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Advancing the next-generation of global food system scenarios: a critical review of existing narratives

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The recent global crises suggest that historic and current trends in the food system become less relevant when frequently disrupted by unexpected events, such as trade conflicts, the rise of inward-looking, right-wing governments, or another global pandemic. In the face of food insecurity, the foresight community is more strongly emphasizing the need to consider various plausible scenarios when preparing critical strategies within and around the intricate global food system. As scenarios have been developed for many decades, two questions arise: how is the food system community engaging in scenario planning, particularly given the urgent need for transformation coupled with current poly-crisis; and what is needed to enhance the process of scenario planning for the global food system? Therefore, the purpose of this paper is to critically review existing scenarios on global food systems, published by key organizations and authors in the last eight years, to identify common themes of plausible food system futures, the key uncertainties and emerging radical ideas. The paper is based on an inductive clustering framework that offers a method for evaluating the potential outcomes of varying governance structures and policy actions within scenario clusters across key dimensions—health and nutrition, livelihoods and equity, and climate and environment. The critical analysis of the scenario clusters leads to two important findings: (i) megatrends such as shifting demography, technology and consumption patterns are often central in reviewed scenario exercises, and radical notions have not significantly evolved but have taken on new dimensions; and (ii) while factors like consumption patterns, technology, and investment influence food systems significantly, governance structures play a crucial role in shaping the environment for these factors to interact. This underscores the importance of adaptive policymaking in responding to evolving uncertainties. This study provides a strong foundation for designing a next-generation global food system scenario exercise. It calls for a more ambitious, inclusive, and innovative approach for delving into a broader range of uncertainties, radical forces of change and prioritizing the interrogation of drivers related to geopolitical tensions, technological innovations, governance, social influences, and social inequalities.

KEYWORDS

agri-food system, scenario narratives, foresight, scenario clusters, critical uncertainties, radical narratives

1 Introduction

Originated in the military and business sectors to plan for potential futures and develop contingency plans (Kelly, 1993; Bradfield et al., 2005; Kahn and Jones, 2017), scenario analysis has become an increasingly valued tool in understanding and planning strategies around complex systems such as the global food system (Reilly and Willenbockel, 2010; Parson, 2008; Swart et al., 2004). Earlier food system scenario studies were based on linear projection models and focused on understanding potential food shortages, agricultural outputs, and the impacts of population growth and demand changes, with every study revealing the major forces of the system and their potential cumulative impact on it (McCalla and Revoredo, 2001). Since then, scenario studies have evolved to become more adaptable and sophisticated, increasingly using integrated assessment models combining empirical methods and participatory approaches to explore various facets of the food systems, such as ecological impacts of agricultural practices (Vervoort et al., 2014). This is the result of increased understanding of the broader context in which food systems operate and the intricate interplay of social, economic and environmental factors affecting food security and sustainability (Ericksen, 2008). However, there have recently been radical disruptions in the food system caused by COVID-19 pandemic and ongoing geo-political conflicts. These serve as a stark reminder of the persistent uncertainties and transformative shifts that continue to evolve and could plausibly intensify the synergies and trade-offs between food system outcomes (food security, social justice, human and planetary health) and key food system activities (production, processing, storage, trade, consumption, disposal) (Béné et al., 2019; Global Panel, 2020b; Bustamante et al., 2024; HLPE, 2020). Such events underscore the need for continuous exploration of plausible future scenarios that incorporate emerging trends, weak signals, a wide range of uncertainties, and unexpected systemic shifts, ensuring a more adaptive and resilient approach to food system transformation.

In decision-making contexts, scenarios have proven to be a sensemaking tool supporting the identification of robust, multi-scale transformative pathways and visions (Vervoort et al., 2014). Moreover, scenario planning has moved beyond a predictive exercise to become an exploratory tool that fosters new worldviews, challenges dominant paradigms, envisions transformative alternatives, merges systems thinking in decision making and brings people together to create a shared language around the global food system (Ramirez and Wilkinson, 2016; Hebinck et al., 2018).

Formulating scenario narratives is a key part of the scenario analysis process and goes beyond quantitative modelling by weaving together qualitative insights, stakeholder perspectives and systemic uncertainties into coherent storylines that capture the complexity of future developments (Reilly and Willenbockel, 2010). This technique enables a deeper sensemaking process, allowing participants to collectively envision challenges, opportunities and transformative pathways. There are many uncertainties that cannot be sufficiently integrated in a simulation modelling framework, for example, global pandemics, a potential third green revolution or volatile governance structures. Exploratory scenario narratives are very useful for managing such uncertainties when there is no historical data (Reilly and Willenbockel, 2010).

Pioneers in scenario narratives like Pierre Wack emphasized that scenarios should not just extrapolate trends but challenge conventional wisdom by exploring "unthinkable" shifts. He introduced the concept of "memories of the future", which refers to radical yet plausible narratives to prepare decision-makers for disruptive changes (Wack, 1985a,b). Incorporating radical ideas in scenarios means using extreme and transformative ideas that break free from linear thinking in scenario development. The scenarios created by food system experts reveal how the influential organizations and scientists are envisioning the food system futures and what plausible disruptions are they trying to prepare the food system thinkers for.

"Uncertainties" in the context of future studies, are the factors whose future direction, magnitude, or interaction with other drivers is unknown or unpredictable (UN Global Pulse, 2022), and which can significantly influence systemic outcomes (Van Der Heijden, 2004; Kosow and Gassner, 2008). Among these, "critical uncertainties" are those with both high impact and high uncertainty (Schwartz, 1998; Van Der Heijden, 2004). The term "radical" in a foresight context denotes ideas or transformations that challenge dominant paradigms, institutions, or assumptions, and envision systemic change beyond incremental reform (Fazey et al., 2020; Vervoort et al., 2015; Hebinck et al., 2018). Accordingly, we define "radical narratives" as elements in the scenario storylines that explore disruptive, transformative, or non-linear pathways for the food system, aimed at expanding the range of imaginable futures and questioning the boundaries of current thinking.

With an expanding body of literature acknowledging the deep uncertainties shaping systemic change, including governance shifts, evolving economic models, structural inequalities and consumer behaviors (Zurek et al., 2022) and the food system experiencing radical shifts and disruptions (Webb et al., 2020), it is vital that scenario studies also expand and evolve. Against this background, this paper assesses how the literature on scenario analysis is growing in the global food system realm. It also analyses the scenario narratives around the global food system to reveal what these studies consider as the key food system elements in the future and how the future is likely to unfold in the visions they created. Through inductive reasoning, the study seeks to uncover common themes, critical uncertainties, radical forces and governance structures embedded within these scenario narratives. Through this synthesis, the study will provide valuable insights for food system experts and foresight practitioners to help them design a scenario analysis study that tackles the important emerging challenges in the global food system.

The paper addresses five research questions:

(1) What are the key themes and commonalities emerging from existing scenario studies on global food systems?
(2) How can these scenarios be clustered to identify distinct potential futures?
(3) What are the critical uncertainties and drivers shaping these potential futures?
(4) How have the radical ideas incorporated in these scenarios evolved over the last decade?

(5) What insights can be gained from analyzing the scenario narratives to inform foresight practitioners and food system researchers?

The paper is structured to guide the reader through the process of how the range of studies was determined; a "clustering" method based on basic commonalities, what critical uncertainties each scenario considered; the degree to which each developed "radical narratives", and how they link to development paradigms.

