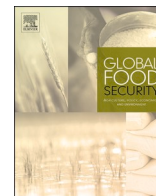


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Exnovation in food systems' sustainability transformation: analysis across supply chains in G20 countries

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ABSTRACT

Food systems face interlinked social-ecological challenges and so require urgent transformation. Innovation remains purported as the main approach to sustainability transformation, while less attention is given to exnovation, which represents the deliberate termination of unsustainable technologies, business models or systems. We use a food systems approach to investigate exnovation across supply chains focusing on G20 countries. Our results show that while exnovation is present in sustainability ambitions, it rarely translates into interventions. Most exnovation tackles environmental challenges rather than socio-economic and health issues. Exnovation interventions tend to rely on regulatory instruments, mainly target substances or products, and focus on production stages that shift the burden to farmers. Very few exnovation interventions included justice considerations. To promote (or reduce resistance to) change, we argue for greater shared responsibility across the supply chain. Overall, exnovation remains fragmented and unstructured: food system transformations could be strengthened with systemic exnovation.

1. Introduction

Food systems face unprecedented challenges across economic, social, environmental, governance and geopolitical spheres (FAO, IFAD, UNICEF, WFP, & WHO, 2024; IPES-Food, 2023). Some of the escalating and interlinked challenges include climate change, biodiversity loss, and lack of food availability and accessibility (FAO, IFAD, UNICEF, WFP, & WHO, 2024; FAO, 2023). Globally, there is a growing call for the transformation of food systems (Benton, 2023; Slater et al., 2022) from, for example, efficiency-oriented (Coggins et al., 2025) to degrowth-aligned pathways (Gibson et al., 2025). However, there remains a lack of progress in transitioning towards socially just and ecologically sustainable food systems (Leeuwis et al., 2021; Webb et al., 2020).¹ Not only there is ample evidence that globally, food systems have failed to mark progress on nutrition, environmental health,

inclusion and equity (Ambikapathi et al., 2022; Sundiang et al., 2025), but transformative interventions are often faced with backlash (e.g., Van der Ploeg, 2020; Finger et al., 2024), which strengthens the lock-in of food systems in ecologically, economically and socially unsustainable configurations (Oliver et al., 2018).

Innovation persists as the main approach to transformation (Rosenbloom and Rinschied, 2020; Koretsky et al., 2022). Currently, in food systems, innovation – the addition of new elements to complex systems – means that the attention of public and private actors (Jaacks, 2021) remains fixed on strategies such as the introduction of new technologies (e.g. precision agriculture, novel packaging materials, lab-grown meat, functional foods (Herrero et al. (2020); Matin et al. (2024)), labels or campaigns (e.g. consumer guidance on dietary choices (Ares et al. (2023)), or practices (e.g. seaweed aquaculture (Visch et al., 2023)). Yet, system change also requires innovation's counterpart

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¹ The terms 'transition' and 'transformation' are variably used in sustainability-related scholarship (Feola, 2015). In this paper, we use the two terms interchangeably to denote a major, fundamental change, as opposed to minor, marginal, or incremental shifts of the social order, resulting in a reduction of the social metabolism, often in association with increasing levels of social justice. Transformation/transition is not a homogeneous process but rather as an ensemble of multi-level, multi-scale processes that may involve material and/or symbolic as well as structural and/or functional aspects of social, socio-technical, or social-ecological systems (Feola, 2015).

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exnovation or “what needs to be done away with to fully establish the new” (David and Gross, 2019, p. 1). Scholarship on sustainability transitions highlights the need for this more direct approach of intentional termination to destabilise unsustainable systems (Kanger et al., 2020; Koretsky et al., 2022; Leeuwis et al., 2021; Rosenbloom and Rinscheid, 2020; Turnheim and Geels, 2013). The notion of exnovation – which originated in organisational planning and medical studies (David and Gross, 2019; Kimberly, 1981; Rodriguez et al., 2016) – has previously been applied to study “the purposive termination of existing (infra) structures, technologies, products and practices” (Heyen et al., 2017, p. 326).

Exnovation introduces a new type of “governance task” (Stegmaier, 2022, p. 97) that requires active interventions to initiate or support decline (Sommer and Frank, 2024). It has been used in previous sustainability transitions, such as in the energy sector (David and Gross, 2019; Turnheim and Geels, 2013). Given that innovation currently dominates over exnovation (Graaf et al., 2021; Kanger et al., 2020), there needs to be more research to understand exnovation across different domains, particularly in food systems.

Comparative assessments of exnovation for food systems transformation are scarce, as exnovation scholarship has largely been focussed on energy systems (e.g., Turnheim and Geels, 2013; Rosenbloom and Rinscheid, 2020; Koretsky et al., 2022). While a few studies have explored exnovation in food systems (e.g., Van Oers et al., 2021; Frank et al., 2024), they tend to be based on single case studies and, therefore, result in limited understanding of possible variations of exnovation interventions across supply chains, countries and regions. Nevertheless, the transformation of food systems requires policy coherence to ensure consistency and policy packaging to ensure integration (Fesenfeld et al., 2020; Webb et al., 2020). This means that exnovation interventions need to be comprehensively integrated into policy mixes: if done effectively, this could also better support their legitimacy and acceptability (Lonkila et al., 2024).

