–2024 Horizon Europe work programme calls for proposals targeting topics including food safety and climate-neutral, social, just and fair trade food systems.

Future research and innovation needs

More efforts should be deployed on innovation and on gathering knowledge specifically on:

¹³¹ European Commission, Directorate-General for International Partnerships, Engel, P., Slob, A., Laanouni, F., Bizzotto Molina, P., van Seters, J., D'Alessandro, C., Dekeyser, K., Smail, T., Meller, M., Pra, M., Hamad, M. and Escudier, L. (2022), [EU support to sustainable agri-food systems in partner countries 2014–2020](#), Publications Office of the European Union, Luxembourg.

¹³² European Commission (n.d.), ['Africa knowledge platform'](#).

- mitigating risks and strengthening the resilience and preparedness of African food systems;
- implementing African food system governance and sovereignty in crisis situations – food and nutrition security, foresight and scenario mapping;
- creating enabling environments for innovative service support for African food entrepreneurs, including farmers and SMEs;
- creating integrated multi-actor innovation approaches for food system transformation;
- enabling innovation accelerators in both rural and urban areas for African food innovators, with a focus on women and young people;
- understanding the dynamics of African city region food systems;
- enabling healthy and sustainable food environments, including the use of local and forgotten food types and protein-rich crops (e.g. legumes) to promote healthy diets;
- boosting food processing by SMEs, ensuring food safety and observing sociocultural preferences, while taking into account regional innovation profiles and, if applicable, geographical indications;
- minimising pre- and post-harvest food loss and waste through new and innovative techniques and best practices;
- favouring agroecological and nature-based solutions, and also securing tenure or ownership rights of land and water resources and other productive assets to incentivise productivity;
- addressing R&I needs in organic food value chains;
- linking food-system-related enterprises with local and regional financial intermediaries to fund profitable and sustainable entrepreneurial ideas, eventually linking these to payment for ecosystem services as security for repayment of loans;
- promoting innovations in African food systems that deliver co-benefits for women by decreasing the working time burden on them;
- raising awareness of the need to transition towards sustainable food systems among citizens and food services using diverse channels, including schools, social media, art and culture;

- supporting policy tools, in both the EU and the AU, that effectively protect people, the environment and the economy (pesticide export bans, value chain transparency laws, etc.);
- fighting greenwashing;
- introducing schemes to drive generational renewal, including education on thought leadership development and skill retention in food systems, paying attention to removing barriers for young people (fair remuneration, decent working conditions, land and resource access, education, etc.);
- promoting rural and urban planning and development, which supports a local and regional sustainable and resilient food systems approach;
- affecting African food systems through EU policy (value chain transparency regulations, food safety standards, certification schemes, etc.).

Summary of relevant research and innovation projects

The Food 2030 projects relevant to this pathway include those presented in the following table.

PROJECT NAME & FUNDING INFORMATION

PROJECT AIM/OUTCOME

InnoFoodAfrica

Locally-driven co-development of plant-based value chains towards more sustainable African food system with healthier diets and export potential

2020–2024, EUR 6.5 million
(Horizon 2020), RIA, Food 2030

The project is addressing key bottlenecks of African food systems, namely limited access to urban markets, affordability and convenience, by using local actions to develop novel technologies in agriculture, food manufacturing and using residual biomass for packaging.

HealthyFoodAfrica

Improving nutrition in Africa by strengthening the diversity, sustainability, resilience and connectivity of food systems

2020–2024, EUR 7 million
(Horizon 2020), RIA, Food 2030

The project will raise consumer awareness of healthy nutrition, while enhancing the capacity of producers and food system actors to deliver diverse, nutritious, high-quality, affordable food. The approach is co-developed in 10 context-specific innovation food system labs in Benin, Ethiopia, Ghana, Kenya, Uganda and Zambia.

<p><u>FOODLAND</u> FOOD and Local, Agricultural, and Nutritional Diversity</p> <p>2020–2024, EUR 7 million (Horizon 2020), RIA, Food 2030</p>	<p>The project will create and validate (at technology readiness level 5) 12 prototypes for crop- and fish-farming and food-processing systems that will deliver 17 novel food products. FOODLAND will empower smallholder farmers and food operators to foster nutrition-responsive and sustainable agrobiodiversity in 14 local innovation food hubs.</p>
<p><u>AfriFOOD-Links</u> Transforming Africa`s Urban Food Environment through Strengthening Linkages between Systems Stakeholders in Cities across the Continent and Europe</p> <p>2022–2026, EUR 12 million (Horizon Europe), RIA, Food 2030</p>	<p>The AfriFOODlinks aims to improve food and nutrition security, while delivering positive outcomes for the climate and the environment and building social and ecological resilience in 65+ cities (15 African and 5 European implementation cities and 40+ network cities) by promoting shifts to healthy, sustainable diets, transforming urban food environments, promoting inclusive multi-actor governance and accelerating innovative agri-food businesses.</p>
<p><u>INCiTIS-FOOD</u> Integrated and Circular Technologies for Sustainable city region FOOD systems in Africa</p> <p>2023–2026, EUR 6 million (Horizon Europe), RIA, Food 2030</p>	<p>The INCiTIS-FOOD aims to develop scientifically underpinned circular agri-food technologies and practices, suitable for African cities to use to address the prevalent deficiency of animal-sourced foods, vegetables and fruits following a multi-actor approach for co-design and co-creation of circular agri-food innovations and business models, involving eight city living labs in six countries from three African regions (East Africa: Kenya; West Africa: Ghana, Nigeria, Sierra Leone; Central Africa: Cameroon, Gabon).</p>
<p><u>HealthyDiets4Africa</u> Combating malnutrition in Africa through diversification of the food system</p> <p>2023–2028, EUR 10.3 million (Horizon Europe), RIA, Food 2030</p>	<p>The project HealthyDiets4Africa is based on the central hypothesis that diversification of the food system helps to combat all forms of malnutrition, while minimising its environmental footprint. It will monitor dietary diversity in eight African countries representing different regions and develop target-group-specific metrics to measure the diversity of the food system and its health outcomes.</p>
<p><u>LEAP-AGRI</u> A long term EU–Africa research and innovation partnership on food and nutrition security and sustainable agriculture</p>	<p>The project fulfilled the ambition of the Europe–Africa dialogue on science and technology (the HLPD) to launch a joint flagship initiative on its chosen priority area: FNSSA. This partnership increased investments in R&I through coordinated bi-regional (EU/Africa) mechanisms and built on the previous projects Developing African–European</p>

2016–2022, EUR 9.2 million
(Horizon 2020), ERA-NET, Food 2030

joint collaboration for science and technology; Towards a long-term Africa–EU partnership to raise sustainable food and nutrition security in Africa; and The agricultural research for development (ARD) dimension of the European research area ERA.