2 Selection of studies

While there is growing attention on global food systems and increasing interest in applying foresight and scenario analysis within food system research, the majority of published scenario studies to date focus on EU countries. At the global level, one of the most influential contributions has been the World Economic Forum's scenario narratives (WEF, 2017). However, since then, a series of global disruptions have fundamentally altered the context in which future food system trajectories are being imagined and assessed. Our objective is to synthesize insights from studies that aimed to address the food system at a global scale, or those with substantial global relevance and influence since the WEF, 2017 report. Approximately 19 studies were identified through targeted searches (Google, organizational portals, grey literature). This was not a systematic literature review; rather, it aimed to identify the most globally relevant and narrative-rich foresight exercises available. As such, some regional or academic studies may not have been included. From this set, eight were selected based on four inclusion criteria:

(1) Scenario narratives: The study includes narrative descriptions outlining assumptions around drivers and possible trajectories (not just quantitative trajectories).
(2) Focus: The scenarios had to center on the future of food systems, including their economic, environmental, and social dimensions—not merely agriculture or climate, unless explicitly linked to food system transformation.
(3) Timeframe: Published from 2017 onwards to ensure contemporary relevance in light of recent global disruptions.
(4) Source: Produced by leading international organizations or published in high-impact academic journals, ensuring methodological rigor and policy relevance.

The shortlist was reviewed and confirmed in consultation with foresight and food system experts involved in the FoSTr program (FoSTr, 2025) and the Food Systems of the Future report (Gupta et al., 2025). The final list of eight studies were primarily global, with one EU-wide scenario study that hold broader implications due to the EU's central role in global food governance. These eight studies yielded a total of 30 distinct scenario narratives for analysis (Table 1).

The eight scenario studies are diverse in terms of their focus, scenario methodology employed, and degree of stakeholder engagement. However, all scenario analyses are explorative (rather than normative), and they have all been developed using differing combinations of critical uncertainties. Methods/tools adopted in these studies include consistency matricies, quantitative economic tools, 2 × 2 matricies, morphological matricies, expert consultations and a combination of quantitative models. The scope, methodology, and critical uncertainties used in the selected studies are summarized in Table 1. All have various limitations in scope, rigor, and/or stakeholder engagement.

The eight studies exhibit varied focal points such as food security, sustainability, nutrition, or global shocks reflecting the diverse approaches to envisioning the future of global and regional food systems. "*Three scenarios for Europe's food sector in 2035*" (Moller et al., 2020) emphasizes regulatory, technological, and societal changes within Europe, addressing the unique challenges and opportunities the region faces, such as the implications of EU policies, the shift toward sustainable diets, and innovations in food production. "*Exploring global food system shocks, scenarios, and outcomes*" (Hamilton et al., 2020) and "*Shaping the Future of Global Food Systems: A Scenarios Analysis*" (WEF, 2017) study potential shocks that could disrupt the global food system and their resulting outcomes. These reports emphasize resilience, exploring how unexpected events—such as pandemics, scarcity of resources, climate extremes, or geopolitical conflicts—could rapidly alter the food system. The focus here is on the systemic vulnerabilities and the need for robust strategies to mitigate risks and adapt to sudden changes. Similarly, "*Using scenario analyses to address the future of food*" (Benton, 2019) also emphasizes current trends and emerging issues, such as shifts in consumer preferences, technological innovations, and global markets. While "*Four Futures for the Global Food System*" (Unnikrishnan et al., 2022) stresses the implications of food system scenarios on key actors and the inequalities in food system outcomes for high income and low-middle income countries. "*Future Food Systems: For people, our planet, and prosperity*" (Global Panel, 2020a) takes a holistic view, integrating social, environmental, and economic dimensions into its foresight exercise. This report emphasizes the interconnectedness of food systems with broader global challenges, such as poverty alleviation, environmental stewardship, and economic inclusivity. It advocates for a food system transformation that supports sustainable development goals, emphasizing equity, health, and planetary wellbeing. Finally, "*The future of food and agriculture: Alternative pathways to 2050*" (FAO, 2018) and "*The future of food and agriculture: Drivers and triggers for transformation 2022*" (FAO, 2022) focus on multiple global trends and uncertainties. They explore how different pathways could influence global food security, environmental sustainability, and economic development, providing a more comprehensive analysis of possible future scenarios on a worldwide level.

The most comprehensive scenario study in terms of broad stakeholder consultation was that conducted by the World Economic Forum. However, this consultation was mostly with global-level experts and institutions, with limited national or local-level input. Actors from across international institutions, civil society, governments, and research were involved. However, because the study was conducted under the auspices of the World Economic Forum, it is not necessarily seen as an unbiased global consensus document by all actors.

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TABLE 1 Summary of foresight studies with scenario narratives around food system.

Study	Author	Year	Focus	Methodology	Stakeholder participation	Critical uncertainties used	Scenarios
Three scenarios for Europe's food sector in 2035	Europe: Fraunhofer Institute for Systems and Innovation Research ISI	2023	Future governance of European Union food systems	Multi-factor with consistency matrix	Experts and FOX partners	Appreciation of products promoting ecosystem services; Measures to reduce climate change in the food sector; Degree of centralisation of food production; Purchasing behaviour related to food; Public and private investment in food and agriculture; AI in the value chain	Scenario 1: Strong regulation puts the brakes on entrepreneurship and public trusts government. Scenario 2: Society drives sustainability—food is sourced locally, shorter supply chain saves resources, and customers care more about environment and climate change. Scenario 3: A CO_2-currency and retailers dominate trade and consumption.
The future of food and agriculture Alternative pathways to 2050	Global: FAO	2018	Global food systems, generally	Based on Shared Socio-Economic Pathways (SSPs)	Combination of various activities involving different levels of stakeholder involvements	Economic growth, international governance, human development, energy use and GHG, welfare and lifestyle, land and water use, agricultural policies, yields and innovation.	Scenario 1: Business as Usual (BAU) Scenario 2: Toward sustainability (TSS) Scenario 3: Stratified societies (SSS)
Exploring global food system shocks, scenarios and outcomes	Global: Hamilton et al.	2020	Possible shocks to the future of food systems	Prioritization of likely shocks	Stakeholders from research, policy, retail, NGO's, production, energy and insurance sectors. All residing in the UK.	Technology, connectivity, trade, food price, environmental health, food waste, food diversity	Scenario 1: Automation Scenario 2: extreme weather Scenario 3: financial speculation Scenario 4: monoculture vulnerability
Using scenario analyses to address the future of food	Global: Tim Benton	2019	Global food systems-generally	Two critical uncertainties matrix (2 × 2)	No stakeholders involved. Authors' perspectives	Dietary shifts: level of connectivity (globalized vs. localized)	Scenario 1: Unchecked consumption in a globalized world Scenario 2: Sovereign (in)sufficiency Scenario 3: Global, green and healthy Scenario 4: Localised and sustainable
Shaping the Future of Global Food Systems: A Scenarios Analysis	Global: World Economic Forum	2017	Global food systems -generally	Two critical uncertainties matrix (2 × 2)	Extensive with global level stakeholders	Demand Shift (resource-intensive vs. resource-efficient); Market Connectivity (high connectivity vs. low connectivity)	Scenario 1: Survival of the richest Scenario 2: Unchecked consumption Scenario 3: Open-source sustainability Scenario 4: Local Is the new global
Four Futures for the Global Food System	Global: BCG	2022	Global food systems -generally	Multi-factor	Unclear	The state of the world's agriculture, climate change, and global economic and geopolitical dynamics	Scenario 1: Uneven progress Scenario 2: The rise of Africa Scenario 3: Every country for itself Scenario 4: Coordinated step forward
The future of food and agriculture—Drivers and triggers for transformation 2022	Global: FAO	2022	Global food systems -generally	Two critical uncertainties matrix (2 × 2)	Based on expert consultations and previous scenario development work by FAO communities	Geopolitics and power; Economic growth and employment; Demography; Resources and climate; Agriculture; Technology and investment in agrifood systems; Poverty, inequality, food security and nutrition outcomes	Scenario 1: More of the same (MOS) Scenario 2: Adjusted future (AFU) Scenario 3: Race to the bottom (RAB) Scenario 4: Trading off for sustainability (TOS)
Future Food Systems: For people, our planet, and prosperity	Global: Global Panel	2020	Nutrition oriented focus on global food systems	Two critical uncertainties matrix (2 × 2)	Wide range of experts	Environmental risks (environmental breakdown vs. green and stable) and the nature of economic growth (profit at any cost vs. inclusive growth).	Scenario 1: Perfect storm, business as usual Scenario 2: Volatile, but inclusive Scenario 3: Green, but unequal Scenario 4: Perfect calm

3 Scenario clusters

Cork et al. (2023) describe scenarios as "narratives constructed to explore alternative futures and to test or develop the logic behind the futures-thinking involved". As noticed in the selected articles on scenario analysis, methods for developing scenarios (e.g., models, creative works), processes (e.g., expert-driven, participatory), and objectives (e.g., optimizing and enhancing current power structures, challenging the status quo, fostering novel futures) vary. Another primary distinction in the selected studies lies in the "critical uncertainties" or "key drivers" around which they are constructed.