In this study, we adopted a holistic food system approach and analysed food policy documents in five languages, from 2015 to 2024, to investigate exnovation across the Group of Twenty (G20) countries, with the aim to contribute to the understanding of exnovation for food systems transformation. We identified a clear gap between sustainability exnovation ambitions and exnovation interventions; however, both tend to focus on environmental challenges rather than socio-economic and health aspects. Exnovation interventions (i) rely mainly on regulatory instruments and on exnovating substances or products, and (ii) focus primarily on production stages, which imposes a considerable burden on food producers. Considerations of justice and barriers to exnovation are mainly absent from policy documents. Finally, while this exnovation analysis examined food systems transformation, this approach could be applied to other sectors.

2. Methods

2.1. Searching criteria and scope

This study focused on exnovation across the Group of Twenty (G20) countries. G20 countries represent the world's major and systemically important economies. They represent 85% of global GDP, 75% of international trade and two-thirds of the world's population (G20, 2023). Their economic and political power places them in a favourable position to lead systemic change towards sustainable futures. Due to their size and importance for the global economic and food systems, these countries' transformation strategies and efforts are likely to influence food systems outcomes globally. Table 1S in the supplementary material presents the list of G20 countries and the policy documents analysed.

This study aimed to provide comparative insights into G20 members' policy for food system transformation, and to explore the ways in which exnovation as a crucial transformative leverage point is addressed in major economies. We compiled a corpus of documents on food system

(transformation) policy for each G20 member country, including the African and European Unions. As a document base, we used holistic food systems transformation strategies where they existed. To ensure comparability, we used strategic policy documents submitted to the UN Food Systems Summit 2021. Some countries did not submit such documents, while others published more recent documents, and so we complemented the dataset with an additional search using the string ‘food system AND transition OR transformation AND [respective country name] AND government’ in Google Search, consulting the first ten pages of the search results. If several documents were available, we selected documents based on whole food system coverage (rather than coverage of specific subsystems, such as production, or aspects, such as nutrition), scope and comparability. Multiple reports were selected when no holistic report on food systems transformations was found. We used the search terms in English, French, Italian, Spanish and German languages (e.g. ‘transition agri-alimentaire’, ‘transición agro-alimentaria’), which correspond to the languages spoken by the authors. Occasionally, a snowball search was undertaken from websites found within Google search. We considered reports published since 2015, the year the Sustainable Development Goals were introduced and when countries committed to a systemic approach to sustainability. We identified 25 government policy documents on national food system governance in G20 countries (based on the eligibility criteria, see supplementary material), comprising 792 pages. The full list of documents analysed is presented in Table 1S (supplementary material).

2.2. Iterative and cooperative coding scheme development and analysis

The coding scheme presented in Table 2S (in the supplementary material) was used to code the documents. We developed the coding scheme by identifying theoretically salient facets of exnovation interventions from the literature (i.e. Table 2S), such as the governance mechanisms and value chain scope of the policy in question, which served to structure the content of the materials (Mayring, 2015). The codes included: policy stringency (exnovation ambition or interventions), mechanisms (market-based, information-based, or regulation-based instruments, other), scope (production, processing, distribution, consumption, other), target (business model, institutional logic, product/substance, among others), timeframe, geographical area, consideration of justice, consideration of barriers, sustainability category (environmental, socio-economic, health), positioning in the report (Table 2S). To test the coding scheme and develop context-specific coding rules, all three authors independently coded the same two documents, discussing and harmonising the coding scheme after each round of coding. Coding was carried out in Microsoft Excel between January 2024 and September 2024. Each document was coded by one author; the results were then reviewed by all other authors to reduce bias. Any disagreement was discussed between all authors until an agreement was reached. In some instances, coding rules were again clarified and coding repeated. All codings were reviewed with the final coding scheme (Table 2S).

This study sought to explore exnovation approaches across countries and specifically across the supply chain: it did not seek to analyse country-specific interventions and contexts. Based on the coded information, the qualitative analysis sought to inventory sustainability exnovation ambitions and interventions (i.e. Tables 3S and 4S in the supplementary material, and section 2.3). We defined exnovation ambitions as broader sustainability goals that aim to achieve social-ecological well-being through discontinuing unsustainable elements or configurations of food systems (for example, the aim to reduce premature mortality from non-communicable diseases i.e. Australia, Canada, Germany, Türkiye, USA). We defined exnovation interventions as policy instruments or actions that aim to discontinue specific unsustainable elements (e.g. a substance or business model), such as the ban on the use of polystyrene foam buoys in the fishery sector by the Republic of Korea. We calculated the number of exnovation ambitions and interventions

present in each country. An exnovation intervention requires specificity in terms of an exnovation target (what?) and a concrete measure (how?); additional dimensions of specificity include the amount of reduction (by how much?) and a timeframe (by when?). If these criteria are insufficiently met, the section is coded as an exnovation ambition. We further explored exnovation ambitions and interventions across the supply chain. The goal was to code each exnovation ambition or intervention for a specific supply chain stage. When the text clearly addressed multiple supply chain stages, we coded for multiple stages (e.g. some exnovation interventions related to advertising were coded in the distribution and consumption stages. E.g. Table 4S, above, ID 1, 'Consumption'). For example, where clear, some food loss and waste strategies have been coded for both production and consumption stages. However, we used the residual 'other' category when the supply chain stage was unclear.

