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RESEARCH BRIEF

Transformative innovation for the ecological transition of food systems

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European Sustainable Agriculture Dialogue

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The European Sustainable Agriculture Dialogue (ESAD) is a multi-stakeholder platform created in 2019 that brings together key actors from across society – including industry, civil society, universities, and research centres – to discuss key topics, exchange our views and standpoints, and ultimately shape decisions towards sustainable agriculture. The brief was developed in consultation with ESAD members and the authors took their inputs into account in the drafting process. The paper does not reflect the views and opinions of single ESAD members. As such, their contribution is not to be interpreted as an endorsement of the final paper.

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EXECUTIVE SUMMARY

Innovation plays a critical role in driving the ecological transition of food systems amidst ongoing crises such as climate change, geopolitical instability, and social unrest. This policy brief highlights the need for transformative innovation—systemic changes that challenge existing structures and practices while fostering sustainability, equity, and resilience.

The recently published report of the Strategic Dialogue on the Future of EU Agriculture clearly states *"Innovation, technology and knowledge play a key role in the transition of the agri-food sector"* (p.13), identifying the need to leverage technology and innovations as one of its ten guiding political principles. It emphasises the need for technical and social innovations that are inclusive, accessible, and co-developed with end users to ensure relevance to specific contexts.

Past food system transformations were largely propelled by technological and economic drivers within rapidly changing societies. For instance, the 'supermarket and food service revolution' has dramatically reshaped consumer behaviour, while the 'nutrition transition' has shifted traditional diets rich in cereals and fibre toward those dominated by sugars, fats, and animal-source foods. Public policies at the time prioritised growth, productivity, and abundance, aligning private and public goals without significant tension.

Achieving a sustainable transition in food systems requires more than the continued reliance on private and technological drivers. It demands clear directionality—explicit goals, rules, and incentives that prioritise the public good and address pressing societal challenges. Transformations of this scale rely on active participation from civil society and public administrations to foster behavioural and organisational change. The research and innovation underpinning this shift must also change.

A research agenda for transformative innovation should be guided by the following principles:

1. Adopt a systemic approach: Break down sectorial and disciplinary siloes, seeking synergies between sectors and fields to achieve common goals. Identify the systemic causes of societal problems and activate mechanisms to address them.
2. Link long-term with short-term goals: Implement short-term solutions that activate systemic mechanisms contributing to long-term objectives. Explore synergies and trade-offs between short-term actions and long-

term perspectives. Use foresight studies to develop future scenarios and visions.

3. Build a narrative for transformative innovation: Develop credible and motivating theories of change that can inspire researchers, enterprises, civil society, and public servants.
4. Integrate multidimensional solutions: Combine nature-based, technology-based, socially-based, and institution-based solutions to address complex problems. This approach generates synergies between ecological, technological, social, and institutional innovations.
5. Develop context-specific solutions: Transformative innovation encourages research to consider the diversity of contexts and develop tailored solution
6. Engage stakeholders in research: Involve stakeholders in the research process to add legitimacy and relevance to scientific methods and institutions. Include representatives of diverse values and interests, and foster collaboration and communication among various stakeholders.

1. INTRODUCTION: THE CENTRALITY OF THE CRISIS AND THE ECOLOGICAL TRANSITION

The overarching commitment of the European Commission in the past legislative period was "*to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use" (European Commission, 2019, p.2)*. During this period, Europe faced a series of crises that reshaped the political and social landscape, altering Europeans' perceptions of the future (Eurobarometer, 2020; De Vries and Hoffman, 2020). Brexit triggered a significant political crisis, weakening the Union's strength and requiring extensive negotiation efforts. The unexpected COVID-19 pandemic in 2020 created momentum for a collective European response, resulting in the NextGenerationEU (NGEU) temporary recovery instrument. With a budget of around 800 billion Euros, the plan allowed the European Commission, for the first time in the Union's history, to borrow substantial funds on behalf of the EU from capital markets to finance recovery efforts. The pandemic was soon followed by the next crisis: the war in Ukraine. This largely unforeseen conflict exposed Europe's dependency on external energy resources and disrupted several supply chains, including food. Despite the vulnerabilities revealed by the crises, European demonstrated their resilience and highlighted the benefits of European integration.

At the beginning of the new legislative period, Europe faces a war at its borders which absorbs significant financial resources. At the same time, the region is grappling with social protests and growing anti-system movements, and increasing geopolitical disorder, which in turn generates uncertain business prospects and contestation of the legitimacy of European Institutions. The advent of this 'permacrisis' (Turnbull, 2022) as the 'new normal' demands a profound re-evaluation of the goals and the pathways to achieve them. Is the ecological transition set out by the Green Deal still a valid goal? If not, what are the alternatives? And, if yes, what could a transition look like in this changed context?