FOSC

Food System and Climate (FOSC):
Assessing the impact of climate change on food and nutrition security and designing more sustainable and resilient food systems in Europe and beyond

2019–2024, EUR 5 million
(Horizon 2020), ERA-NET, Food 2030

The FOSC project is the ERA-NET Cofund on food systems and climate that implements a range of joint activities to contribute to the creation of a strong and effective R&I network between Africa, Europe and Latin America. It will assess climate-change-related risks for food value chains, reduce volatility in agri-food production and develop novel approaches to valorise side streams and reduce food waste.

NB: RIA, research and innovation action.



PATHWAY 10

DATA & DIGITAL TRANSFORMATION¹³³



1. SYSTEMIC CHALLENGES

Data and digital technologies continue to transform our economy, our society and our daily lives. Food systems are no exception, as these technologies reshape the way we produce, buy and consume food and how we do research on it. Data¹³⁴ are playing an important role in this digital change. Data have become the currency that drives digital transformation, a key asset to many digital solutions and a source of competitive advantages, opportunities and power for many established and new actors in food systems. The benefits of digital transformation are felt or anticipated in every single aspect of our food systems, ranging from more personalised sustainable, healthy diets and better-informed consumers, to safer, leaner, more robust, transparent and agile food supply networks and to more customised, competitive, circular and sustainable food production. This transformation has the potential to give citizens the agency to shape their food systems, to improve the resilience of food systems to shocks and disruptions and to better link food system value chains with other sectors of the wider bioeconomy.

The challenge for EU policymakers is twofold. Firstly, they must enable citizens, institutions, companies and society as a whole to harness the many opportunities and positive impacts that data and digital solutions can bring in different thematic areas¹³⁵, from farm to fork and in practice. This also includes making sure that digital transformation delivers on EU goals for food systems and the bioeconomy, including with regard to the green transition, circularity and carbon neutrality¹³⁶. Secondly, they must simultaneously ensure that the data economy and the digital transformation are fair and inclusive, in line with the EU's values¹³⁷ and the objective of a just transition, and that potential negative side effects of the digital transformation are monitored and mitigated. This also means ensuring that a broad spectrum of citizens, farmers, small businesses and public authorities can benefit from digital transformation and have agency and trust over what is done with their data.

Practice has shown that delivering on the potential of digital technologies and solutions within food systems remains a challenge. The small size of many companies, fragmentation, the speed of technological progress and the lack of digital skills contribute to this challenge. In 2021, only 55 % of SMEs reached at least a basic level of adoption of digital technologies. Only 8 % use AI and 14 % use big data¹³⁸. More should therefore be done to deploy specific digital technologies at scale in and across different parts of

¹³³ With acknowledgements to the following independent experts (listed in alphabetical order by surname) who provided ideas and comments during and after the 10 March 2023 Food 2030 workshop in Brussels: George Beers, Grigorios Chatzikostas, Angelika Hilbeck, Shane O'Seasnaín, Andras Sebok and Harry Smit.

¹³⁴ The volume of data produced in the world is growing ever more rapidly, from 33 zettabytes in 2018 to an expected 175 zettabytes in 2025. There is an increase in the number of smart connected objects, and a growing proportion of data is expected to be processed at the edge, closer to the users and where data are generated (European Commission (2020), [Commission communication – A European strategy for data](#), COM(2020) 66 final).

¹³⁵ In particular, contributing to the priorities and pathways of Food 2030, or to the five objectives of the 2018 EU bioeconomy strategy.

¹³⁶ Muench, S., Stoermer, E., Jensen, K., Asikainen, T., Salvi, M. and Scapolo, F. (2022), [Towards a green and digital future](#), Publications Office of the European Union, Luxembourg.

¹³⁷ European Commission (2021), [Commission communication – 2030 digital compass: the European way for the Digital Decade](#), COM(2021) 118 final. The communication outlines that the EU will pursue a human-centric, sustainable vision for digital society throughout the Digital Decade to empower citizens and businesses.

¹³⁸ Eurostat (2023), [Digitalisation in Europe - 2023 edition](#), interactive publication.

food systems. Investments in social science insights will be key to deliver on the potential of data and digital technologies. They are essential to successfully develop and scale solutions and technologies in practice. They help to advance areas such as data sharing and reuse, the development of business models for multisided platforms¹³⁹, the integration of digital solutions and AI into human-centred processes, and the search for effective and efficient approaches for training and skill improvement.

Finally, also within the research profession, digitalisation can still deliver on its potential to accelerate and improve results. Further integration of digital technologies such as AI¹⁴⁰ into research activities and increased sharing and reuse of research data remain important challenges.

2. POLICY CONTEXT AND SYNERGIES

Overarching EU policy priorities, most prominently the [European digital strategy](#) and the [Green Deal](#) (and the acts, strategies and actions that are linked to them), form an important part of the policy context for this Food 2030 pathway. In particular, the pathway supports the objectives of key EU strategies, including the [farm-to-fork](#) strategy, the [fit for 55 package](#), the 2018 [EU bioeconomy strategy](#), the [EU data strategy](#) and the [strategy for shaping Europe's digital future](#).

This pathway has synergies with other EU R&I funding initiatives connected to Horizon Europe, including those under clusters 4 and 6 and under the [Sustainable Food Systems Partnership for People, Planet and Climate](#). It complements the activities of other EU funding initiatives, including the [digital Europe programme](#), [EIT Food](#) and the [European open science cloud](#).

The next two sections outline key barriers, lock-ins and enablers of change for the digital transformation of sustainable food systems.

3. BARRIERS AND LOCK-INS

- Low awareness of the potential of data-driven innovation, lack of understanding of the enabling capabilities of digital solutions and low adoption of digital solutions by citizens and the private sector (especially among SMEs).
- Lack of available data, limited data sharing and reuse – concerns about data quality, privacy, fairness and inclusiveness.

¹³⁹ Digital multisided platforms enable multiple interactions among users on different sides through ICTs (Ardolino, M., Saccani, N., Adrodegari, F. and Perona, M. (2020), 'A business model framework to characterize digital multisided platforms', *Journal of Open Innovation: Technology, Market, and Complexity*, Vol. 6, No 1, 10). Examples of multisided platforms are food delivery platforms, platforms to valorise food waste, data exchange platforms in the supply chain and asset-sharing platforms.