2.3. Limitations

The selected strategic high-level documents partially lacked specific details about policies, implementation mechanisms or policy addressees. Due to the high-level nature of the documents analysed, we could not establish details of individual exnovation interventions, such as policy instrument design or funding. Additionally, there are variable levels of detail between policy documents, such that the differences between documents may not reflect the comprehensiveness of national policy mixes.

An additional limitation of the analysis included that, for this type of exploration, it matters how sentences are framed and can change the coding results. In our study, for example, calls to phase out of fossil fuel energy sources represented exnovation. However, we considered that statements simply mentioning the need to increase renewable energies did not necessarily represent exnovation: statements of this type do not explicitly express the need to discontinue fossil fuels (i.e. they might simply represent energy expansion strategies). Therefore, we coded for exnovation only when a clear element of discontinuation could be discerned.

3. Results

3.1. Predominance of sustainability exnovation ambitions over exnovation interventions

The focus of this study was to conduct a content analysis of government policies implementing exnovation. The analysis led to the need to discern between 'sustainability exnovation ambitions' (or exnovation ambitions) from exnovation interventions. We found that exnovation ambitions clearly dominate over exnovation interventions: the analysis indicates that the policy documents for 66% of countries either had more exnovation ambitions than interventions or no interventions at all. Fig. 1 shows the detail of the number of exnovation ambitions and interventions in the sampled policy documents for each G20 country. Of the 185 codes, 67 % related to exnovation ambitions and 33% to interventions. Policy documents of 33% of countries did not mention any exnovation intervention (Brazil, Canada, India, Saudi Arabia, South Africa, Türkiye and the USA), another 33% mentioned more exnovation ambitions than interventions (e.g. Australia, Indonesia), only 24% mentioned more exnovation interventions than ambitions (France, Italy, Japan, Mexico, EU), and 10% mentioned an equivalent number of ambitions and interventions (China and Republic of Korea).

3.2. Exnovation ambitions and interventions in environmental, socio-economic and health challenges

Exnovation ambitions tended to focus on environmental challenges more than social-economic or health challenges. Fig. 2 (left) shows the exnovation ambitions found across G20 countries by frequency of

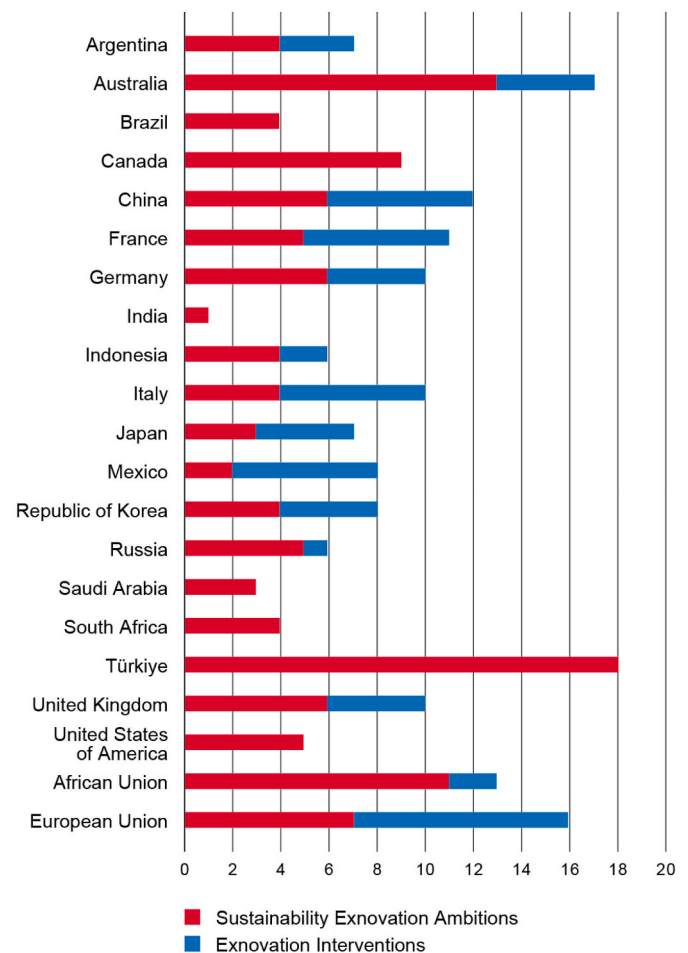


Fig. 1. Number of food systems exnovation ambitions and interventions in G20 Countries.