Along with the unexpected crises, Europe has experienced an increase in severe droughts, catastrophic floods, heat waves, and wildfires in recent years. According to the European Environment Agency (2024), the summer of 2024 was the hottest year ever recorded, both in Europe and globally. Wildfires destroyed more than 370,000 hectares in the first nine months of 2024, and around two million people

across Central Europe were affected by the severe flooding in September alone[1]. The instability generated by the trespassing of planetary boundaries – six out of nine have now been trespassed (Richardson et al, 2023) – inarguably demonstrates that the ecological transition of the economy is more urgent than ever. However, the polarised debate surrounding the Green Deal and its associated policy initiatives shows that a deeper understanding of the dynamics between policy, politics, and social trends is necessary. If top-down, technocratic policies risk generating societal resistance, it becomes essential to mobilise bottom-up drivers and foster alliances for change (da Silva et al, 2024).

In the Green Deal strategy, food is one of the keys to transition. People deal with food every day, and much of their health and well-being depend on it. Beyond its nutritional value, food embodies knowledge, values, and behaviours. While individuals have the freedom to make dietary choices, these behaviours are shaped by structural factors. Transforming food systems is one of the most challenging transitions, requiring a fundamental challenge to entrenched values, interests, routines, and structures

Research and innovation are key to transformation. Food systems have undergone significant transformations over the past decades, shaped by technological advancements, economic shifts, and organisational changes. These developments have profoundly influenced how food is produced, processed, and consumed, particularly in developing countries. The 'supermarket and food service revolution' has heavily affected consumers' behaviour (Barret et al, 2022); the 'nutrition transition' has changed traditional diets which were high in cereals and fibre to diets high in sugars, fats, and animal-source food (Popkin, 1993). In the past, this transformation mainly proceeded through the push of technological and economic drivers within societies that were undergoing deep processes of change. Public policies, at that time, interpreted transformation of food systems in terms of growth, productivity, and abundance, so there was not an apparent conflict between private and public goals (Sonnino et al, 2016). This narrative, however, requires updating; policies must now recognise food as a common good rather than merely a commodity (Jackson et al.). 2021).

The sustainability transition of food systems requires more than private and technological drivers. It needs a strong directionality, i.e. clear goals, consistent rules, and effective incentives that serve the public good and address societal challenges. Strong involvement of civil society and public administrations is a

[1] European Environment Agency (EEA) (2024) Extreme weather: floods, droughts and heatwaves, https://www.eea.europa.eu/en/topics/in-depth/extreme-weather-floods-droughts-and-heatwaves, accessed 2 November 2024. .

prerequisite of successful system transformations as they depend on behavioural and organisational change. For this reason, a different type of research and innovation is needed: transformative innovation, which focuses on systemic change to address root causes and build sustainable solutions.

The objective of this brief is to identify and analyse narratives and potential priorities for Research and Innovation (R&I) in transforming food systems, with a specific focus on insights gathered from a participatory workshop organised by the Institute for European Environmental Policy (IEEP) in June 2024. It aims to provide a framework for guiding systemic changes in food systems, particularly in the context of ongoing crises, while exploring how transformative innovation can play a pivotal role in driving these changes. In this regard, it also aims to contribute to the debate activated by the Strategic Dialogue at the beginning of 2024[2], which will inform the European Commission's Vision for future agriculture and food expected to be launched in early 2025.

The next section introduces the concept of transformative innovation and illustrates its role in innovation policies. The paper then adapts the current food system narrative to the crisis context, outlining key action tracks. Following this, it explores multidimensional solutions, including nature-based, technology-based, and institution-based innovations. Insights from the Strategic Dialogue are discussed, focusing on R&I priorities that emerged from the workshop. Finally, the conclusion ties together the importance of balancing short-term crisis responses with long-term ecological goals, emphasising the role of collaboration and foresight in future R&I strategies.

2. RESEARCH AND INNOVATION FOR THE TRANSFORMATION OF FOOD SYSTEMS

An innovation is considered ‘transformative’ if it addresses the systemic causes of societal problems and activates systemic mechanisms to fix them. 'Transformative' innovation goes beyond the notions of 'incremental' or 'radical innovation', which primarily measure innovation in terms of productivity, by embodying societal values, and aligning with societal goals, enabling diverse pathways for change (Stirling, 2024). Transformative innovation also implies changing dominant institutions in the social context (Avelino et al, 2017). By

[2] The Strategic Dialogue was established by Ursula von der Leyen in response to widespread farmer protests in 2023 and 2024. The final document is the joint effort of the 29 stakeholders representing all activities of the food system, see https://agriculture.ec.europa.eu/document/download/171329ff-0f50-4fa5-946f-aea11032172e_en?filename=strategic-dialogue-report-2024_en.pdf

disrupting existing economic, social, and technological structures, transformative innovation mobilises agents of transformation, develops new paradigms, builds new infrastructures and fosters the introduction of new regulations (Schot and Steinmueller, 2018). It is both creative and destructive, as it removes the obstacles to change while building new configurations. Transformative innovation relates also to multiple dimensions of innovation: not only technological, but also social (Avelino et al, 2019).