¹⁴⁰ European Commission, Directorate-General for Research and Innovation, Arranz, D., Bianchini, S., Di Girolamo, V. and Ravet, J. (2023), [Trends in the Use of AI in Science – A bibliometric analysis](#), Publications Office of the European Union, Luxembourg.

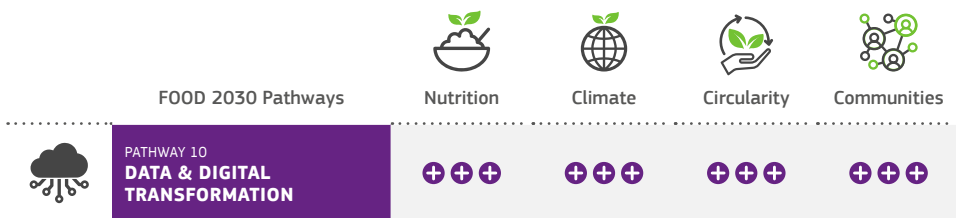
- Lack of a systemic approach to technological innovation that also incorporates other perspectives, including those from social science.
- Lack of data governance in food systems and beyond.

4. ENABLERS OF CHANGE

- Governance and infrastructure. Set clear rules such as those for access and reuse of data, while favouring innovation; customise generic infrastructure, technologies, standards and tools to the specific context of food systems; and advance open science.
- R&I investment. Boost public investment to develop a data economy that delivers for society (e.g. open data), set up favourable incentives and an enabling environment for developing innovative solutions and making private investments (including in start-ups).
- Competences. Invest in skills and data literacy across food systems, especially for SMEs, and in related research fields. Invest in easy-to-use digital tools to support human decision-making (e.g. AI-powered assistants, data visualisation).
- Partnerships. Collaborate across all parts of food systems on data and the digital transformation. Develop and promote the multisided business models that will be needed in tomorrow’s data economy.

5. FOOD 2030 CO-BENEFITS

This pathway fosters R&I in areas where the data economy and digital transformation can act as leverage points for the transition towards sustainable, resilient, healthy and inclusive food systems, and towards a circular bioeconomy. This includes support to improve the understanding and governance of the emerging data economy around food systems, to identify the key elements of an enabling framework for the digital transformation of food systems and to boost digital innovations in areas such as nutrition, food safety, processing, packaging, retail, food service and regulatory oversight. The Food 2030 ambitions underpinning this pathway have the potential to address and deliver the following co-benefits.



Nutrition and health

- Make it easier for consumers to adopt a healthy diet by providing them with actionable information and digital tools.
- Share public and private data across value chains and systems to increase the knowledge of all food chain actors, to improve nutritional value, to reduce pollution and waste and to contribute to healthier lifestyles (improved food offers, better dietary choices).
- Enable early detection of and faster responses to food safety threats through digital technologies, including AI.

Climate and sustainability

- Enable timely supply chain transparency on the sustainability and climate impact of food products and processes.
- Strengthen predictability and resilience to shocks in food systems through better forecasting, what-if analyses and scenario planning.
- Ensure the authenticity of claims and information related to the sustainability and climate impact of products and processes.

Circularity and resource efficiency

- Optimise resource efficiency through the improvement of process control and decision-making in processing (e.g. by using data visualisation, AI and digital twins).
- Reduce food waste and nutrient losses by improving the traceability of waste streams, increasing the responsiveness of value chain actors and by creating links between bioeconomy value chains.
- Enable circular approaches within and across supply chains.

Innovation and communities

- Engage citizens in an inclusive way as active and capable participants in their food systems and in the transformation to a more sustainable, future-proof food system, including through the use of digital (AI) assistants and tools.
- Ensure fairer competition in the data economy and mitigate the power asymmetries of a few actors owning large shares of data, for example by providing an open data commons for food and food system data needed in tomorrow's data economy.
- Increase the efficiency and impact of research by increasing the use of AI and open research data.

6. RESEARCH AND INNOVATION OUTCOMES AND FUTURE NEEDS

This section provides a snapshot of the R&I being carried out in relation to this pathway. It describes the R&I investments (European Commission financial contribution) supporting projects that have been funded as outcomes of relevant Food 2030 calls for proposals, in the context of societal challenge 2 of Horizon 2020 and cluster 6 of Horizon Europe. Furthermore, it describes the range of thematic issues covered, identifies future R&I needed and provides a summary of Food 2030 projects.

Investments

Between Horizon 2020 and Horizon Europe, it is estimated that the European Commission financial contributions in this area have exceeded EUR 49.8 million. Out of the projects contributed to, four projects were direct outcomes of this Food 2030 pathway, representing an investment of EUR 27.6 million. An additional amount of approximately EUR 18 million is also expected as a result of the 2023 and 2024 Horizon Europe topics related to this pathway.

Issues addressed

R&I calls and projects linked to this pathway complement the R&I calls on digitalisation and data technologies in agriculture, and therefore focus on post-farm-gate challenges and food system data governance.

Existing EU-funded projects are addressing several aspects, including security and transparency, citizen empowerment, smart sensor systems and personalised nutrition. The Food 2030 framework has provided a clearer direction and narrative to EU R&I programming, especially under Horizon Europe. As a consequence, projects and work programmes use a holistic approach to reach ambitions like mapping and improving the data economy for food systems or increasing transparency with regard to sustainability. Increasingly, projects have been asked to work more closely with SMEs and start-ups to create viable solutions that can be scaled in practice. Future calls under Horizon Europe (2023–2024 work programme) are expected to contribute to data-driven solutions to improve industry's contribution to inclusive and sustainable food systems, and to using citizen science and data-driven innovations as a leverage point for fostering the transition to sustainable food systems.

Future research and innovation needs

The following R&I needs could be further specified and addressed, for example, in Horizon Europe, in Horizon Europe partnerships – in particular the Sustainable Food Systems Partnership for People, Planet and Climate – or in Horizon Europe missions.

- Innovative and agile approaches are needed to improve the governance and the monitoring of the data economy and data value chains, at different levels (EU, national, regional).