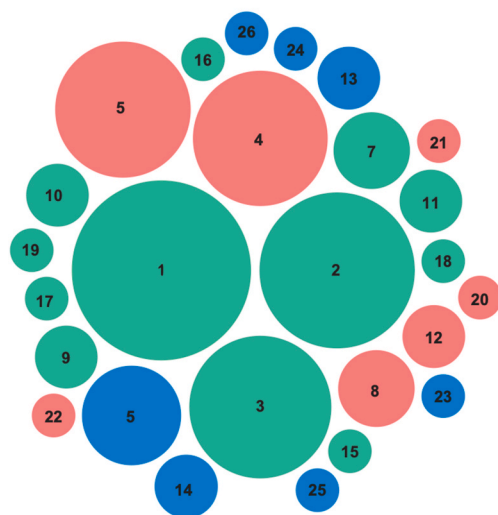
mentions in each country's analysed policy documents. The most frequent exnovation ambition was 'food waste and loss reduction', present in 16 countries' policy documents (i.e. No. 1, Fig. 2, right). Other ambitions were present only in single countries, such as meat consumption reduction (EU) (i.e. No. 17, Fig. 2, right) or alcohol consumption reduction (UK) (i.e. No. 24, Fig. 2, right). Other ambitions included, for example, goals to reduce GHG emissions, diet-related diseases or poverty.

We also found that the highest number (12) of exnovation ambitions tackle environmental challenges (green, Fig. 2), while an equivalent number (7) of ambitions address socio-economic (pink, Fig. 2) and health ones (blue, Fig. 2). Table 3S (i.e. supplementary material) provides examples and details of specific ambitions.

The environmental category also accounts for the highest number (54%) of exnovation interventions, followed by 36% of health-related interventions and 10% of socio-economic interventions. Fig. 3 presents the distribution of these categories per country. Table 4S (i.e. supplementary material) provides the list of exnovation interventions classified by target and supply chain stages. While most countries' policy documents analysed show a majority of environmental exnovation interventions, France's and Germany's have a higher number of health interventions. The African Union did not present any environmental exnovation intervention.

3.3. Exnovation interventions, targets and instruments across the supply chain

The analysis of exnovation interventions across the supply chain,



	No.	Exnovation Ambition	No. Country	
Environmental	1	Food waste and loss reduction	16	
	2	GHGs emission reduction	12	
	3	Application of chemical fertilizers and pesticides reduction	10	
	7	Shortening food transport and supply chains, reducing transport impacts	3	
	9	Fossil fuels reduction	2	
	10	Combat land degradation, desertification and land erosion	2	
	11	Water use reduction	2	
	15	Dependence on hydrocarbons reduction	1	
	16	Packaging and plastics reduction	1	
	17	Meat consumption reduction	1	
	18	Dependency on critical feed materials reduction	1	
	19	Combat illegal finishing and overfishing	1	
	Socio-economic	4	Fight against hunger, food insecurity and malnutrition	9
		5	Poverty eradication	9
		8	Modern slavery and poor working conditions eradication	3
		12	Health inequalities reduction	2
		20	Number of middlemen reduction	1
		21	Prevent food fraud	1
		22	Migration from rural to urban areas prevention	1
Health	6	Burden of diet-related disease reduction	5	
	13	Foodborne diseases reduction	2	
	14	Processed food reduction	2	
	23	Livestock feed antibiotics reduction	1	
	24	Alcohol consumption reduction	1	
	25	Exposure to toxic elements reduction	1	
26	Reductions in levels of childhood stunting	1		

Fig. 2. Left – Packed circle chart of exnovation ambitions. The circle size is proportional to the number of G20 countries that have the ambition mentioned. Right – List of exnovation ambitions per category. Categories include environmental exnovation ambitions (green), socio-economic exnovation ambitions (pink) and health exnovation ambitions (blue). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