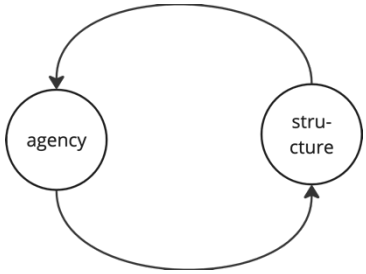
In the context of food system, transformative innovation implies a shift from monoculture to diversity (Jacobs et al, 2020), from yield maximisation to resilience (Allen et al, 2011), from unsustainable to responsible consumption (Webb et al, 2008).

To understand transformative innovation, a systemic perspective is necessary. A system comprises a set of interdependent activities that mobilise actors, rules, artifacts, and resources to achieve a shared goal (Meadows, 2008). Hence, everyday life activities are enabled and constrained by material and immaterial structures created through repeated patterns of interaction. Practices, the basis of daily life, are routinary activities that embody values, knowledge, social norms, and physical infrastructures. Changing a practice – for example, a dietary habit or an agricultural operation – requires more than individual willpower. It does not depend only on individual choice, but on the network of relationships in which actors are embedded. Transformative innovation challenges existing mental, social, institutional, physical structures to enable new practices that contribute to sustainability.

Assessing whether a solution is truly transformative requires a deep understanding of the systemic nature of the underlying problems. For instance, when a new pest appears in a crop, a conventional solution might involve identifying a pesticide to combat it. In contrast, a transformative solution examines the underlying causes of the pest's emergence, for example by analysing the changes in the crop ecosystem and develops a mix of actions to tackle or prevent the problem. Curative approaches maintain the status quo while preventive approaches drive systemic transformation.

Transformative innovation seeks to change behaviour, which implies considering actors at the centre of any innovation. It mobilises agency - the capacity of individuals, groups, and organisations to act independently - to drive changes in the normative, cognitive, legal, technological, and material structures that shape daily life experiences (Giddens, 2014) (Figure 1). These changes involve trial, error, and learning, progressively replacing old structures with new ones.

Figure 1. The dynamics agency-structure



By activating learning processes, transformative innovation can create new patterns and contribute to removing barriers to change. Building on this understanding, the next section explores how this concept can reshape narratives around food system transformation in times of crisis.

3. FOOD SYSTEM TRANSFORMATION: ADAPTING THE NARRATIVE TO THE CRISIS

Without a clear direction, innovation systems tend to adapt to a demand-supply scheme rarely deviating from established pathways. The effectiveness of a transformative innovation agenda depends on its capacity to provide clear directionality (Ropke, 2012). A key aspect of this directionality is the presence of compelling underlying narratives capable to 'win the hearts and minds' of researchers, enterprises, civil society, and public servants through a credible and motivating theory of change (Crows and Jones, 2018).

With regard to food systems, a narrative of 'food system transformation' has been developed using the United Nations' (UN) 2030 Agenda for Sustainable Development[3]. This narrative has been elaborated further by the Committee of Food Security (HLPE, 2020) and reinforced by the outcomes of the UN Food System Summit of 2021[4]. Its main messages can be summarised as follows (Webb et al, 2020):

- Current food systems have failed, as evidenced by food insecurity, environmental degradation, and contribution to climate change, and rising non-communicable diseases.

[3] The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, https://sdgs.un.org/2030agenda

[4] https://www.un.org/en/food-systems-summit

- A system approach must replace traditional production-oriented approaches and assign responsibilities across processing, retailing and consumption activities.

- A system approach should integrate health, environmental, economic, social goals, and policies

The 2021 UN Food System Summit[5] mobilised states, civil society organizations, and private companies around five 'action tracks':

1. ensure access to safe and nutritious food for all;
2. shift to sustainable consumption patterns;
3. boost nature-positive production;
4. advance equitable livelihoods; and
5. build resilience to vulnerabilities, shocks, and stress.

These priorities are now widely endorsed by international and national organisations, but the ongoing permacrisis demands an adaptation of this narrative. Centring the crisis in the food system transformation narrative could begin with recognising megatrends - such as climate change and environmental degradation, demographic decline, technological revolutions, geopolitical instability, political polarisation, growing inequalities, economic and financial concentration – as sources of stress on human systems. These slow-moving processes gradually erode a system's equilibrium (Lawrence et al, 2024).

Often, these stresses are amplified by systemic patterns within human systems. For instance, water scarcity increases the demand for irrigation systems, which leads to intensified withdrawal from groundwater reservoirs, making communities more vulnerable to future droughts. Similarly, the widespread use of antibiotics contributes to increasing antibiotic resistance, which intensifies as diseases become more prevalent.