- There is a need for support actions that create an enabling R&I environment for digital innovation and transformation, and R&I actions that help to deploy generic technologies in the context of food systems.
 - Support structures (e.g. living labs, communities of practice, infrastructure, innovative datasets), actions (e.g. awareness raising, cross-sectoral collaboration) and legislative conditions that contribute to an effective and successful innovation ecosystem should be put in place.
 - R&I needs to adapt generic technologies (digital twins, virtual/extended reality, AI, edge, internet of things, big data, blockchain, robotics and ambient intelligence) and solutions to the context of food systems, or to address cross-cutting challenges in food systems (e.g. interoperability, standards, ethics and trust, data quality, data spaces and data sharing).
 - R&I activities are needed that boost (higher technology readiness level) digital solutions in areas such as food safety, processing, packaging, retail, food service, training or regulatory oversight, while supporting the twin digital and green transitions.
 - These R&I activities need to focus on pragmatic solutions in the sector, potentially learning from proven applications in other sectors, and provide stakeholders with the capacity to benefit from them and scale them in their contexts. Solutions should meaningfully connect to support mechanisms already in place and be compliant with new data and AI regulatory frameworks, making the most of opportunities. Demonstration of the potential of solutions should support their uptake and the general interest in the digitalisation of food systems.
- There is a need for actions to continuously advance digital and data skills and knowledge among consumers, scientists, the private sector and other food system actors in order to enhance the sustainable food systems transformation and use the full potential of data and technology. Actions to deploy AI to assist and train food system actors are also needed.

Summary of relevant research and innovation projects

The Food 2030 projects relevant to this pathway include those presented in the following table.

PROJECT NAME & FUNDING INFORMATION

PROJECT AIM/OUTCOME

<p><u>S3FOOD</u> Smart Sensor System for Food Safety, Quality Control and Resource Efficiency in the Food Processing Industry</p> <p>2019–2022, EUR 5.0 million (Horizon 2020), IA, Food 2030</p>	<p>S3FOOD facilitated the modernisation and digitalisation of the food processing industry. It stimulated the integration of the internet of things and related technologies.</p>
<p><u>PROTEIN</u> Personalized nutrition for healthy living</p> <p>2018–2022, EUR 7.0 million (Horizon 2020), IA, Food 2030</p>	<p>PROTEIN developed an end-to-end ecosystem that will engage people in a healthy, pleasurable, nutritional and sustainable diet by offering a daily programme adapted to their needs and driven by their personal preferences, physical and physiological characteristics and health status. It created an ICT-based system for providing personalised nutrition.</p>
<p><u>FNS-Cloud</u> Food Nutrition Security Cloud</p> <p>2019–2023, EUR 10.2 million (Horizon 2020), IA, Food 2030</p>	<p>FNS-Cloud worked to overcome fragmentation by bringing together data on diet, health, consumer behaviour, sustainable agriculture and the bioeconomy. This increased the exploitation of knowledge of food nutrition security, reduced knowledge gaps, supported the food industry and facilitated informed and healthy choices by consumers.</p>
<p><u>Data4Food2030</u> Pathways towards a fair, inclusive and innovative Data Economy for Sustainable Food Systems</p> <p>2022–2026, EUR 10.0 million (Horizon Europe), RIA, Food 2030</p>	<p>Data4Food2030 aims to design principles for and a clear roadmap towards fair, inclusive data spaces that support sustainable food systems in Europe, that is, the project targets policy makers, supply chains, and individuals and groups who influence what we eat.</p>
<p><u>TITAN</u> Transparency solutions for transforming the food system</p> <p>2022–2026, EUR 9.6 million (Horizon Europe), IA, Food 2030</p>	<p>TITAN aims to demonstrate the latest transparency-related solutions to help drive the formation of a demand-driven European economy based on the production and consumption of healthy, sustainable and affordable food.</p>

DRG4Food

Empowering a fair and responsible European Food Register, fostering citizen sovereignty and creating a data-driven food system.

2022–2025, EUR 4.0 million
(Horizon Europe), RIA, Food 2030

DRG4Food aims to achieve trust in data-driven food systems by implementing digital responsibility goals for the food sector. This will enable new levels of innovation, for example in food safety, sustainability and personalised nutrition, a reduction in food waste and fair conditions throughout the entire food chain.

FOODITY

FOod and nutritiOn Data-driven innovation respectful of citizen's Data Sovereignty

2023–2025, EUR 4.0 million
(Horizon Europe), RIA, Food 2030

FOODITY aims to fund 12 industry and research collaborations to develop pilots demonstrating the potential of data-driven innovations in health and nutrition, while engaging citizens. The pilots will contribute to more just and environmentally friendly food systems.

NB: RIA, research and innovation action; IA, innovation action.



PATHWAY 11

ZERO POLLUTION FOOD SYSTEMS¹⁴¹



1. SYSTEMIC CHALLENGES

Food systems are putting significant pressure on natural resources and the environment. Pollution coming from the food systems takes many forms, originates from all sectors of food systems and has impacts on all environmental compartments (air, soil, water), biota (plant and animal life of a region) and human health. About 31 % of GHG emissions came from food systems in 2020 (globally)¹⁴². The global and European food system is the primary driver of biodiversity loss¹⁴³. ‘Zero pollution food systems’ refers to the EU zero pollution vision for 2050, applied to food systems: ‘Air, water and soil pollution is reduced to levels no longer considered harmful to health and natural ecosystems and that respect the boundaries our planet can cope with, thus creating a toxic-free environment’¹⁴⁴.

Two issues are considered in this pathway. The first issue is environmental pollution, which includes the emission into soil, water and air of pollutants that are generated by EU food systems and are a potential risk to food safety, human health and ecosystem quality. The second issue is food contaminants and how environmental pollution might become food contamination (if these pollutants reach food, they become food contaminants and therefore a food safety issue that is covered in the food safety pathway).

Concerning environmental pollution, according to the [Joint Research Centre’s consumption footprint platform](#), meat (beef, pig or poultry) is the food product group with the most impact on several impact categories: acidification of the natural environment, climate change, freshwater ecotoxicity (potential for biological, chemical or physical stressors to affect ecosystems), marine and terrestrial eutrophication, land use change, ozone depletion and fossil resource use.

Emissions of undesirable chemicals into the environment can accumulate within and transfer between soil, water and air media. Food production can lead to soil pollution due to the excessive use of fertilisers and pesticides, the misuse of manure and tillage or inefficient livestock management. Other sectors of the food systems also contribute significantly to soil, water and air pollution, which can, in turn, affect food production and quality, food security and food safety, biodiversity and human health. Plastics (including from fishing nets) and food packaging also have negative impacts on land, soil, water and marine ecosystems and biodiversity (including due to the release of chemicals in plastics). Plastic particles of various sizes¹⁴⁵ generated by different sources within the food systems are ubiquitous in the air, soil, freshwater, oceans and seas, biota, and therefore also make

¹⁴¹ With acknowledgements to the following independent experts (listed in alphabetical order by surname) who provided ideas and comments during and after the 10 March 2023 Food 2030 workshop in Brussels: Violette Geissen, Reniera O’Donnell, Pascal Sanders, Esther Sanyé-Mengual and Mieke Vercaeren.