The principles governing future food systems can be delineated and categorized based on the priorities of various scenarios, offering distinct clusters that describe future food landscapes. Clustering the scenarios into different worldview categories is one of the methods for synthesizing scenarios in the literature. For example, the "global scenario archetype" framework is used extensively in the Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services (IPBES) regional assessments to summarize the trends in various scenarios and deduce their impact on system outcomes and their policy implications (Sitas et al., 2019). This framework, although not focusing on the food system *per se*, uses mental models that assume economic growth, environmental protection, population change and policy as the key attributes for the global system's future paradigms. These are also relevant for in discussions about how to transform food system outcomes (Ingram and Thornton, 2022).

Analysis of the eight studies detailing various food system scenarios collectively presented 30 distinct scenarios. Inspired by IPBES clusters (Sitas et al., 2019), an inductive reasoning approach was applied to thematically categorize the scenarios into overarching themes, called "clusters" based on the underlying assumptions about key food system drivers and the worldview represented in the scenario (Sitas et al., 2019). These clusters were named: continuing trends; global sustainability; local solutions; rising inequality; and uncontrolled chaos (Table 2: The numbers in column 2 refer to the specific narratives as listed in the Supplementary material).

While each individual scenario does not necessarily fit perfectly with these scenario clusters, the clusters do give an overview of broad commonalities.

(1) **Continuing trends**: a business-as-usual scenario with some minor corrections to manage immediate issues but a continuation long-term negative impacts, driven by the existing dominant structures of the food system.
(2) **Global sustainability**: recognition of emerging food system risks drives a new global compact across governments and businesses to transform the food system to avoid crises.
(3) **Local solutions**: in a world of increasing geopolitical tensions and an inability to construct global agreements for change, national governments and local communities bring change based on ideas of food sovereignty and localized food systems.
(4) **Rising inequality**: nations and individuals with wealth act to protect their own interests in the short term, leading to escalating inequality, increasing exploitation in the food system, and disparities in those who can afford to eat healthy diets and those who cannot.
(5) **Uncontrolled chaos**: escalating crises caused by climate change or other shocks, with no effective governance on national or global scales leads to a breakdown of food systems with social and political instability and large-scale humanitarian crises.

The story lines for each of the scenarios are constructed around the critical uncertainties (Table 1, column 7) supplemented by a broader set of trends and contextual drivers that inform assumptions about how the future unfold in that scenario. In scenario development, trends provide a contextual backdrop, while critical uncertainties shape the branching logic of divergent futures. These drivers of change broadly include: (1) Policy and governance structures, (2) Global development, (3) Diet and consumer behavior, (4) Technology, innovation and information, (5) Environmental conditions and resource use, (6) Climate change, and (7) Inequality issues (Gupta et al., 2025). The variation in assumptions made about these drivers across the selected scenario studies reflects the cone of future uncertainty—a concept that illustrates how the range of plausible futures widens as we project further into the future (Hancock and Bezold, 1994; Gall et al., 2022).

Below, we summarize which drivers and their associated trends were explicitly explored in the 30 reviewed scenarios, with scenario numbers indicating where each trend appears. A more detailed meta-analysis of how these drivers were addressed across the studies is provided in the Supplementary material.

(1) Policy and governance structures range from centralized, authoritarian control to decentralized, participatory governance. Key trends:

i. Strong state control: varying degrees of state involvement in the food system (scenario 1, 12).
ii. Market-based approaches: reliance on market forces to drive change (scenario 3, and 29).
iii. Multi-stakeholder partnerships: collaboration between governments, businesses, and civil society (scenarios 2, 5, 17, 18, 22, and 26).

(2) Global development including global cooperation range from isolationism and protectionism to enhanced international collaboration. Key trends:

i. Fragmentation: increased geopolitical tensions and trade barriers (scenarios 12, 15, and 21).
ii. Multilateralism: cooperation on global challenges such as climate change and food security (scenarios 5, 13, 17, and 22).
iii. Dependency: enhanced interconnectedness of global supply chains and economies (scenarios 3, 11, 13, 16, and 17).
iv. Power dynamics: shifts in global power balance and increasing influence of certain actors (scenarios 3, 11, 15, 19, 20, 25 and 29).

TABLE 2 Scenario clusters (rows) based on global growth direction, key drivers (columns) and the general assumptions in scenarios (cells).

Cluster	Scenarios aligned with these assumptions	Policy and governance structures	Global development	Diets and consumer behavior	Technology, innovation and information	Environmental conditions and resource use	Climate change	Inequality issues
Continuing trends	4, 23, 24	Fragmented efforts for change constrained by economic interests	Status quo—struggling to be effective	Food insecurity and unhealthy diets increase	Driven by short-term market opportunities	Largely exploitive with some minor improvements	Gradual improvement but not fast enough	Focus on basic needs, trade-off
Global sustainability	5, 13, 17, 20, 22, 26, 30	International agreements and institutions	Strong, collaborative approach	Achieving good nutrition becomes driving force	Focused on achieving health and environmental outcomes	Efficient, focus on renewable resources	Major efforts and investments for mitigation and adaptation	Increasing equity is a driving force
Local solutions	2, 12, 14, 18, 21	Highly decentralized and participatory	Nations turn inwards due to ineffective global mechanisms	Improving diets drives many local initiatives	Focused on appropriate technology and indigenous knowledge	Efficient, focus on sustainability, and biodiversity	Local communities take action, but global mitigation is weak	Local quality of life by less resource intensive
Rising inequality	6, 15, 19, 29	Heavily influenced to protect short-term interests of wealthy	Dominated by powerful economic interests	Duality of good and poor nutrition between rich and poor	Works largely to the interests of elites	Poorer nations and people forced to exploit resources to survive	Focus on adaptation which can only be afforded by rich	Extreme, with punitive measures against unrest
Uncontrolled chaos	11, 16, 25, 27	Weak and ineffective at all levels	Significant breakdown of global order	All nations struggle to meet food security and nutrition needs	Technology fails to be help tackle emerging crises	Natural disasters and collapse of ecosystems become overwhelming	Severe negative impact, extreme weather affecting all	Extreme with conflict civil unrest

The numbers in column 2 refer to the specific narratives listed in the supplementary.

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(3) Diet and consumer behavior patterns range from resource-intensive, high-consumption lifestyles to minimalist, plant-based diets focused on local and seasonal foods. Key trends:

i. Resource-intensive consumption: least consciousness of the source of food consumed (scenarios 3, 11, 12, 15, and 16).
ii. Shift toward healthier and more sustainable diets: increased preference for diverse foods, with higher proportion of locally sourced and produced foods (scenarios 2, 5, 13, 14, 17, 18, and 30).
iii. Conscious consumption: growing awareness of environmental and social impacts driving consumer choices (scenarios 2, 17, 18, and 26).
iv. Polarization: disparity in affordability of healthy diets between high-consumption and low-consumption populations (scenarios 15, 16, 27, and 29).