A crisis occurs when a trigger event activates a chain of cascading consequences in a system weakened by stresses. Often, a crisis in one subsystem affects other subsystems. For example, the Ukrainian war disrupted the agricultural supply chains due to a shortage of fertilisers, of which Russia and Ukraine are leading exporters. Another example are the restrictions on mobility and social interactions imposed during the 2020 pandemic which significantly disrupted, among others, food supply chain operations. Following the initial shock, the food supply chain

[5] https://www.un.org/en/food-systems-summit/action-tracks

underwent extensive reorganisation, affecting production, processing, retailing, and consumption activities (Bisoffi et al, 2021).

Crises often generate new conflicts and exacerbate existing ones, creating new barriers to transformation. For instance, the farmers' protests of the spring of 2024 brought the resistance of those who might be most affected by transition - such as intensive farmers – to the public's attention and highlighted their unwillingness to bear the costs without adequate support. These social protests have moved from the streets to the ballot box, fuelling the rise of anti-systemic political forces and putting the European political system at risk. How can those that are potentially negatively impacted by transitions be motivated to change themselves from opponents to proponents and become drivers of change through incentives and support for transformational activities?

Whereas the UN's Agenda 2030 viewed crises as potential future events, focusing on ways to prevent them, the question is no longer whether the next crisis will occur, but when and in what form, and how to manage it. If crises are now a permanent part of our life, they influence both present choices and perceptions of the future. In this new context, creating a safe space for daily lives, and improving the capacity to cope with adversities become shared priorities. Hence, the question is: Is it possible to build a safe space for humanity and communities that balances safety with openness and security with solidarity? Can food system transformation become a component of 'positive peace', where the roots of violent conflicts are actively removed and replaced with conditions for cooperation and mutual understanding?

Transformative innovation should provide solutions to the immediate crisis while anticipating, and mitigating, the next ones. The next section will explore how this concept can reshape narratives around food system transformation in times of crisis.

4. THE DIMENSIONS OF TRANSFORMATIVE INNOVATION

Transformative innovation addresses the systemic causes of a problem. For example, in the case of antibiotic resistance, given that new antibiotics soon or later will generate new resistance, systemic solutions include new breeding models that enhance animals' resilience to infectious diseases, thus reducing the need for antibiotics. Another example would be that pressures on natural resources for food production cannot resolved solely through more efficient processes. Theu also require changes in consumption patterns.

Systemic solution, however, often diverge from current practices, leading to resistance from actors. Even when systemic solutions are available having demonstrated their technical feasibility, to be applied in practice further obstacles, most notably the costs of uptake need to be overcome. Transition theories based on the 'multilevel approach' (Geels, 2018; Markard et al, 2012) propose dynamic models where 'niche' innovations, developed locally and at small scale by visionary or technologically advanced entrepreneurs, overcome local barriers to change. Once costs are reduced, infrastructures are created, legal and ethical barriers are removed, these innovations can be gradually integrated into the broader system. Transition is a process that requires both demolishment as well as construction, which may include past investments in equipment and knowledge, business models, chain configurations, and routines.

Systemic solutions to complex problems have multiple dimensions: they affect at the same time the ecological, social, institutional, as well as technological dimensions. If a problem has systemic causes, technological solutions that do not address other conditions may only buy time before the next crisis. For example:

- Nature-based solutions mobilise natural processes to improve system equilibrium (Seddon et al, 2020).
- Technological solutions introduce new artifacts (or replace old ones) or new processes in the system (Geels, 2007).
- Social solutions introduce new organisational patterns and redefine system goals (Avelino et al, 2017). I
- Institutional solutions establish new rules (or remove old ones) that provide new frames for reference for practices (Loconto, 2017).

Often, the different types of innovation do not occur in isolation: any innovation in one dimension generates effects on others.

Transformative innovation aligns with principles and objectives of systemic solution while taking into consideration existing constraints. It drives processes of and gradually removes obstacles to change, thus creating synergies between ecological, technological, social, and institutional innovation. The key to transformative innovation lies in targeting leverage points that make systems work differently, activating processes of change that promote coherence among practices. Below are examples of potentially transformative innovations.

Box 1: Nature-based solutions – regenerative agriculture

Is regenerative agriculture a transformative innovation? It depends on what we mean by the term. There is wide agreement that the primary mission of regenerative agriculture is to restore soil quality (Schreefel et al, 2020): this implies that all practices that fall into this category should contribute to this goal. Regenerative agricultural practices include cover cropping, reduced tillage, rotational grazing, and agroforestry, which have showed to improve soil biodiversity and reactivate the soil microbiome (Hermans et al, 2023). These principles and practices are common to several farming systems, most notably organic agriculture, and are largely based on agroecology. However, as such, regenerative agriculture does not exclude the use of chemical fertilisers and pesticides, especially herbicides. The question, then, is: to what extent can regenerative agriculture be transformative? The answer is in the identification of the goal: regenerative agriculture is transformative as long as it restores agri-ecosystem services, for example, soil quality, at a satisfactory rate. This focus on the overarching goal gives farmers the flexibility to adapt practices to their specific context while implying a progressive phasing-out of chemicals and a tendential transition to fully nature-based solutions. The use of biocontrol[6], for instance, can help reduce the use of pesticides and thus negative impacts on soil organisms which will in turn improve soil health overall (Hulot and Hiller, 2021). To be transformative, regenerative agriculture will affect other dimensions. At the social level, regenerative agriculture implies a reorganisation of the farmers' routines. While farmers have been accustomed to follow routines based on context-independent standard prescriptions, regenerative agriculture has the potential of reintroducing feedback mechanisms supported by observation, data, and peer-to-peer interaction, able to activate learning processes. Technological innovation could support farmers in data management and physical operations. The adoption of regenerative agriculture could have institutional implications by changing the systems of incentives from compliance to performance. Institutional innovation could occur with the introduction of an official definition of regenerative agriculture, and monitoring and control systems focused on learning and reward rather than on sanctions. This may avoid the term being captured by greenwashing strategies. However, the extent to which this practice would have positive transformative impact at scale has still to be proven.