¹⁴² FAO (2022), [Greenhouse Gas Emissions from Agrifood Systems – Global, regional and country trends, 2000–2020](#), Faostat Analytical Brief Series, No 50, Rome.

¹⁴³ Benton, T. G., Bieg, C., Harwatt, H., Pudasaini, R. and Wellesley, L. (2021), [Food System Impacts on Biodiversity Loss – Three levers for food system transformation in support of nature](#), Chatham House, London; Sanyé-Mengual, E., Biganzoli, F., Valente, A., Pfister, S. and Sala, S. (2023), [‘What are the main environmental impacts and products contributing to the biodiversity footprint of EU consumption? A comparison of life cycle impact assessment methods and models’](#), International Journal of Life Cycle Assessment, Vol. 28, pp. 1194–1210.

¹⁴⁴ European Commission, [Commission communication – Pathway to a healthy planet for all – EU action plan: ‘towards zero pollution for air, water and soil’](#), COM(2021) 400 final.

¹⁴⁵ Macroplastics, diameter ≥ 5 mm; microplastics, diameter between 1 μm and 5 mm; nanoplastics, diameter between 1 nm and 1 μm .

their way into our diet, and ultimately, our body. However, there are not enough suitable analytical methods for detecting nanoplastics and microplastics in food systems¹⁴⁶. Very little is known about the impact of microplastics on food systems, including accumulation in plants and animals, processed food and how these may affect human health (acute and chronic impacts)¹⁴⁷. It is also estimated that 81 % of ocean plastics originate from Asian rivers¹⁴⁸. While European and national strategies remain important to reducing plastic and other types of pollution, international cooperation is key to ensure that efficient and impactful measures are put in place to protect our oceans and ecosystems. Finally, other non-negligible sources of pollution from the food systems are light and noise.

Despite tangible efforts, environmental pollution still poses high risks to human health and is one of the key drivers of biodiversity loss. There are significant regional differences in the impact of environmental pollution, depending on the type of pollutant. Contaminants have been accumulating in food products, such as nanoplastics and microplastics or chemical mixtures, or are coming from food contact materials and food-processing plants. Human biomonitoring studies in the EU point to a growing number of hazardous chemicals in human blood and body tissue, including certain biocides, pesticides, pharmaceuticals, heavy metals and plastic compounds¹⁴⁹.

Food systems, on the one hand, are a source of pollution and, on the other hand, suffer from the consequences of pollution. Moving towards zero pollution food systems can therefore contribute to building the resilience of food systems and the natural ecosystems on which they depend.

2. POLICY CONTEXT AND SYNERGIES

The zero pollution pathway is relevant to policies such as the [common agricultural policy](#), the [common fisheries policy](#), the [European Green Deal](#), the [farm-to-fork strategy](#), the EU [biodiversity strategy](#), the [circular economy action plan](#), the [EU action plan 'towards zero pollution for air, water and soil'](#), the [chemicals strategy for sustainability towards a toxic-free environment](#), the [bioeconomy strategy](#), the strategy 'A clean planet for all' and Commission communication – [Safeguarding food security and reinforcing the resilience of food systems](#). Also of relevance are several strong regulatory and strategic frameworks, including the [environmental noise directive](#), the [outdoor noise directive](#), the [drinking water directive](#) (which provides a list of harmful substances, for example endocrine disruptors), the [urban waste water treatment directive](#), the [bathing water directive](#), the [industrial emissions directive](#), the [ambient air quality directives](#), the [EU soil strategy for 2030](#), the [marine strategy framework directive](#), the [water framework directive](#) and the [packaging and packaging waste directive](#).

¹⁴⁶ German Federal Institute for Risk Assessment (2019), '[Microplastics – facts, research and questions](#)', press release, 6 June 2019.

¹⁴⁷ Liu, Q., Chen, Z., Chen, Y., Yang, F., Yao, W. and Xie, Y. (2021), '[Microplastics and nanoplastics: emerging contaminants in food](#)', *Journal of Agricultural and Food Chemistry*, Vol. 69, No 36, pp. 10450–10468; Gruber, E. S., Stadlbauer, V., Pichler, V., Resch-Faust, K., Todorovic, A., Meisel, T. C., Trawoeger, S., Hollóczki, O., Turner, S. D., Wadsak, W., Vethaak, A. D. and Kenner, L. (2023), '[To waste or not to waste: questioning potential health risks of micro- and nanoplastics with a focus on their ingestion and potential carcinogenicity](#)', *Expo Health*, Vol. 15, pp. 33–51.

¹⁴⁸ Ritchie, H. (2021), '[Where does the plastic in our oceans come from?](#)', *Our World in Data*, 1 May 2021.

¹⁴⁹ German Federal Institute for Risk Assessment (2019), '[Microplastics – facts, research and questions](#)', press release, 6 June 2019.

This pathway has synergies with other parts of Horizon Europe cluster 6 focusing on biodiversity, circular economy or agriculture, and with activities developed by the [European Innovation Council](#) on plastics. Synergies also exist with the activities developed by EIT Food through its [net zero food system plan](#). Finally, this pathway also has synergies with the [European Research Cluster to Understand the Health Impacts of Micro- and Nanoplastics](#) and with the [European Partnership for the Assessment of Risks from Chemicals](#).

There are also synergies to be found with projects funded by other related EU instruments, for example the [European Innovation Partnership for Agricultural Productivity and Sustainability](#) and the [Desira initiative](#). The former is developing activities related to the sustainable use of pesticides. The latter, which aims to contribute to the climate-relevant, productive and sustainable transformation of agriculture and food systems in low- and middle-income countries, also develops projects related to this pathway under its pillar 1 (R&I in agricultural and food systems). The [LIFE programme](#) also funds several projects on the impact of food production on the environment.

The next two sections outline key barriers, lock-ins and enablers of change for the promotion of zero pollution food systems.

3. BARRIERS AND LOCK-INS

- Difficulty getting a clear picture of and detecting food system pollution since it originates from many sources and sectors.
- Difficulty putting in place and having access to effective methodologies/measurements for pollution reduction.
- Lack of effective international collaboration to reduce food-system-related pollution (e.g. pollution coming from non-EU countries, from production to consumption practices).
- Lack of policy enforcement and incentives to change in this area.