(4) Technology, innovation and information ranges from highly developed and integrated systems to more traditional methods. There is a tension between technology as a tool for sustainability and efficiency vs. its potential to exacerbate inequalities and create new risks. Key trends:

i. Increased automation and data: high levels of automation in agriculture and food processing (scenarios 7, 11, and 16), optimizing supply chain (scenarios 1, 3, and 17), and the rise in e-commerce for food distribution and consumption (scenario 3).
ii. Improvements using biotechnology and genetic engineering: focus on developing high-yielding and resilient crop varieties (scenarios 11 and 16) or enhancing product quality and shelf life (scenario 3).
iii. Renewable energy growth: integration of renewable energy sources into food production and processing (scenarios 2, 5, 13, 14, 7, 18, 22, and 26).
iv. Data sovereignty: governments or corporations controlling vast amounts of data (scenarios 1 and 3).
v. Agro-ecological practices: ecological regeneration and reduced external inputs in agricultural production (scenarios 30).

(5) Environmental conditions and resource use ranges from intensive resource exploitation to circular economy approaches. Key trends:

i. Efficiency: focus on maximizing resource productivity, increasing crop yield, and maximizing profits (scenarios 2, 5, 7, 13, 14, 17, 27, and 29).
ii. Depletion: overexploitation of resources in some scenarios leading to scarcity and conflict (scenarios 3, 4, 6, 11, 15, 16, and 25).
iii. Regeneration: efforts to restore and conserve resources through sustainable practices (scenarios 2, 5, 14, 26, and 30).

(6) Climate change ranges from increase in emissions to reversal of climate change impacts. Key trends:

i. Failure to stem climate change: lack of mitigation and adaptation strategies coupled with resource intensification drives climate change and worsens impacts (scenarios 8, 11, 12, 15, 16, 19, 20, 21, 23, 24, 25, 27, 28).
ii. Proactive measures to abate climate change: The worse impacts of climate change abated to certain extent (scenario 13, 17, 22, 26, 29).
iii. Targets achieved: significant efforts to achieve the objectives of the Paris Agreement results in reversal of climate change impacts (scenario 30).

(7) Inequity issues range from increasing inequality to greater social justice. Key trends:

i. Disparity: the widening gap between rich and poor, both within and between countries (scenarios 3, 4, 6, 11, 15, 16, 19, 23, 25, and 29).
ii. Inclusive growth: efforts to reduce poverty and mitigate worse impacts of climate change on rural poor through inclusive economic models and public-private support (scenarios 1, 5, 17, 18, 22, 26, 28, and 30).
iii. Social unrest: Potential for conflict and instability due to lack of resilience to price volatility, climate change, crop diseases and injustices (scenarios 8, 27).

The "*continuing trends*" *cluster* represents a pathway where the *status quo* prevails, characterized by reliance on the existing development paradigm focused on fossil fuels, power concentration and short-term thinking. Economic growth and efficiency are prioritized over long-term sustainability and social equity. Consumer desires and purchasing power shape consumption patterns, while market giants drive technological change, focusing on short-term gains in resource efficiency and economic profits. Climate change and environmental degradation are addressed through isolated efforts and minor policy adjustments, lacking a systemic approach to long-term sustainability. This pursuit of economic growth exacerbates disparities and ethical conflicts. Yet in some regions, there is a growing emphasis on sustainability and global cooperation, which offer potential positive food system outcomes. While other clusters explore alternative approaches, this cluster highlights the risks and consequences of maintaining the *status quo*.

The most optimistic pathway for the food system outcomes is the characterized in the "*global sustainability*" *cluster*, which stands in contrast to the other clusters due to its emphasis on international collaboration and coordinated action to address global food system challenges, including inequality and the climate crisis. As the key players in the food system interact and collaborate, the dependencies and trade-offs in the global food system is recognized, which is important for developing holistic and balanced policy frameworks considering environmental, social, and economic factors. These factors together create a foundation for addressing food security, sustainability and equity issues on a global scale. In the scenarios focusing on global sustainability, while challenges undoubtedly persist, the cooperative approach offers the greatest potential for positive change. This cluster highlights the embeddedness of synergic governance mechanisms

which are responsible and influential at all scales in the successful systemic transformation.

As the name suggests, the "*local solutions*" *cluster* focuses on local food production, reduced reliance on global supply chains, and increased self-sufficiency. In this pathway, the food system can benefit from technological advances, but the focus is on reducing the environmental footprint and resilience at the local scale, as opposed to the "continuing trends" and "global sustainability" clusters. Consumer empowerment and strong local governance inherently play a major role in achieving local goals, therefore participatory approaches in bringing systemic changes become crucial. Compared with the assumptions in the "global sustainability" cluster, those within the "local solutions" cluster align with the difference in geographical scale and type of transformative elements. For example, food safety regulations and monitoring systems, consumer preference tracking and response systems, etc. are important tools in managing local systems.

The "*rising inequalities*" *cluster* highlights the potential for worsening social and economic disparities, with serious implications for food security, environmental sustainability, and social stability. A central theme across these scenarios is the widening gap between rich and poor, both within and between countries, leading to unequal access to resources and opportunities. While the "continuing trends" cluster shares some similarities, particularly around unmanaged inequalities, "rising inequalities" explicitly focuses on social stratification and the breakdown of social support systems. These scenarios also point to environmental degradation in low- and middle-income countries as a consequence of economic development in wealthier nations. Although there is recognition of integrated environmental and climate strategies, this cluster warns of potential social unrest if these strategies are not implemented inclusively.

The last cluster "*uncontrolled chaos*" incorporates worst case scenarios with multiple system failures and where the absolute downfall of the food system is realized. The cluster is characterized by a focus on the negative consequences of unsustainable development and the failure to address global challenges. These scenarios highlight the risks of unchecked consumption, resource depletion, climate change, and inequality and serve as a stark warning of the potential consequences of inaction and the urgent need for coordinated global efforts to address the challenges facing the food system. While the direction of drivers in "*continuing trends*" and "*rising inequalities*" may also lead to challenges in the future, the "uncontrolled chaos" cluster emphasizes the chaotic and unpredictable nature of these challenges. This cluster can also be interpreted as the extreme version of the "continuing trends" cluster, where the negative consequences of inaction escalate to a critical level.

In essence, clusters with potentially most positive outcomes are "*global sustainability*" and "*local solutions*" where synergic sustainability is prioritized. While the underlying goal in both clusters is sustainability for healthier people and the planet, they differ in scale and approach. Sustainable localization focuses on local solutions, while global cooperation seeks to address challenges through international collaboration. Although these two clusters might appear contrasting, they are not mutually exclusive and have overlaps. Both models recognize the role of technology in driving food system transformation. For instance, "scenario 2: CO_2-currency" highlights technological innovation in a market-driven context, while "scenario 22: coordinated step forward" emphasizes technology's role in climate-smart agriculture within a cooperative framework. Another overlap is that both models acknowledge the importance of global trade, albeit with different priorities. Market-driven globalization emphasizes trade for profit maximization, while global cooperation views trade as a tool for shared benefits and sustainable development.

As not all worldviews lead to a positive trend in key drivers, a balance between market forces, global cooperation, and sustainable localization may be required when considering food system transformation. For instance, global cooperation can create a framework for fair trade and sustainable development goals; market-driven globalization can drive innovation and economic growth; and sustainable localization is required to promote self-sufficiency and community wellbeing while considering social equity issues. However, without effective governance and regulation, market forces can exacerbate global inequalities and environmental problems.