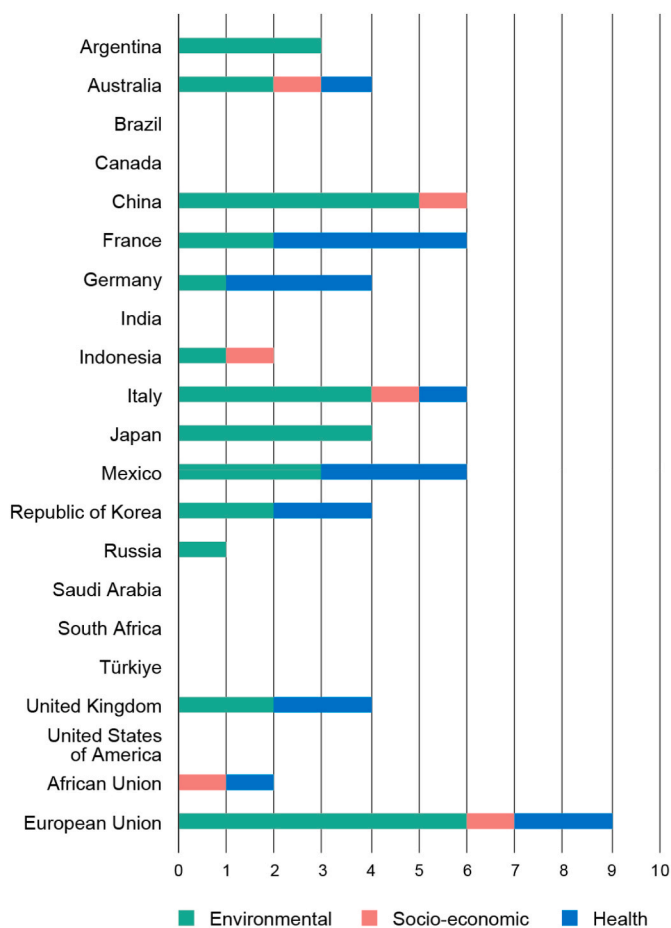


Fig. 3. Number of exnovation interventions per G20 country per environmental area (green), socio-economic area (pink), and health area (blue). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

including exnovation targets and instruments, showed they mainly target production (57% as shown in Fig. 4, above). The exceptions are Australia, Germany and the EU (Fig. 4, below).

Additionally, exnovation interventions target mainly substances and products (51%), followed by business models (34%), policy instruments (7%), technology (3%), and institutional logic (2%) (Fig. 5, above). None of the interventions aims to exnovate a stakeholder group (e.g. supply chain intermediaries).

Through their exnovation intervention, countries tend to target substances and products (e.g. chemical pesticides – EU), followed by exnovating business models (e.g. reducing dependence on long-haul transportation – EU) (Fig. 5, below). Just three countries target policy instruments (e.g. parallel elimination of all forms of agricultural export subsidies – Indonesia), two a technology (e.g. phasing out of problematic and unnecessary plastics packaging – Australia and Japan). Just one country targets an institutional logic (e.g. setting a cap on the value of basic support that farmers can receive per hectare, which challenges the logic of scale in favour of one of limits – Italy).

Exnovation targets change along supply chains, with a different focus at different stages (Fig. 6). Substances and products dominate as exnovation targets across the production, processing and consumption stages, while business models are mainly exnovated in the distribution stage. Analysing intervention mechanisms (i.e. Table 2S, supplementary material) identified 57% of exnovation interventions rely on regulatory instruments: e.g. Argentina introduced a law that sets maximum values for sodium in food to promote reducing sodium consumption. Furthermore, 15% rely on market-based instruments: e.g. Italy has designed schemes that compensate farmers for the additional costs and loss of income resulting from the application of more environmentally and climate-friendly practices, including a reduction in the use of fertilisers and pesticides. Finally, 12% rely on information-based instruments: e.g. Mexico introduced front-of-pack labelling that included information of the nutritional content of pre-packaged foods and beverages, thereby promoting reduced consumption of products with excess critical nutrients.