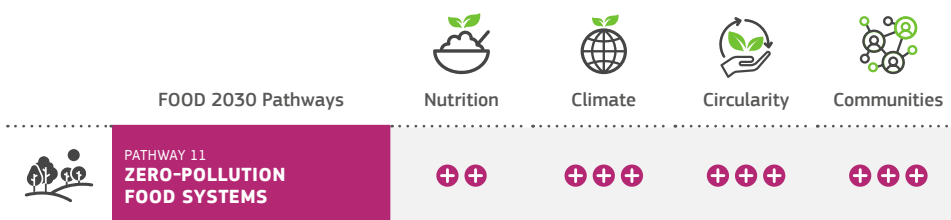
4. ENABLERS OF CHANGE

- Opportunities for healthier and affordable food and a cleaner environment.
- Awareness raising regarding persistent pollutants (e.g. those that can still be found in plastics, microplastics and nanoplastics) to which food systems need to be adapted.

- Political will and commitment to reduce pollution.
- Increased willingness of citizens to reduce pollution thanks to robust data and awareness of the problem.
- Empowerment of all actors of food systems, since pollution has many sources.
- Promotion of measures to improve circularity.
- Development and use of regenerative agriculture/aquaculture and agroecological approaches.

5. FOOD 2030 CO-BENEFITS

The R&I pathway ‘Zero pollution food systems’ aims to advance knowledge and solutions that reduce pollution originating from food systems. It is closely connected to the Food 2030 pathways on food safety and resource efficiency. The Food 2030 ambitions underpinning this pathway have the potential to address and deliver the following co-benefits.



Nutrition and health

- Improving the safety of food through the reduction of contaminants.
- Improving the nutritious quality and healthiness of food.

Climate and sustainability

- Mitigating climate change through a major reduction in GHG emissions and air pollutants.
- Improving soil, air and water quality.
- Protecting and improving biodiversity and ecosystem services.

Circularity and resource efficiency

- Reducing the environmental footprint of the food system as harmful inputs are reduced or replaced with safe and sustainable alternatives (e.g. replacing fossil-based products with sustainable bio-based products).
- Ensuring circular systems by converting the outputs and waste streams into new inputs for agriculture or other industries.
- Regenerating polluted areas/soil.

Innovation and communities

- Promoting higher investment in innovative circular economy business models aiming to reduce food-system-related pollution (e.g. reducing chemical use in production, reducing waste).
- Triggering innovation and new jobs in sustainable food systems to promote change, leaving no one behind.
- Developing healthier cities and rural areas.

6. RESEARCH AND INNOVATION OUTCOMES AND FUTURE NEEDS

This section provides a snapshot of the R&I being carried out in relation to this pathway. It describes the R&I investments (European Commission financial contribution) supporting projects that have been funded in relevant calls for proposals, in the context of societal challenge 2 of Horizon 2020 and cluster 6 of Horizon Europe. Furthermore, it describes the range of thematic issues covered, identifies future R&I needed and provides a summary of relevant projects.

Investments

'Zero pollution food systems' is a very broad subject. R&I investment could focus directly on this issue or could tackle issues in other sectors that might have indirect impacts on zero pollution food systems. Therefore, it is very difficult to provide figures on the level of investment and number of projects funded so far on this subject, and thus the figures below are estimates.

Between Horizon 2020 and Horizon Europe, it is estimated that the European Commission financial contributions in this area have exceeded EUR 190 million, through at least 24 projects. An additional amount of approximately EUR 15 million is also expected as a result of the 2023 and 2024 Horizon Europe topics related to this pathway.

Since this pathway is new, further investment under the framework of Food 2030 will occur in the next work programmes.

Issues addressed

Existing EU-funded projects related to this pathway predominantly address plastic pollution and pollution with pesticides and fertilisers. While this knowledge is important, there is now a need to use the outcomes of research projects to foster more downstream innovation and the technological scale-up and scale-out of promising results already obtained. Pollution aspects have been studied in a rather siloed way by focusing on specific sectors or actors. Therefore, there is a need to adopt a systems approach to understand the combined impact of pollution (cocktails) generated by food systems and harmful to food systems, and more generally its impact on the environment and society.

Further Food 2030 R&I projects related to this pathway are expected to be supported as an outcome of the 2023–2024 Horizon Europe work programme calls for proposals targeting topics on the prevention and reduction of pollution from plastic food packaging and on its environmental impact. Future topics in this work programme will also target agroecology, thus addressing pollution resulting from pesticides and fertilisers, microplastic pollution, air pollution, nitrogen and phosphorus pollution, diffuse pollution in urban water run-off and food waste.

Future research and innovation needs

Within the context of this pathway, there is a need for R&I activities to better understand food-system-related environmental pollution: its nature (e.g. microplastic and nanoplastic pollution, chemical pollution), its sources, its sinks, its dynamics, its impacts on terrestrial, freshwater and ocean ecosystems (including bioaccumulation¹⁵⁰), its physico-chemical matter (quantities released, size, shape, composition), its exposure and hazard assessment for humans, flora and fauna (ingestion, excretion, digestion, combined or enhanced effects with other pollutants, interaction with the human microbiome) and its monitoring.

Other R&I activities are also needed to define what the most effective methods could be to reduce food-system-related pollution from all actors and sectors but especially through the empowerment of consumers (e.g. communication, awareness raising, behaviour, understanding).

R&I needs also concern the development of bio-based alternatives of currently used products that lead to pollution from food systems (biodegradable plastics, biopesticides, etc.). The question of circularity is central to all the R&I needs identified above.

While knowing more about pollution originating from the food systems is useful to devise targeted and effective solutions for moving towards zero pollution, the impact of

¹⁵⁰ Increase in the concentration of a substance in a biological organism over time.

restoration measures on long-term food productivity (and therefore resilience) should also be better understood. This could have important consequences for food and nutrition security (accessibility, quality and stability against drought and water floods, climate change and other disturbances).

Summary of relevant research and innovation projects

Zero pollution is a broad subject that extends beyond food systems. Many projects related to environmental pollutants have been funded under Horizon 2020 and in previous EU R&I framework programmes. Under Horizon Europe, some projects specifically target food systems, while others address pollution from food systems among other sectors. The first calls resulting from this pathway were only launched in 2023. Given this, the project table below lists some projects pre-dating the pathway. It provides a starting point for future zero pollution food systems ambitions.