There are many overlaps of cluster trends in scenarios. Some scenarios incorporate a balance between global sustainability and controlled economy (e.g., scenario 29: green but unequal), while in others, despite substantial local efforts and capacity building, challenges persist for environmental and socio-economic systems at the larger scale (e.g., scenario 24: adjusted future). Some scenarios exhibit both positive and negative outcomes. For example, scenario 17 promotes resource efficiency while acknowledging potential inequality. These clusters therefore need to be read with consideration that they are just different ways of narrating future food system outcomes—there are many factors not in Table 2 that could be important in some scenarios (such as consumer power, civil society movements, type of technological advancement, investment systems and role of bilateral).

4 Critical uncertainties used in scenario studies

Understanding which uncertainties are considered most critical across scenario exercises can provide valuable insights into how different actors envision the future of food systems and where they see the greatest potential for disruption or transformation. In scenario planning, critical uncertainties are defined as drivers that are both highly uncertain in terms of future trajectories and highly impactful in shaping outcomes (Van Der Heijden, 2004; Schwartz, 1998). By clustering these uncertainties across the reviewed studies into thematic groups, this section aims to highlight areas of convergence and divergence in how food system futures are framed.

All eight scenario studies used a combination of uncertainties to construct their set of future scenarios. These are the key drivers or factors for which the future state is highly uncertain and will have high impact, called "critical uncertainties' in scenario terminology. Some of the scenarios were constructed using two critical uncertainties in a 2 × 2 matrix (Duckett et al., 2021; FAO, 2022; WEF, 2017; Global Panel, 2020b), while others used a larger number of uncertainties for example in studies applying

morphological analysis (Moller et al., 2020). These uncertainties have been clustered into common groups, leading to eight main areas of uncertainty:

(1) **Biological shocks**: the degree to which human or animal disease, or pest, outbreaks could disrupt food systems.
(2) **Business structure**: the degree of control of food systems by large global corporate entities and how much opportunity there is for smaller scale producers and food system enterprises.
(3) **Climate change**: the extent to which climate change impacts food systems and how the food system may respond to the needs for mitigation and adaptation.
(4) **Diets**: the degree to which diets shift to consumption patterns that support better health and better environmental outcomes.
(5) **Environment**: the extent of the impact of food production on the environment and the level of more resource conserving practices.
(6) **Equity**: the extent to which poorer groups can afford healthy diets, how exploitive the food system is of its producers/workers, and which poorer groups are more vulnerable to food systems shocks.
(7) **Globalization**: the degree to which food is widely traded globally or locally produced and consumed, the degree of food sovereignty for nations, and the degree of global cooperation or competition/conflict around food system related issues.
(8) **Technology**: the impact of new technologies (known and unknown) on the overall structure and function of the food system (e.g., AI, reducing labor, radically different food production technologies and innovations in health monitoring).

The is a considerable degree of commonality and consistency across the scenarios in terms of assumptions about the key factors that are likely to impact the future of food systems. The most common factor or uncertainty is, unsurprisingly climate change, followed by diet (consumption patterns).

The clustering of critical uncertainties across scenario studies reveals a notable degree of convergence in how global food system futures are conceptualized. Climate change, dietary transitions, and technological innovation emerge as dominant axes of uncertainty (Table 1), reflecting widespread recognition of their potential to transform the food system in unpredictable ways. This consistency also suggests a shared mental model among the scenario developers regarding which forces are most likely to shape the future. However, the clustering also highlights areas that are underexplored or unevenly represented. For example, uncertainties related to consumer's behaviors (Moller et al., 2020), business structure (Moller et al., 2020), and geopolitical dynamics (Unnikrishnan et al., 2022).

Moreover, the current framing of critical uncertainties often reflects the epistemic priorities of institutions in the Global North, reinforcing particular narratives of risk and opportunity while marginalizing others. For instance, while climate change is rightly prioritized, uncertainties around land access, informal markets, or traditional knowledge systems, which may be critical in Global South contexts, are rarely foregrounded. This underscores the importance of fostering epistemic diversity in scenario development (Vervoort and Gupta, 2018), ensuring that different knowledge systems, regional priorities, and lived experiences shape the construction of uncertainty and the exploration of plausible futures.

Finally, the use of critical uncertainties as a structuring device often follows a conventional 2 × 2 matrix format, which, while effective for generating contrasting pathways, may also limit the complexity and plurality of futures considered (Mietzner and Reger, 2005). More participatory and interdisciplinary foresight methods involving morphological analysis (Johansen, 2018; Lord et al., 2016), Delphi or updated Delphi i.e., Causal Layered Analysis (Pfendtner-Heise et al., 2024; Inayatullah, 1998; Tapio, 2003; Mozuni and Jonas, 2017), or Participatory Backcasting (Carlsson-Kanyama et al., 2008; Robinson et al., 2011), can allow for richer engagement with uncertainty and help surface novel or transformative system logics (Wilkinson et al., 2013; Fergnani, 2019). To move toward next-generation scenario practices, it will be important to complement dominant uncertainties with context-specific ones, and to co-create futures with actors who experience systemic uncertainties in highly differentiated ways.

5 Radical narratives

At the time scenarios are built, radical ideas sound extreme and unthinkable, but *what if* they become a reality? A crucial part of lateral thinking involves imaging these "what ifs" (De Bono, 1994). A good example is Shell's scenario work, where the rise of environmental activism and the digital revolution were used as unexpected changes but later became reality (Wilkinson and Kupers, 2013). This example shows that radical ideas can also reveal future opportunities while scrutinizing the vulnerabilities and deep uncertainties within the system.

What are these radical ideas? They are hyper-divergent perspectives around various contexts like unconventional innovations, paradigm-shifting governing structures, and unthinkable destructive forces or events that depart from current norms and expectations, potentially leading to profound changes in the system (Wilkinson and Kupers, 2013; Kahane, 2012; 4STRAT, 2025). The role of radical ideas in food system scenarios has evolved significantly over the past few decades. Initially, food system scenarios focused on predicting supply and demand trends and largely missed radical ideas, but over time, they have incorporated systemic disruptions, radical power shifts, and transformative innovations. Food system scenario studies reveal the stages of this evolution.

Until the 1990s, the focus of FAO was to report the trends and status of food supply-demand and trade, while incorporating discussions on the impact of technological intensification considering the Malthusian concerns (Alexandratos, 1995). From the late 1990s until the 2010s, the use of forward-looking approaches in these discussions gained importance, with scenario-based studies such as the Millennium Ecosystem Assessment and IPCC changing the norms for food system assessments. This period was focused on new sustainable systematic approaches that

recognized ecological limits, governance challenges, and global inequalities. The radical ideas incorporated in scenarios at the time were often treated as alternative pathways toward sustainability. Key examples include global environmental governance and nature-based solutions in food futures (Millennium Ecosystem Assessment, 2005), planetary boundaries framework (Rockström et al., 2009), agroecology and food sovereignty (Altieri, 2002), decolonizing food systems (i.e., shifting power from agribusiness to local food networks) (Patel, 2009), long-term climate risks (Pachauri and Reisinger, 2007), and cellular agriculture and climate-engineered crops (Datar and Betti, 2010). The focus from the 2010s to 2020 was on incorporating radical socioeconomic, food production, and governance changes in forward-looking studies, including radical dietary and food production shifts (The Government Office for Science, 2011), circular food economies (Ellen MacArthur Foundation, 2013), post-capitalist food economies, food beyond profit-driven markets (Raworth, 2018), and food as a human right, guaranteed minimum food policies, shifting away from market-based food access (Caraher and Furey, 2018). Some other key radical ideas developed in this period include the end of industrial livestock (alternative proteins, plant-based diets) (Willett et al., 2019), AI and automation in agriculture, precision farming and digital food governance (Rotz et al., 2019).