[6] Biocontrol is defined in the dictionary of agroecology and plant pathology as the use of living organisms or natural substances to manage or mitigate damage and diseases caused by harmful entities like animal pests, weeds, and pathogens (Busson, 2019, Prajapati et.al, 2020)

Box 2: Technology-based solutions: precision fermentation

Protein availability is a key concern for food security and strategic autonomy (Albaladejo Roman, 203). Scientific evidence illustrates that the increase in consumption of animal proteins is generating pressure on natural resources, as animal production is much less energy-efficient than plant-based food (Willet et al, 2019). Moreover, a diet with an excess of animal proteins is proven to be linked to Non-Communicable Diseases (Willet et al., 2019). Europe is structurally dependent on imported plant proteins as animal feed to sustain its level of animal production (Albaladejo Roman, 2023). A systemic solution would be a progressive alignment of animal protein consumption to the WHO dietary guidelines[7], as the EAT-Lancet report recommends (Willett et al, 2019). Meanwhile, precision fermentation is one solution advanced to address the problem of pressure of intensive livestock on natural resources, especially land and water. It is a technology that relies on modern life science to identify the specific gene responsible for producing the desired protein or molecule in a source organism (such as a plant or animal), synthesise or extract the identified gene and insert it into a microorganism, such as yeast, bacteria, or fungi and cultivate the engineered microorganisms in bioreactors, where they are provided with nutrients like sugar to grow and produce the desired protein or molecule. The fermentation environment is carefully controlled to optimise growth and production efficiency. According to proponents of precision fermentation, the technology could help satisfy some of the growing global demand for animal products. A key function of precision fermentation is to produce ingredients to improve the taste of plant-based food products, thus increasing their appeal to consumers (Graham and Ledesma-Amaro, 2023). It is suggested that precision fermentation could have significant effects on the structure of the supply chains and the structure of the agricultural sectors, potentially replacing animal production altogether (Tubb and Seba, 2019) and moving the sector towards a 'post-animal bioeconomy' (Mylan et al, 2023). This technology has generated a strong debate regarding the disruptive effects it could have on the agricultural sector and consumers' acceptability (Broad et al, 2023). Moreover, the precise sustainability impact of widespread adoption of this technology has still to be proven (Knychala, 2024). First life-cycle analyses of precision fermentation products show major benefits in reducing greenhouse gas emissions and land use compared to conventional animal protein, for example, for egg white protein (Järviö et al, 2021)

Box 3: Socially-based solutions: community-supported agriculture

Smaller farms often use intermediaries to sell their produce to supermarkets. Community-supported agriculture groups have blossomed in the last 20 years (Brown and Miller, 2008), mainly to avoid being tied into 'captive supply chain governance' (Gereffi, 2005) with supermarket chains or big processors. This allows especially smaller farmers to cut out intermediaries and respond to consumer demand for fresh - often organically grown- food (Renting et al, 2003). Whist arrangements might vary, they usually involve consumers organising themselves into purchasing groups, using digital tools to manage orders and community premises to distribute the products, and mobilising voluntary work for the orders, the distribution, and the choice of suppliers. The distribution of vegetables is often organised via weekly 'box schemes', with set prices for a fixed weight of a mix of products the composition of which depends on the season. Proponents of these schemes suggest that this allows farmers to keep the amount of unsold produce to a minimum. Moreover, consumers pay for the service at the beginning of the season, so farmers can rely on a positive cash flow. Consumers and producers meet periodically to discuss the management of the farm and to improve the match between demand and supply. However, whether these practices have any lasting transformative impact has still to be proven.