PROJECT NAME & FUNDING INFORMATION

PROJECT AIM/OUTCOME

<p>CRONOGARD High performance advanced material platform for active and intelligent food packaging: CRONOGARD™</p> <p>2017–2020, EUR 1.1 million, SME, Horizon 2020</p>	<p>The project developed a patented technology for treating raw materials used in the food packaging industry, which extends food's shelf life by up to 200 %. Packaging manufacturers added value to their products. Retailers and food manufacturers increased the quality of packaged food and decreased waste. The use of non-recyclable, eco-friendly substances enabled consumers to enjoy safer products.</p>
<p>SHERPACK Innovative structured polysaccharides-based materials for recyclable and biodegradable flexible packaging</p> <p>2017–2020, EUR 1.3 million, RIA, Horizon 2020</p>	<p>The project developed new biodegradable, recyclable, flexible, paper-based packaging for dry food, such as cereals or coffee. The layers of this novel material provide a barrier and sealing functionality and added stiffness, while decreasing the overall weight (three patented innovative technologies).</p>
<p>MYPACK Best markets for the exploitation of innovative sustainable food packaging solutions</p> <p>2017–2021, EUR 4.6 million, IA, Horizon 2020</p>	<p>The project created infographics showing the environmental impact of various packaging materials in comparison with the production of 0.5 kg of tomatoes; the infographics were used for public awareness raising. To tackle barriers associated with the uptake of innovative packaging, the project produced an online tool to guide material/packaging providers and packaging users in the process of product packaging design/development.</p>

<p><u>DIVERFARMING</u> Crop diversification and low-input farming across Europe: from practitioners engagement and ecosystems services to increased revenues and chain organisation</p> <p>2017–2022, EUR 10 million, RIA, Horizon 2020</p>	<p>The project aimed to increase the long-term resilience, sustainability and economic revenues of agriculture across the EU by assessing the real benefits and minimising the limitations, barriers and drawbacks of diversified cropping systems under low-input agronomic practices that are tailor-made to fit the unique characteristics of six EU pedoclimatic regions, and by adapting and optimising the downstream value chain organisation.</p>
<p><u>NUTRIMAN</u> Nutrient Management and Nutrient Recovery Thematic Network</p> <p>2018–2021, EUR 2 million, CSA, Horizon 2020</p>	<p>The project developed a nitrogen and phosphorus thematic network compiling ready-for-practice knowledge for recovered product applications, practices and technologies, interconnecting applied science and industrial practice, for the user interest and benefit of agricultural practitioners. The project objective was to improve the exploitation of the nitrogen/phosphorous nutrient management/recovery potential for the ready-for-practice cases not sufficiently known by practitioners.</p>
<p><u>GLOPACK</u> Granting society with LOW environmental impact innovative PACKaging</p> <p>2018–2021, EUR 5.6 million, I A, Horizon 2020</p>	<p>The project proposed a cutting-edge strategy addressing the technical and societal barriers to spreading innovative eco-efficient packaging able to reduce the food environmental footprint throughout our social system. Focusing on accelerating the transition to a circular economy concept, the project aimed to support users' and consumers' access to innovative packaging solutions enabling the reduction and circular management of agri-food, including packaging and waste.</p>
<p><u>Organic-PLUS</u> Pathways to phase-out contentious inputs from organic agriculture in Europe</p> <p>2018–2022, EUR 4.1 million, RIA, Horizon 2020</p>	<p>The project aimed to provide high-quality, transdisciplinary, scientifically informed decision support to help all actors in the organic sector to reach the next level of the EU's organic success story. The objectives were to identify and valorise contentious inputs currently used in European agriculture, provide specific technical solutions to minimise or phase out their use, provide environmental, social and economic assessments of phase-out scenarios, and disseminate knowledge, ideas and results.</p>

NUTRI2CYCLE

Transition towards a more carbon and nutrient efficient agriculture in Europe

2018–2023, EUR 6.9 million, RIA, Horizon 2020

The project used an integrated approach to enable the transition from the current (suboptimal) nutrient management in European agriculture to the next generation of agronomic practices, characterised by improved upcycling of nutrients and organic carbon.

Circular Agronomics
Efficient Carbon, Nitrogen and Phosphorus cycling in the European Agri-food System and related up- and down-stream processes to mitigate emissions

2018–2023, EUR 7 million, RIA, Horizon 2020

The project provided a comprehensive synthesis of practical solutions to improve the current carbon, nitrogen and phosphorus cycling in European agroecosystems and related upstream and downstream processes within the value chain of food production. The objective was to contribute to development towards sustainable, resilient and inclusive economies that are part of circular and zero-waste societies.

BIOSCHAMP

Biostimulant alternative casing for a sustainable and profitable mushroom industry

2020–2024, EUR 3.7 million, IA, Horizon 2020

The project is developing peat-free casing soil to serve as a carrier for the selected microbiota that will act as crop biostimulants. The solution will be tested at four mushroom farms across the EU that integrate all the European cropping systems. The goal is to improve industrial profitability while reducing the agronomical need for pesticides by 90 %. This will help mushroom growers meet consumer demands to find alternatives to fungicide dependence.

EJP SOIL

Towards climate-smart sustainable management of agricultural soils

2020–2025, EUR 40 million, co-fund, Horizon 2020

The main objective of EJP-SOIL is to create an enabling environment to enhance the contribution of agricultural soil to key societal challenges such as climate change adaptation and mitigation, sustainable agricultural production, ecosystem service provision and prevention and restoration of land and soil degradation. It is building a sustainable European integrated research community on agricultural soil and developing and deploying a roadmap on climate-smart sustainable agricultural soil management.