We reviewed food system scenario narratives in the selected publications to map the radical ideas that are captured in recent literature and to provide insights on the novelty of these ideas. Table 3 provides details of the radical ideas emerging in the reviewed scenarios. They are increasingly shaped by emerging drivers such as artificial intelligence (AI), social media, misinformation, and data ownership. The evolution of these drivers introduces new dimensions to previously considered disruptions, intensifying their impact and accelerating their manifestation. For instance, state ownership of agricultural land and data sovereignty (scenarios 1 and 12) is no longer simply a matter of political ideology, but it is now influenced by AI-driven governance and digital control over food systems. Similarly, the rise of highly-automated food systems (scenarios 3 and 7) is being pushed further by advancements in robotics and AI, which not only replace human labor but also make supply chain decisions in real-time. Meanwhile, the increasing role of misinformation, particularly via social media, can amplify food system shocks, whether by fueling panic buying, manipulating food prices, or spreading distrust in sustainable practices. This links closely to retailer data sovereignty (scenarios 7 and 17), where major corporations use consumer data to shape dietary choices and monopolize food markets. As digital and algorithmic forces reshape food security, trade, and access, traditional ideas of food sovereignty, consumer agency and global cooperation must be reconsidered in light of these disruptive influences. Similarly, neo-extractivism, historically linked to resource-intensive agriculture, is intensified by financialized digital food markets, where speculative investments, often fueled by AI-generated risk models, exacerbate inequalities. Climate apartheid, previously understood through geographic and economic disparities, is now accelerated by data-driven exclusion, where predictive AI models allocate resources and insurance based on biased risk assessments. These examples illustrate how emerging drivers do not simply replace old disruptions but rather transform them, creating new risks and opportunities that demand deeper foresight and governance.

The radical ideas in scenario narratives developed in the last 7–8 years are not entirely distinct from the ideas that were developed in earlier years. These more recent ideas intertwine historical precedents with emerging transformations, revealing both continuity and novelty in global agri-food trajectories. Some disruptions, such as state ownership of agricultural land and protectionist food policies, have deep historical roots in state-controlled economies (e.g., Soviet collectivization, Chinese agrarian reforms) (The Rockefeller Foundation, 2010). However, their modern manifestations particularly with the rise of digital data sovereignty, introduce new complexities in governance and control (Kitchin, 2014). Similarly, local self-sufficiency trajectory echoes historical subsistence farming traditions, however today's food sufficiency pathways are links sustainability and development leveraging technological innovations such as vertical farming and regenerative agriculture (Altieri and Nicholls, 2020). Other evolving disruptions, like climate apartheid and neo-extractivism, build upon historical patterns of inequality and resource exploitation but are exacerbated by climate change and financialized food systems (Newell and Taylor, 2018). While many reviewed scenarios build on existing trends, they also incorporate a few genuinely new dynamics that have the potential to radically transform food systems if they diverge strongly from historical patterns. Notably, these include highly automated, AI-driven food systems and retailer data sovereignty, where advances in artificial intelligence and big data are reshaping power structures, supply chains, and consumer behavior in unprecedented ways (Rotz et al., 2019). As these old and new radical ideas converge, future scenarios must explore their interplay, assessing both opportunities and risks for food system resilience and equity.

To truly transform our food systems, we must go beyond merely reacting to disruptions and instead reimagine radical futures. With the growing influence of AI and blockchain technologies used by companies to monitor consumer behavior and the increasing role of social media in shaping food choices, we need to explore scenarios where large-scale, transformative shifts emerge through innovation.

Some of the most provocative ideas in food system debates include AI-driven "food-as-medicine," where real-time personalized nutrition adapts to individual health needs, and at-home bioreactors that enable people to produce cultured meat, fish and dairy, decentralizing protein production. The "Half-Earth" proposal envisions dedicating vast landscapes to ecological restoration, while the concept of a "law of ecocide" seeks to criminalize environmental destruction. Blockchain-powered bioregional food networks could enhance local resilience, yet also raise pressing concerns about digital governance, power imbalances, and the potential for techno-colonialism. Meanwhile, AI-generated misinformation threatens to distort food policies and global narratives around sustainability.

The true power of foresight lies not only in analyzing the individual potential of radical events, concepts and innovations but in identifying the unexpected intersections that emerge between them. These interactions create new possibilities, challenge existing

TABLE 3 Radical ideas emerging within the reviewed scenarios.

Radical event/concept/ disruption	Scenario numbers	Reasoning for diverging from current norms	Age and novelty	Aspects for further exploration
State sovereignty (ownership of agricultural land, data, and market control)	1, 12	Challenges private ownership and market-driven agriculture. Centralizes control in government.	Old: state-controlled agriculture has historical precedents (e.g., Soviet Union and China), but modern digital data sovereignty is a newer concept linked with the ultra-digitisation and automation of food supply chains (S1). Emerges from protectionism concept (S12).	How does digital sovereignty affect power dynamics, societal, ethical, and nutritional outcomes in food systems?
Monoculture vulnerability	8, 10, 11	Highlights risks of pathogen attacks, biodiversity loss and dependency on single crops.	Old: seen in historical crop failures (e.g., Irish Potato Famine), but relevant due to climate change (S10), inter-nation food dependencies (S8) and increased protein intake (S11).	Yes, how changing diets may increase or decrease monoculture vulnerabilities.
Biodiversity and ecosystem loss for profit	3, 16	Prioritizes economic efficiency over ecological preservation.	Old: seen in historical deforestation and industrial farming but exacerbated by globalization.	Already being explored, assessment of alternative business models particularly in ultra globalized scenario.
Protectionism and inward-looking food policies	12, 18, 21	Moves away from global trade, emphasizing domestic food system control, self-sufficiency and closed markets.	Old: protectionist food policies have existed, but geopolitical shifts (climate change migration, supply chain disruptions, trade wars) make this relevant again.	Yes, would be interesting to assess feasibility, role of global co-operations in protectionist economies and if it induces "unknown" disruptors for food system outcomes.
Plant based diets	18, 22	Moves away from traditional diverse diet, emphasizing that plant-based diet is sustainable.	Old: the notion that plant-based diet is sustainable is old but it's growing especially among environmentally conscious consumers.	Yes, need to explore the impacts of large-scale transition to plant-based only diet on global producers and health, and the constraints in different ethnic groups and societies.
Low-carbon economies become global power	19	Diverges from GDP based growth norms, here countries such as Canada and the Nordics that build on their low-carbon exports controls the global food supply-chains.	Old: new global powers emergence is not new but the radical shift in power-dynamics to low-carbon economies like Canada is unanticipated.	Yes, specially to analyze the potential for global tensions and inequalities in access to diverse nutritious food.
Extreme social stratification	6, 15, 25	Wealthy access better food, innovation and climate resilience while others suffer. This notion doesn't diverge truly from the current realities in many countries.	Old: food inequality has existed for centuries, but climate change exacerbates disparities. Innovation driven by elite interests at global level is a radical thought (S15).	Yes, especially the extent of social stratification.
Extreme export-oriented economies and vulnerabilities to extreme climate events	8	Export-dependent food economies collapse under climate stress.	Old: climate risk modelling is evolving, but globalized food dependency is old. Extreme monoculture in LMCs and global inequalities is linked to extreme vulnerabilities (S8) and may have new drivers.	Yes, if taken to extreme-especially to explore the pathways to developing resilience for vulnerable economies.
Climate apartheid	6, 15, 25	Wealthy nations and elites adapt, while the poor suffer from climate disasters, resource unavailability and unhealthy environments.	Old: historical precedent in feudal and corporate rule but evolving with globalization. climate inequalities are widening, reinforcing economic stratification.	Yes, to evaluate influence of Extreme level of oligarchy on governance, innovation, policy mechanisms for global climate justice and consumer preferences.
PPPs as greenwashing devices	23, 24, 25	Public-private partnerships claim sustainability but serve corporate interests.	Old: scrutiny in sustainability efforts has exposed issues in the PPP models.	Not sure.
Modern colonialism and the end of smallholder farming	29	Large-scale land acquisitions in Asia and Africa by powerful nations.	Old: seen in colonial and modern land grabs but worsening.	Yes, particularly in terms of rural livelihoods and resilience.
End of small-hold farming	29	Small holders either work for industrial farms on contracts or migrate in search for jobs.	Old: seen in colonial and modern land grabs but worsening.	Yes, end of small-holders will induce major changes diversity in food production and socio-economic dynamics. More exploration needed.
High local self-sufficiency with a focus on sustainability	2, 14, 18	Isolate regional food systems. Decentralizes food production, prioritizing local farming and sustainability over global trade.	Somewhat old: seen in historical subsistence farming and wartime economies, but modern sustainability-focused self-sufficiency is relatively new.	The degree of localization and how it balances economic viability, between country inequalities, nutritional outcomes, and environmental impact.