[7] https://www.who.int/news-room/fact-sheets/detail/healthy-diet

Box 4: Institution-based solutions: organic districts

Organic farmers are often underrepresented in national policy networks (Moschiz and Stolze, 2009), as mainstream farmers' organisations tend to back the interests of the more numerous conventional farmers. Since the beginning of organic farming, organic farmers have striven to break isolation through social interaction (Michelsen, 2002): the first farmers markets were set up by organic farmers, and peer-to-peer learning networks were established to gain visibility and public support for this production system (Brunori et al, 2008). Whit the expamsion of organic farming in Italy, government introduced 'organic districts' through national regulation[8]. These districts are networks of farmers, small businesses, local administrations, and civil society organisations that carry out a range of activities, including joint projects aimed at promoting territorial development through the improvement of the quality of the products organisation of events, promotion of local brands and the territory, and integrating tourism and local handicraft activities. These networks, as long as they are sufficiently representative, are recognised by regional administrations as interlocutors and potential beneficiaries of funding. According to their proponents, organic districts might have the potential to drive the transformation of local governance. However, their long-term transformative impacts still need to be evaluated.

Nature-based, technological, social, and institutional solutions are not necessarily mutually exclusive. Transitions would require a systemic approach that combines a mix of solutions. For instance, in the anticipated protein transition, alternative proteins can be found across all three domains, each addressing different barriers to change – ranging from consumers' habits to business interests – and potentially generating a new 'land dividend' (Collas and Benton, 2024). The directionality of innovation policies will play a crucial role in this process.

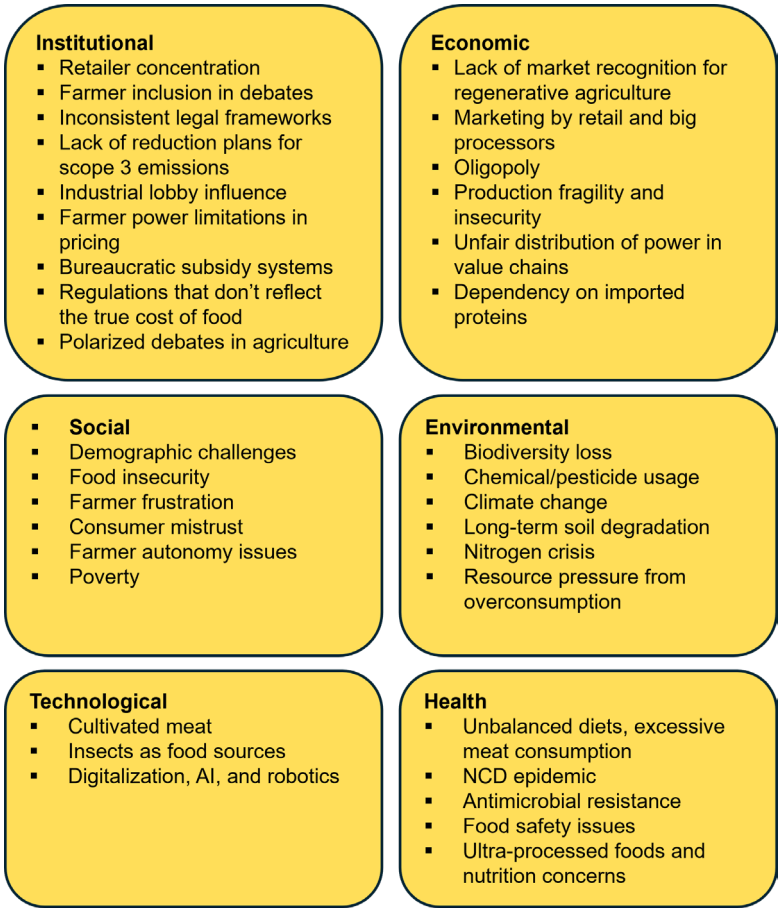
Having presented examples of potentially transformative nature-based, technological, social, and institutional innovations, we propose three different frames which might create narratives that could facilitate policy actions for transformative innovation.

[8] https://aiab.it/biodistretti/

5. BUILDING A NARRATIVE FOR TRANSFORMATIVE INNOVATION

In June 2024, IEEP organised a stakeholder workshop to identify agri-food challenges requiring further research, and for which transformative innovations are needed. In interactive sessions, the approximately 20 participants from farming organisations, industry, environmental NGOs, and research first identified the main issues which transformative innovation strategies should address; this included i) mainstream challenges that are already present in the public debate, but that warrant either more research and/or different approaches, and ii) emerging issues, that are only marginally considered in the public debate, but are potentially disrupting in the middle and the long run. The identified issues were then clustered into economic, policy, environmental, health, and technology blocks (see Figure 2). Building on this analysis, participants were then asked to propose and discuss potential nature-based, technological, and social solutions to the identified issues.

Figure 2. Issues identified during the workshop



From the analysis of the discussion, we can identify three major frames that justify the promotion of public policies aiming at transformative innovation.

1. The first frame concerns the connection between the transition and the current crisis: How can transformative innovation shape the transition in this context?
2. The second focuses on the role of farmers: Can farmers become drivers of the transition rather than its strongest opponents? What role can transformative innovation play in this process?
3. The third frame addresses on policies: How should policies change to foster transformative innovation to facilitate the transition?