3.4. Food systems exnovation: justice and barriers

Direct mentions of justice considerations in the documents analysed

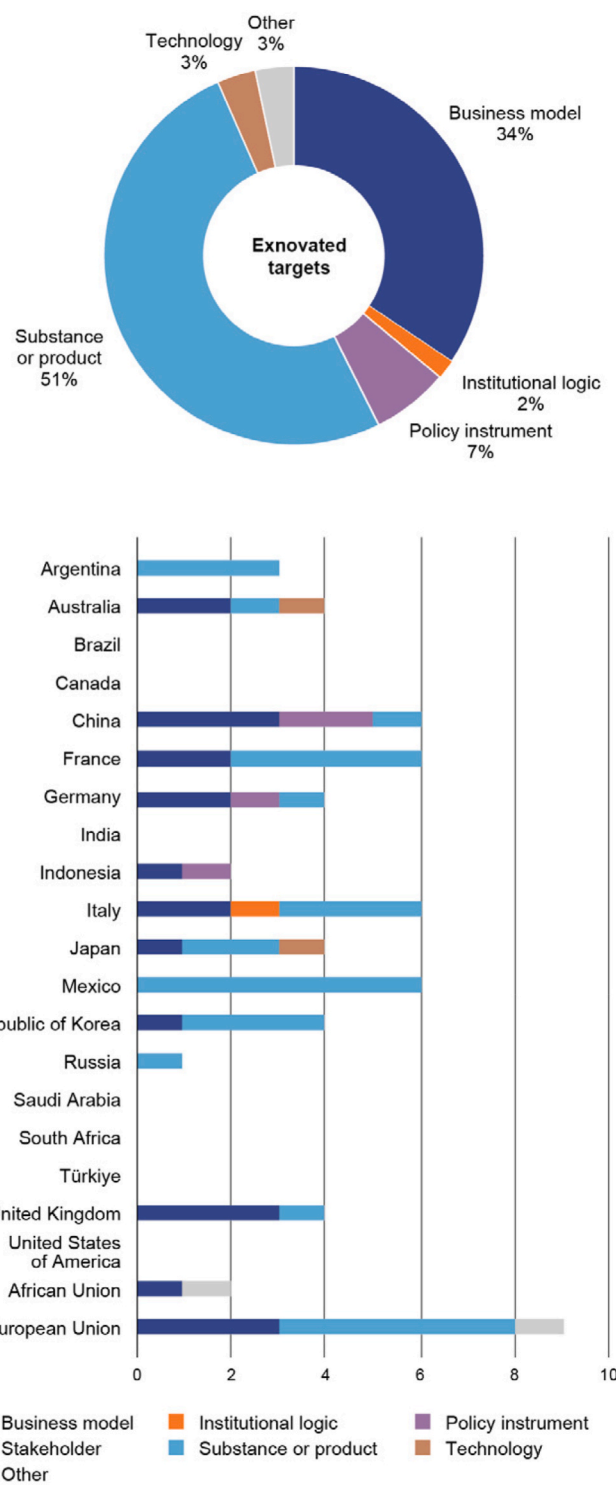
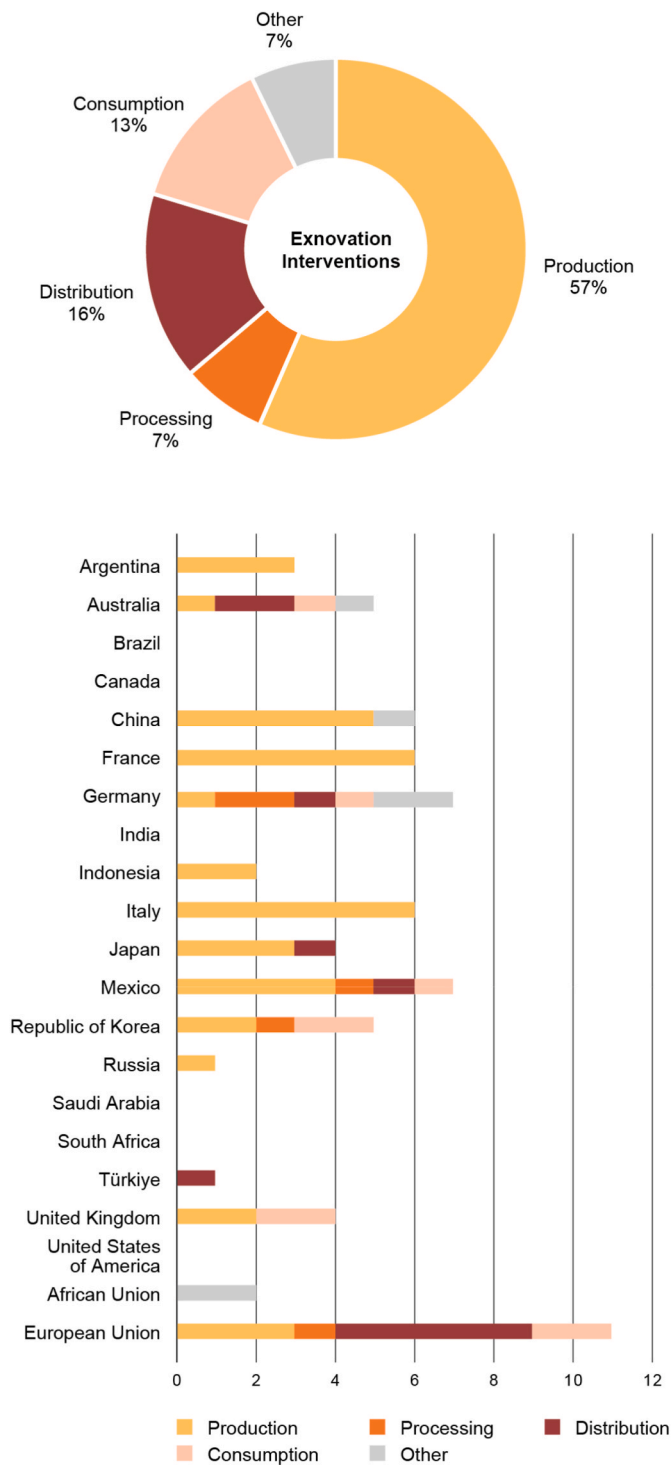


Fig. 4. Above - Food system exnovation interventions across the supply chain; Below - Number of food system exnovation interventions across G20 countries and across the supply chain. Note: For the supply chain analysis, interventions have been counted multiple times at various stages of the supply chain (i.e. Table 4S, supplementary material).

Fig. 5. Above - Food system exnovation targets; Below - Number of food system exnovation targets per country.

are mostly absent in relation to exnovation. Specific justice considerations could encompass compensation measures, participation processes or mentions of affected groups. Justice considerations directly linked to exnovation interventions were present in only 9.8% of the cases. Such direct justice considerations are related to affected stakeholders (e.g. consumers or farmers' income – EU) or countries (e.g. unequal distribution of EU subsidies – Italy; support needed for global south countries

and vulnerable groups to raise their capacity for food security – China). However, several policy documents reported an indirect justice consideration, such as an engagement with diverse food system actors (e.g. as per goals of the National Food Systems Dialogues) and included general mentions of justice elements: e.g. the Republic of Korea or the UK (i.e. Table 5S in supplementary material).