(Continued)

TABLE 3 (Continued)

Radical event/concept/ disruption	Scenario numbers	Reasoning for diverging from current norms	Age and novelty	Aspects for further exploration
Food as a service	2	Shifts power from producers to consumers, emphasizing sustainable choices.	Somewhat old: emerging from food solidarity but now links with sustainability.	Yes, how "food as service" balances economic viability, nutritional outcomes, inequalities and environmental impact. Scalability and impact on traditional supply chains is crucial.
Highly automated food system with AI and efficiency	3, 7	Fully automated supply chain, including logistics and production, with minimal human intervention.	Somewhat new: automation is a subset of digitization, but integration with AI is new and is driving its rapid expansion. Big data ownership is not new but in ultra-automated systems it challenges the current power dynamics, with retailers (e-commerce) taking over the full data sovereignty (S3).	Yes, particularly in assessing social consequences (job losses, resilience), food prices and the level of data sovereignty with the retailers and sales.
Highly speculative, financialized food system	9	Surge in social media and health-conscious diets drives food production and food pricing. Speculative financial profits drive markets.	Somewhat new: financial speculation on food exists (e.g., futures markets), but social media as a driver of financial speculation is emerging. Hyper-financialization linked with land consolidation, agribusiness dominance, corporate land control is also emerging strongly.	Yes, particularly in terms of ethics, impact on small holders, migration and potential economic instability.
Internalization of hidden costs	2, 17, 26	Normalizing paying higher price for sustainable food commodities.	Somewhat new: the norm in food-system has always been to make food price lower and stable, willingness to pay internal environmental cost amongst consumers is emerging.	Yes, particularly in how sophisticated technologies in agri-food system can balance the hidden-cost to make healthy diet globally accessible.
Neo-extractivism	9	A resurgence of resource-intensive exploitation justified as economic necessity.	Somewhat new: rooted in historical extractivism but radical from the perspective of the future and modern globalization.	Yes, particularly in assessing sustainability risks and social impacts.
Niche-driven entrepreneurship	15, 25	Small, specialized food enterprises controls technologies.	Somewhat new: emerging extreme stratification of societies and hyper digitalization of food system.	Yes, to explore ethical regulations and data control regulations to prevent spread of misinformation.
Shift from GDP-based growth indicators to multi-dimensional metrics	26, 28, 30	Moving away from economic growth as the primary success metric.	Somewhat new: academic and policy debates are emerging, but adoption is limited. Indicators like the economic growth of small-holder and woman farmers can become more important.	Yes, especially in practical implementation and political feasibility.
Second green revolution (this time actually green)	29	A new Green Revolution, but genuinely green, rather than one that prioritizes yields, however inequalities are not managed.	Somewhat new: the green and sustainable doesn't always means just and equal. This take is new.	Yes, for analyzing the equity challenges.
Extreme regional blocs	20	Developing nations bypass traditional global powers to create food alliances like south-south cooperation leading to reduced global trade.	New: gaining traction as an alternative to Western-dominated trade systems. Unanticipated regional blocs in Africa and South is an emerging idea.	Yes, to assess the impact of global trade-dynamics in closed food systems and understand geopolitical shifts.
Long-termism	26	Shift in the governance structures and policy structures to long-termism where the immediate wellbeing of all citizens, except most vulnerable, is traded off for longer term investments in sustainable production processes, energy transition, GHG reduction, and natural resource conservation and restoration.	New: current governance structures are dominated by short-term goals.	Yes, especially analyzing scenarios through long-term back casting.

(Continued)

TABLE 3 (Continued)

Radical event/concept/ disruption	Scenario numbers	Reasoning for diverging from current norms	Age and novelty	Aspects for further exploration
Retailer data sovereignty	3	Large retailers control vast consumer data, shaping purchasing behavior and supply chains.	New: data-driven consumer insights are emerging as a major power lever.	Yes, to understand ethical implications and regulatory responses.

S1–S30 in the table refers to the reviewed scenarios as presented in the Supplementary material.

paradigms and necessitate the development of strategic pathways to navigate complex transitions. By engaging with this complexity, governance structures can be designed to proactively foster justice, resilience, and sustainability, rather than merely responding to change.

6 Governance structures and development paradigms

Crucially, governance structures are emerging as a defining force in shaping food system transformation. The reviewed scenarios highlight how different governance models, whether centralized state-led interventions, decentralized community-driven approaches or corporate-led food regimes, can either accelerate or hinder radical change. Policies around data ownership, trade regulations, environmental protections, and food sovereignty will determine whether innovations drive equitable and sustainable outcomes or deepen existing inequalities. The governance of digital infrastructures, intellectual property rights, and transnational food policies will profoundly shape the future of food systems, influencing who benefits from technological advancements and who is left behind.

All 30 scenarios reflect, either explicitly or implicitly, assumptions about the nature of food system governance. They show the varying roles and power of national governments, global institutions, local communities, and corporate entities in how food systems and wider economic and social systems are governed.

Associated with these ideas about governance are a deeper set of differing ideas, assumptions, and paradigms about what constitutes positive development and how it can be achieved. These include assumptions about economic growth, the role of globalization, the influence of different cultures and economic power blocks, the degree to which consumption patterns should be influenced by government interventions and the role of different forms of agriculture.

Each scenario involves a unique set of key stakeholders who trigger events, and which carries strategic implications for these stakeholders. Our analysis is not built around governance *per se* but notions about food system governance are implicit in the selected driving forces and storylines, revealing five different notions of food system governance:

(1) Government-centric control and sustainability: strong governmental control over food production and distribution with a focus on sustainability and national security. Key trends:

i. Government ownership and management of agricultural land.
ii. Emphasis on sustainable practices and environmental stewardship.
iii. Extensive data access, utilization of data sovereignty for efficient resource allocation.
iv. Trust in government for providing nutritious food and ensuring accessibility for all citizens.
v. Limited consumer understanding of food production complexities.

(2) Community-led and local sustainability: decentralized governance with emphasis on local sustainability and community involvement. Key trends:

i. Consumer-driven demand for sustainable and local food production.
ii. Limited role of national government with strong local governance.
iii. Consumer preferences driving sustainable and local food production.
iv. Revival of traditional and seasonal eating practices.
v. Reliance on local markets and community-based agriculture.

(3) Influenced by big cooperates and globalization: market-driven approach with heavy reliance on technology and efficiency. Key trends:

i. Specialized global markets and dominance of large retailers.
ii. Emphasis on technological progress and efficiency in production.
iii. Consumer profiling and data sovereignty for personalized services.
iv. Economic success prioritized over environmental concerns.
v Limited emphasis on sustainability and environmental impacts.