5.1 Frame 1: The link between crisis and green transition of the food system

Should the green transition be suspended in times of crisis? Should exceptional measures be taken to keep the transition on track? Should the crisis be seen as an opportunity to remove the transition from the policy agenda? Or should it be viewed as a chance to accelerate the transition? The political and scientific debate at the EU and national level in recent years has revolved around these questions. To provide an effective answer, it is necessary to take a step back from the debate and try to identify a set of observations on which to build a consensus.

1. Scientific evidence tells us that humanity has trespassed six out of nine planetary boundaries (Richardson et al, 2023). According to scientific evidence, this means that human systems have entered a phase of instability.
2. Although we are aware that planetary boundaries have been trespassed, scientific evidence is not sufficient to identify clear causality between different behaviours of regions, groups, and sectors. This allows, without falling into denial, the possibility of questioning the urgency of the transition.
3. During the crisis, the costs of 'business as usual' are often overlooked. It has been estimated that the costs of climate-related catastrophic weather events, excluding reconstruction costs, amount to US$ 143 billion/year of direct and indirect losses globally (Newman and Noy, 2023).
4. In times of crisis, urgent matters often take precedence over important ones. There is a risk of falling into 'the trap of emergency', which favours short-term solutions over systemic changes. Short-term solutions are often characterised by 'shifting the burden' strategies (Meadows, 2008), where resources that would normally be allocated to long-term goals (for example, prevention, maintenance, research and innovation) are redirected, thus increasing future risks.

5. The crisis amplifies the sense of unease among the potential losers of the transition and pushes vulnerable people to blame the transition as the source of their difficulties.

These assumptions have important implications for a research agenda. Understanding the crisis as a normal component of contemporary life requires a stronger focus on the future and how it is shaped by today's choices. Foresight studies and impact assessment of innovation, incorporating different scenarios and different potential stressors and triggers, should become a key component of research. Research should adopt the 'planetary boundaries' approach at different scales, to provide policymaking with realistic targets for mitigation. The costs (and not economic) of inaction need to be systematically assessed to provide decision-makers and citizens with timely information.

Research should also develop approaches that combine short-term with long-term perspectives. Synergies and trade-offs between short-term action and long-term action should be explored: in times of permacrisis, preparedness for the crisis can be built while simultaneously addressing the crisis itself, as the concept of 'building back better' suggests. In this context, synergies and co-benefits of adaptation to mitigation need to be explored together, which, surprisingly, is rarely done, and for which there is a clear research gap (Sharifi, 2021; Smith and Olesen, 2009).

The multidimensionality of transformative innovation could help to explore the synergies between short-term and long-term goals. For instance, introducing nature-based innovations might reduce the environmental impact of agricultural practices while generating learning processes that foster demand for new technologies to make these practices more effective.

Coping with the crisis requires a strong effort to build consensus around a common future. Scientific evidence is key to building consensus, pointing to the importance of having credible scientific evidence. However, it is becoming increasingly clear that interests and values play an equally important role in consensus-building (Deconink, 2023). To enhance the legitimacy and relevance to science, institutions and scientific methods, it is necessary to involve stakeholders in research (Duncan et al, 2022).

5.2 Frame 2: The role of farmers in food system transformation

Agriculture is and will continue to be at the core of the food system. One key question for future research is why, despite the vast resources devoted to agriculture, farmers often show resentment towards agricultural policies and, in

some cases, European institutions. How can research and innovation help make farmers drivers of the transition?

It is widely acknowledged that the necessary transition of the agriculture sector will need the support of farmers. Hence, a priority will be to better understand who 'the farmers' are today. The term 'farmers' hides a great deal of diversity, and its use in the political debate can be misleading. The farm model on which agricultural policies are based is a mid-size family farm, operated by a male holder who is fully employed on the farm. In this model, farms sell their products to cooperatives or to wholesalers who operate in the global markets. Although this model represents a significant share of farmers and is strongly represented in farm lobbies, the farming landscape today includes many other types of farmers, such as:

a) Farmers who have disconnected their operations from existing supply chains, adopting business models based on on-farm processing and selling, short supply chains, and diversified income streams, such as touristic offers. This model has enabled them to increase the added value per unit of production.
b) Farmers (and farm households) who have integrated farming with other jobs, thus earning only part of their income from agricultural activities.
c) Farmers who have specialised and enlarged their scale of operations, investing heavily in technology and dimensional growth, or relying on large numbers of seasonal workers. Many of these farms have become fully integrated pinto global supply chains led by corporates and losing much of their autonomy.
d) Tertiarized farmers who have delegated most farming operations to service providers.
e) Corporate farms, which have grown through financialisaton and land grabbing processes (Guarin et al, 2020; Bock et al, 2020).

One reason for the research gap in farming diversity is that research efforts have mainly focused on individual agricultural practices and crops, overlooking the farming system level, i.e. the mix of technical, natural, and human resources, and their connection to the ecosystem and the commodity system (van der Ploeg and Ventura, 2014). Neoclassical economics, with its focus on methodological individualism, fails to explain farm diversity because it does not consider farmers' choice. Focusing on farming systems and business models helps to identify barriers to change and leverage points. System approaches – based on interdisciplinarity and interaction between researchers and stakeholders - are the point of departure for transformative innovation of farming.