Similarly, considerations of barriers to exnovation were present in only 6.5% of exnovation interventions. We found mentions of barriers in the policy documents of Australia, China, Germany and the EU. For

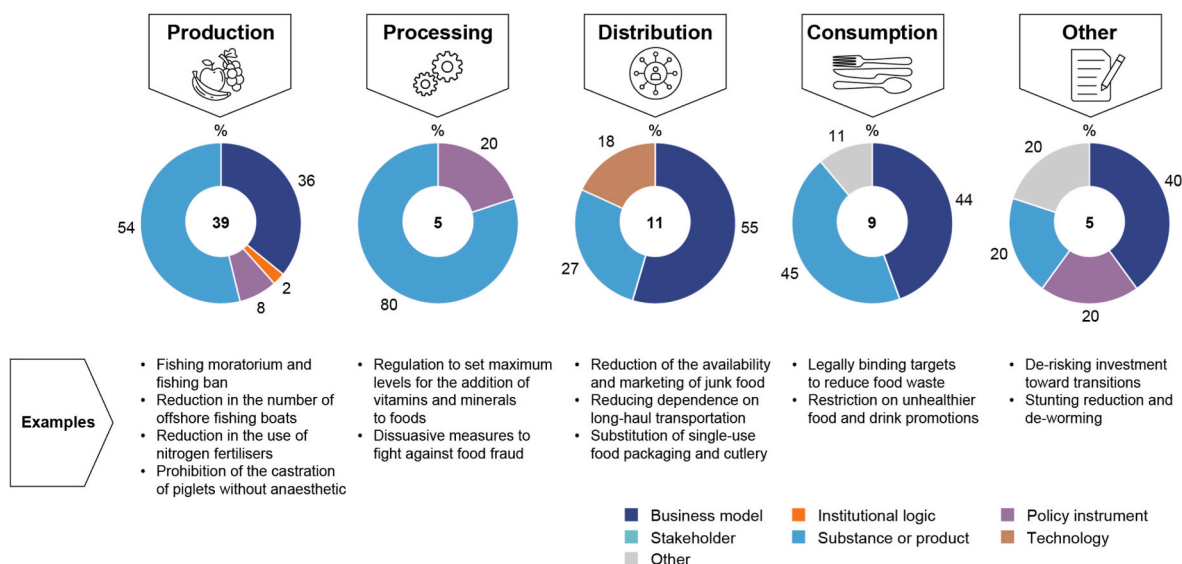


Fig. 6. Exnovation targets across the supply chain. The centre of the circles contains the number of exnovation interventions per supply chain stage. A full list of exnovation interventions with categorisations of exnovation targets can be found in the supplementary material (Table 4S).

example, for Australia, barriers refer to economic and technical challenges (i.e. cost, installation delays, intermittency and unpredictability of supply) in the reduction of reliance on fossil fuels in the agricultural value chain. For China, exnovation interventions – linked to returning farmland to forests and grassland, returning grazing land to grassland and preventing and controlling desertification – referred to the rising constraints of resources and environment (land and water) related to the pressure of a large population. Germany included the EU’s inaction to shift away from foods that promote excessive intake of vitamins and minerals with detrimental effects on human health. The EU’s exnovation interventions to reduce overweight and obesity rates were linked to barriers of routinised food patterns and habits.

4. Discussion

4.1. Catalysing food systems transformations: the need for more coherent exnovation interventions

Food system transformation requires that innovation-led approaches are complemented with a systemic and coherent focus on exnovation. Our study showed that such complementing is lacking in G20 food systems sustainability strategies, which currently continue to prioritise innovation and fail to engage systemically with exnovation interventions for transformation.

First, current exnovation ambitions for food systems do not clearly address causes and instances of unsustainability on the path to supporting transformations. Such transformations are frequently framed as reductions or discontinuations (e.g. poverty or food waste reduction), which may constitute exnovation ambitions but are rarely linked to specific exnovation interventions with clear instruments, targets or timeframes. The prevalence of broad and non-binding exnovation ambitions over exnovation interventions reveals a significant gap in translating ambitions into respective actions. Thus, even when so-called “game-changing solutions” are proposed (i.e. supplementary material Brazil’s report, page 9), food system transformation continues to rely mainly on adding more innovation, such as new technology, new monitoring techniques, additional food information and guidelines, or new (nature-based) markets. Thus, food system transformation requires continual innovation (Herrero et al., 2020), also crucial for this governance are specific and actionable exnovation interventions (Frank and Schanz, 2022; Hebinck et al., 2022).

Second, exnovation interventions address single targets rather than

structural changes. Where exnovation interventions are present, they mainly target single substances or products. Interestingly, although exnovation interventions mainly rely on regulatory instruments, there was no mention of taxes that could be an instrument to leverage exnovation by discouraging unsustainable activities or products. Moreover, we found no connection between exnovation and the broader goals of environmental, socio-economic and health areas. This meant there was a gap in adopting more structural changes (e.g. exnovating institutional logics). Instead, there is a focus on exnovating single elements (e.g. pesticides or plastic cutlery), which signals that symptomatic solutions and technological fixes are prioritised over deeper systemic leverage points (Abson et al., 2017; Meadows, 1999), or barriers to change that are required to match the call for food systems transformation. For example, policies may target obesity through the introduction of ‘precision health’ technologies (e.g., smart watches) rather than through banning junk food, thereby challenging deeply seated consumption practices and power concentrations in the food system.