(4) No one leads: inadequate response to global challenges, resulting in persistent issues and unmet sustainability goals. Key trends:

i. Social and environmental inequities.
ii. Failure to address food access, utilization, and sustainability challenges.
iii. Efforts to achieve Sustainable Development Goals (SDGs) fall short.
iv. Lack of coordination in addressing food access and utilization.

v. Persistent food insecurity, poverty, and environmental degradation.
vi. Emphasis on short-term gains over long-term sustainability.

(5) Global institutions push for sustainability and resilience: Global cooperation toward sustainable development and equitable access to food. Key trends:

i. Emphasis on global cooperation, sustainability, and resilience.
ii. Social, environmental, and economic dynamics promoting equity and sustainability and equitable access to resources and food.
iii. Universal progress toward achieving SDGs and continued efforts post-2030.
iv. Focus on resource-efficient and inclusive food production systems.
v. Adoption of climate-friendly technologies and practices.
vi. Transparent and resilient supply chains.
vii Collaboration among nations and stakeholders for climate mitigation and resilience.
viii Focus on health and nutrition.

These governance configurations are not isolated features but are deeply embedded within the broader logics of the scenario clusters and the framing of critical uncertainties. For instance, governance is frequently intertwined with uncertainties around globalization, equity, food security, climate change strategies and policy direction, all of which shape the plausibility and orientation of each scenario. Moreover, the distribution of agency across governments, corporations, communities, and global institutions reflects underlying political and development paradigms. Importantly, this analysis reinforces that food systems are deeply political, shaped by power relations, contested interests, and institutional arrangements that determine whose knowledge counts, whose voices are heard, and whose futures are prioritized (Sodano and Gorgitano, 2022; Leach et al., 2020; Clapp, 2020; Lang et al., 2009; Holt Giménez and Shattuck, 2011). Anchoring governance within scenario narratives reveals how differing institutional arrangements and power dynamics either enable or constrain transformative pathways (Pereira et al., 2018; Scoones et al., 2020). By highlighting this, we aim to support foresight practitioners and food system researchers in better understanding governance not just as a backdrop, but as a central driver and site of intervention for shaping equitable and sustainable food futures.

7 Conclusions

This review highlights the growing body of foresight work related to food systems. However, despite the critical role food systems play in the climate debate, achieving the Sustainable Development Goals (SDGs) and ensuring long-term planetary and human wellbeing, there is currently no work of comparable scale and depth to that which the IPCC has achieved for climate futures. As a result, the existing foresight efforts often raise as many questions as they answer. For many drivers of food system transformation, analysis of their future evolution and the factors influencing this, is still limited.

This is perhaps not surprising given the complexity of food systems and the multiple interactions with all other human and natural systems. Further, food systems foresight analysis needs to contend with numerous political-economic and social factors, and very different contexts across localities, countries and regions. Consequently, larger questions emerge about how the utility of foresight and scenario analysis can be optimized in supporting food systems transformation. Broadly there are two dimensions: scientific and societal engagement.

On the scientific side, the scientific community needs to prioritize the development of innovative transdisciplinary methodologies for generating fundamentally new mental models about how food systems function, evolve, and respond to internal and external pressures. Mental models that challenge prevailing cultural biases and established worldviews are crucial for advancing the strength of the scenario analysis in instigating paradigm shifts in food system transformation. This entails rigorously seeking and exploring radical ideas and their potential cause-and-effect relationships within the context of emerging drivers and weak signals of change in the food system, although we recognize this is challenging due to the innovative ideas needed. Ultimately, however, this scientific push should aim to equip us with more nuanced and insightful lenses through which to understand the present and anticipate a range of plausible futures for our food systems.

On the societal engagement side, participatory approaches are underutilized. Although there has been growing interest in foresight for food systems transformation, there has been little investment in large-scale, multi-stakeholder scenario development, especially at the global or regional levels. While technical reports have compiled existing scientific data, these lack the depth of participatory foresight that engages stakeholders across spatial levels, critical for achieving inclusive and actionable insights. For example, despite efforts such as the 2021 UN Food Systems Summit, and national food systems dialogues that accompanied this process, there is still no comprehensive scenario development process that incorporates diverse perspectives from global to local levels. The most comprehensive foresight work to date has been focused on the compilation of existing scientific data into technical reports, of which the most widely used quoting work on global food systems scenarios is the 2017 WEF report. The range of participatory workshops developed by the Foresight for Food Systems Transformation (FoSTr) program (FoSTr, 2025) demonstrate an approach to address this need. These were designed to interface in time and content with the national policy planning cycle and have proven an effective way of engaging a range of policy makers and other stakeholders, and local scientists in joint scenario development and analysis based on national need. This has necessitated in depth consultations and relationship building with key national policymakers to ensure governmental "buy-in" to the process. Without this foundation the process is less likely to be of value to national food system planning, but this will also need a shift in "mindset" (Webb et al., 2020) by both government and the populous to capitalize on new agenda as identified and mapped out in given scenarios.

With respect to new scenario work described in the analyzed studies, five clusters emerged that portray varying underlying principles and worldviews about how the world, and its food

system could change in the future. The clusters vary on basic ideas around the role of globalization and cooperation across nations, the role of the governments, local communities or markets as key shapers of food systems, the role of equality and social cohesions in society as well as on the role of a focus on environmental sustainability in the future. Depending on how these differing key issues vary in importance, and how these are shaping different combinations of driving forces, has major implications for food system outcomes. The scenarios clusters also differ in interventions options, from policy to technology to education and beyond. Thus, they provide a good overview of the breadth of options for change (and their potential implications) that can be considered by the many stakeholders working on solving our current food system dilemma and striving for better outcomes.

The scenario narratives offer a glimpse into potential future food systems, where radical departures from current paradigms take shape in their most extreme forms. Concepts such as full automation, exclusive reliance on cultured meat, or absolute localization, while grounded in existing trends, represent profound systemic shifts when extrapolated to their logical extremes. These speculative yet plausible futures warrant rigorous scholarly inquiry and collaborative refinement to ensure they contribute meaningfully to food system transformation.

Participatory research methodologies are critical in this process, as they enable the integration of diverse stakeholder perspectives, ensuring that innovations remain contextually relevant, socially equitable, and practically implementable. This approach not only mitigates unintended consequences but also fosters collective ownership over transformative change. Moreover, the rapidly evolving technological landscape and shifting geopolitical realities underscore the need for sustained interdisciplinary dialogue among global experts. Ongoing critical discourse is essential for anticipating emerging challenges, assessing the ethical and socio-economic implications of extreme scenarios, and developing adaptive governance frameworks.

By synthesizing lessons from existing scenario exercises, identifying key thematic and methodological gaps, and emphasizing the importance of participatory and radical futures thinking, this study provides a strong foundation for designing a next-generation global food system scenario exercise. It calls for a more ambitious, inclusive, and innovative approach that can drive real-world transformation in food systems at the scale needed to address twenty-first-century challenges. Importantly, this article also aims to inspire and encourage scenario development efforts across all world regions particularly in the Asian, African, Middle-Eastern and Latin American regions, where food system challenges are immense but remain underrepresented in current scenario literature. Addressing this imbalance is essential to ensure that future-oriented strategies are grounded in diverse realities and inclusive of the voices most affected by food system transformation.

Author contributions

BG: Data curation, Conceptualization, Writing – original draft, Investigation, Writing – review & editing, Methodology, Formal analysis. MZ: Project administration, Conceptualization, Writing – review & editing, Supervision, Resources, Funding acquisition. JW: Funding acquisition, Project administration, Formal analysis, Writing – review & editing, Conceptualization. JI: Funding acquisition, Supervision, Project administration, Writing – review & editing.

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The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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