<p>RUSTICA Demonstration of circular biofertilisers and implementation of optimized fertiliser strategies and value chains in rural communities</p> <p>2021–2024, EUR 7.7 million, IA, Horizon 2020</p>	<p>The project intends to provide a technical solution to converting organic residues from the fruit and vegetable sector into novel bio-based fertiliser products. The project's aims also include the development of economically viable and environmentally sustainable alternatives to mineral fertilisers with the same or improved agronomic value. A multi-stakeholder approach will implement the technologies in the agri-food chain and will lead to sound business models.</p>
<p>Agro2Circular Territorial circular systemic solution for the upcycling of residues from the agrifood sector</p> <p>2021–2024, EUR 14 million, IA, Horizon 2020</p>	<p>The project is developing the first recycling value chain for post-industrial multilayer films based on a synergistic approach. It combines innovative sorting, physical delamination, enzymatic depolymerisation, decontamination and mechanical recycling. The project employs a data integration system as a digital tool to ensure traceability and as a predictive decision tool.</p>
<p>PAPILLONS Plastic in Agricultural Production: Impacts, Lifecycles and LONG-term Sustainability</p> <p>2021–2025, EUR 7.1 million, RIA, Horizon 2020</p>	<p>The objective of the project is to investigate the sustainability of agricultural plastics in relation to releases and impacts of microplastics and nanoplastics in European soil and to provide guidance for policymakers, the agricultural sector and world-class industries to promote sustainable farm production systems.</p>
<p>LABPLAS Land-Based Solutions for Plastics in the Sea</p> <p>2021–2025, EUR 5.0 million, RIA, Horizon 2020</p>	<p>The project plans to determine reliable identification methods for more accurate assessment of the abundance, distribution and toxicity determination of small microplastics, nanoplastics and associated chemicals in the environment, and to develop practical computational tools to facilitate the mapping of plastic-affected hotspots and promote scientifically sound plastic governance.</p>
<p>ENOUGH European food chain supply to reduce GHG emissions by 2050</p> <p>2021–2025, EUR 11 million, IA, Horizon 2020</p>	<p>The project will provide technologies, tools and methods to contribute to the EU farm-to-fork strategy to achieve climate neutral food businesses. The project brings together 30 partners from nine EU nations, Norway, Turkey and the United Kingdom who have in-depth expertise across the whole food chain (refrigeration, cooking, baking, drying).</p>

<p><u>MINAGRIS</u> Micro- and Nano-Plastics in Agricultural Soils: sources, environmental fate and impacts on ecosystem services and overall sustainability</p> <p>2021–2026, EUR 7.0 million, RIA, Horizon 2020</p>	<p>The project will estimate the use of various plastic polymers in agriculture systems, their impact on physico-chemical soil properties, soil biodiversity, plant productivity, ecosystem services and their potential transfer to other parts of the environment and plants, and it will quantify the consequences of unsustainable soil management.</p>
<p><u>ClieNFarms</u> Climate Neutral Farms</p> <p>2022–2025, EUR 12 million, IA, Horizon 2020</p>	<p>The project is developing and upscaling systemic locally relevant solutions to reach climate-neutral and climate-resilient sustainable farms. Twenty demonstration case studies will test innovative systemic solutions. They will cover the diversity of production systems (crops, cattle and dairy) and geographical areas. The solutions will be co-designed with farmers and the related ecosystem in a structure similar to that of a living lab and recorded in the project's data hub.</p>
<p><u>R3PACK</u> Reduce, Reuse, Rethink PACKaging: towards novel fiber-based packaging and reuse schemes uptake</p> <p>2022–2025, EUR 6.9 million, IA, Horizon Europe</p>	<p>The project will contribute to reducing, reusing and rethinking packaging by securing the uptake of innovative technologies allowing the immediate substitution of complex multilayer plastic packaging with high performing fibre-based packaging (13 food product types will be covered). It will thus contribute to reducing plastic waste.</p>
<p><u>RAINFOREST</u> Co-produced transformative knowledge to accelerate change for biodiversity</p> <p>2022–2025, EUR 3 million, RIA, Horizon Europe</p>	<p>The project will use a combination of integrated assessment modelling, input-output modelling and life cycle assessment, based on case studies addressing the nexus of agricultural production, processing and transport, retail, and consumer preferences and diets. The overall aim will be to contribute to reducing the biodiversity impacts of major food and biomass value chains by developing and evaluating just and viable transformative change pathways and interventions.</p>

<p><u>ECONUTRI</u> Innovative concepts and technologies for ECOlogically sustainable NUTRIent management in agriculture aiming to prevent, mitigate and eliminate pollution in soils, water and air</p> <p>2022–2026, EUR 5.6 million, IA, Horizon Europe</p>	<p>The project is addressing water pollution caused by NO₃ and P leaching and run-off from cultivated soil, manure/slurry and plant residues, and GHG (N₂O, CO₂, CH₄) and NH₃ emissions from cultivated soil, barns and organic biomass during storage, composting and land application.</p>
<p><u>NutriBudget</u> Optimisation of nutrient budget in agriculture</p> <p>2022–2026, EUR 7 million, RIA, Horizon Europe</p>	<p>The project is developing the nutriplatform decision support tool. It will be tested and used by at least 40 000 farmers across Europe. The development of the nutriplatform will be based on the algorithms of two advanced, newly developed, holistic nutrmodels. These will quantify the impact of agronomic mitigation measures to optimise nutrient budget and flow across scales, looking at various agronomic and environmental targets. This will result in the reduction of pollution.</p>
<p><u>SUPPORT</u> Supporting Uptake Integrated Pest Management and lOw-Risk pesTicide Use</p> <p>2023–2026, EUR 6 million, RIA, Horizon Europe</p>	<p>The project will analyse the decision-making process to identify barriers and opportunities in the entire agri-food chain related to the adoption of integrated pest management. The project will then develop new strategies and policies enabling and supporting farmers and other stakeholders to apply integrated pest management.</p>
<p><u>EDAPHOS</u> Advanced mapping, risk assessment and nature-based depollution methods are combined to accelerate the recovery of contaminated soils and ensure that ecological restoration enters mainstream business</p> <p>2023–2027, EUR 7 million, RIA, Horizon Europe</p>	<p>The project will develop a framework for land rehabilitation and ecological restoration of contaminated areas featuring nature-based solutions technologies. It will also improve the monitoring of contaminated soil and the understanding of precise pollution sources in selected EU regions.</p>

VISS

Viable, safe and sustainable PHBV value chain for food packaging applications

2023–2027, EUR 5.5 million, IA, Horizon Europe

The project will create a new value chain around PHBV (a copolymer of the polyhydroxyalkanoates family) as a safe, sustainable and cost-effective alternative to conventional plastics, especially for food packaging applications for food with a short shelf life. PHBV will be produced from industrial organic residues and will be formulated and compounded to be transformed and validated as high-performance food packaging, as it is mechanically recyclable and biodegradable.

NB: CSA, coordination and support action; RIA, research and innovation action.

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This publication provides an update on the European Commission's Food 2030 initiative and is meant to guide future research and innovation policy reflections related to Horizon Europe, the farm-to-fork strategy, the European Green Deal and beyond. The report sets out 11 pathways for action where research and innovation can concretely deliver co-benefits related to nutrition, climate, circularity and communities, at multiple levels: from local to international. It also underlines that a systemic interdisciplinary and transdisciplinary approach to research and innovation is crucial for success and improved impact. Transformations are not only technical and academic; they also encompass social, legal, economic, financial, ethical and philosophical dimensions, which need to be fully embedded in future R&I policy and programmes.

Research and innovation policy