5.3 Frame 3: Policies for green transformation

European food systems are heavily regulated and subsidised. Historically, the CAP – particularly through its income support and market measures provided by the European Agricultural Guarantee Fund (EGAF) - has aimed to manage market-driven transformation processes. In response to globalisation, income and investment support along with integration into supply chain, have sought to maintain the competitiveness of this model. Market pressures and support schemes have contributed to the development of global value chains and land concentration in the primary sector (Burja et al, 2020).

Financial support provided by the European Agricultural Fund for Rural Development (EAFRD), the second pillar of the CAP, has attempted, albeit with ambiguities and difficulties, to counter this trend by supporting business models that create value in synergy with rural economies. However, its impact is limited compared to the strength of the incentives provided by income support: payments per hectare take the lion share of the budget with comparatively fewer requirements than rural development schemes.

Concerning innovation, the CAP has contributed to the modernisation of farms, often driven by big players in the supply chain (Papadopoulos, 2015). It has not prevented a top-down knowledge model based on technical standards defined by industry, and when policy objectives have included sustainability considerations, they have been implemented through additional standards, often in conflict with the practices encouraged by the current techno-economic model (IPES Food, 2016). As a result, the ability of farmers to experiment with new ways to improve their ecological performance is limited, and individual innovation is discouraged. Rather than being encouraged to explore the potential of their agri-ecosystems, farmers have learned to optimise the collection of farm subsidies. In a nutshell, the current policy framework has promoted a conservative and passive approach to farming, rather than one that innovates and adapts.

The transition will require a new generation of 'transformative policies' (Rienks and Miłobędzka, 2024), characterised by directionality (i.e., coherent policy mixes addressed at societally relevant goals), reflexivity (the capacity to assess the policy performance and to adapt the policy mix and governance based on lessons learned), and market articulation (the ability to shape to accommodate innovative solutions) (Weber and Rohracher, 2015).

Research in this field is still limited. A transformative policy requires a systems approach, whereas most policies are mainly sectoral. Although sectoral policies are necessary, much more effort should be devoted to policy integration, which involves insuring coherence and synergies between sectoral policies.

A thoroughly reformed Common Agricultural Policy, which is urgently needed, should focus on addressing farmers' incomes through measures that fairly compensate labour, reward ecosystem services, and foster synergies with local rural economies. Incentives should encourage farmers to set up business models that evolve through transformative learning and innovation. Rather than relying on top-down prescriptions and controls, the new model should introduce, at farm as well as at higher levels, feedback mechanisms based on performance indicators. Accountability models, based on data disclosure and communication, should be largely encouraged. This would place primary importance on knowledge and social capital, promoting practices such as study groups, data sharing, and living labs.

In a framework for transformation, the Common Agricultural Policy should be accompanied by a Food Policy (which currently does not exist in Europe) by a radical reform of rural policies (which are often monopolised by agricultural actors or 'hidden' within broader economic and territorial policies), and a set of integrating instruments to ensure coherence with health, welfare, environment, energy, trade policies.

6. CONCLUDING REMARKS

Ecological transition is a socio-technical transition. Innovation is key to this transition, and transformative innovation aims to change the existing state of affairs by introducing mechanisms for systemic change in existing systems. In times of permacrisis, transformative change stresses the importance of anticipation and preparedness, linking the present with the future, and adaptation with mitigation. Rather than thinking in terms of radical versus incremental innovation, transformative innovation combines radical approaches (which allow for paradigm shifts and changes in assumptions) with realistic strategies. It focuses on the capacity of individuals, groups, and communities to challenge existing structures through experimentation, learning, and cooperation, relying on institutional mechanisms that amplify learning processes at different scales.

A research agenda for transformative innovation should be guided by the following principles:

1. **Adopt a systemic approach**: Break down sectorial and disciplinary siloes, seeking synergies between sectors and fields to achieve common goals. Identify the systemic causes of societal problems and activate mechanisms to address them.

2. **Link long-term with short-term goals**: Implement short-term solutions that activate systemic mechanisms contributing to long-term objectives.

Explore synergies and trade-offs between short-term actions and long-term perspectives. Use foresight studies to develop future scenarios and visions.

3. **Build a narrative for transformative innovation**: Develop credible and motivating theories of change that can inspire researchers, enterprises, civil society, and public servants.

4. **Integrate multidimensional solutions**: Combine nature-based, technology-based, socially-based, and institution-based solutions to address complex problems. This approach generates synergies between ecological, technological, social, and institutional innovations.

5. **Develop context-specific solutions**: Transformative innovation encourages research to consider the diversity of contexts and develop tailored solution

6. **Engage stakeholders in research**: Involve stakeholders in the research process to add legitimacy and relevance to scientific methods and institutions. Include representatives of diverse values and interests, and foster collaboration and communication among various stakeholders.

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