In sum, exnovation interventions are insufficiently systemic to support food system transformation. Exnovation remains a) insufficient in scope (i.e. fall short of the magnitude required to match the severity of the problem), b) fragmented (i.e. focus just on some single products or supply chain stages) and c) not structural (i.e. focus just on some single elements, rather than institutions, ingrained logics, or power structures). Our results describe exnovation disaggregation by targets and supply chain stages and show how sparse and unsystematic current exnovation interventions are. Such interventions provide very limited support to food system transformation. In fact, it is well known that individual, fragmented interventions are insufficient to achieve high-level environmental objectives and to leverage change in food systems (Leeuwis et al., 2021; Patay et al., 2025; Sundiang et al., 2025).

The dearth of exnovation interventions can serve as evidence of a general lack of comprehensive food system transformation approaches. In our study, ambitions (and partial new interventions) are added onto established policy – usually agricultural policy – rather than developed with exnovation in mind. We argue that there is a need to explore, design and adopt strategies consistent with clear food system transformation pathways that integrate innovation and exnovation approaches (Fuchs and Ziegler, 2024). For example, supporting an agroecological transition may not only involve supporting innovative agroecological practices (e.g., access to land and funds, or producing new knowledge and testing new practices), but also by simultaneously exnovating industrial agriculture (e.g., banning the intensive use of

chemical inputs or intervening against land concentration). Food systems transformation processes require policy actions to address systemic weaknesses (Webb et al., 2020), and exnovation should play a more prominent and integrated role in policy mixes.

4.2. Implementing just and fair exnovation in food systems

The transformation of food systems needs to be based on principles of fairness and justice. Specifically, exnovation interventions should consider how transformation will affect the role and contributions of all actors across the food system. Our analysis reveals that most exnovation interventions target the production stage with less attention paid to other supply chain stages, including consumption. Consumer sovereignty and economic power concentration, remain largely ignored by exnovation ambitions and interventions. The burden of interventions tends to fall narrowly on food producers (Fig. 6, Table 4S).

We found no evidence of exnovation ambition nor intervention that explicitly targeted other actors (other than food producers) that are influential in food production. These actors – such as producers of agricultural inputs, banks or insurance companies – and their business models often influence food producers' choices, possibilities and options. Despite these actors' influence in food production, their interests remain largely untouched. The focus of exnovation on production stages adds considerable changes and burdens to food producers – reflecting existing imbalances in power relations among food system actors (Clapp and Isakson, 2018; Clapp, 2021; IPES-Food, 2023).

Overall, our results also found little consideration of justice and barriers to exnovation. Future exnovation interventions should include more justice aspects and engage more with power and political dynamics, for example by considering the justice implications across the rationale, process and outcomes of exnovation interventions (Lonkila et al., 2024; Van Oers et al., 2021). In this, it is crucial to realise that governments are best placed to coordinate exnovation between different actors across supply chains, but are centrally enmeshed in the political economy and thus not independent arbiters or neutral actors; increased systematic uptake of exnovation is likely to go against organised interests with considerable power over policy development (Clapp, 2021; Van Oers et al., 2021; Béné, 2022).

Contemporary backlashes to exnovation include farmers' protests across Europe. The proposed termination of fuel subsidies in Germany, regulations aimed at reducing nitrogen emissions from livestock farming in the Netherlands and restrictions on agricultural water use in France (Finger et al., 2024) led to hostile responses to exnovation processes perceived to add pressure on farmers' volatile incomes and well-being. These backlashes led some countries and the EU to retract some policy changes (e.g. on pesticides and animal welfare) (Finger et al., 2024). These examples show farmers' sense of injustice linked to exnovation distributional issues, but also exemplify the fight to maintain the very system that contributes to unsustainable food systems (Van der Ploeg, 2020). Thus, these actions hinder changes towards sustainable states and contribute to the undesirable resilience (lock-in) of food systems (Oliver et al., 2018). Top-down or bottom-up resistance arises when the material and ideological interests related to the status quo are scrutinised or threatened (Geels, 2014; Hess, 2014). Resistance to change might continue or even increase if justice is not considered in exnovation (Lonkila et al., 2024) and systemic transformation more broadly (Patterson, 2023). At this critical time, when transformative actions are required to reduce social-ecological harm and transition towards sustainable societies, just and fair exnovation interventions need to play a more prominent role.

CRedit authorship contribution statement

Sabrina Chakori: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Visualization, Writing – original draft, Writing –

review & editing. **Leonard Frank:** Conceptualization, Data curation, Formal analysis, Methodology, Validation, Writing – original draft, Writing – review & editing. **Giuseppe Feola:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.gfs.2026.100915>.

Data availability

I have attached the supplementary material

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