

At the Crossroads: Food in an Age of Uncertainty






Shaping the future of food systems

April 2026

GORDON AND BETTY
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S Y S T E M I Q

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Foreword

Food systems are entering a period of profound disruption and possibility.

Artificial intelligence and other technological breakthroughs, climate volatility, demographic change, shifting consumer health and nutrition needs and geopolitical fracture are interacting in ways that are reshaping how food is produced, traded and consumed. At the same time, the system remains exposed to highly concentrated risks – where critical inputs and foodstuffs depend on a small number of geographies and routes, as illustrated by the Strait of Hormuz, a chokepoint for up to 30% of globally traded fertilisers.¹ Many of these forces originate beyond the food system, yet their effects on food security, resilience and environmental stability are already unfolding.

The coming decade will reveal how food systems respond to the risks and opportunities before them – with the trajectory far from settled.

Food systems are operating within mounting complexity, making leadership decisions harder and more consequential. Deliberate, holistic decisions and solutions are required, grounded not only in what is needed, but in what is realistically achievable. If the system that emerges is to meet a broader set of objectives – economic productivity, affordability, environmental sustainability and structural resilience – we will need more open and honest dialogue about this uncertain direction of travel, and a step-change in global coordination on solutions.

It was in this context that we teamed up on a futures thinking and foresight effort over the last year.

As the Gordon and Betty Moore Foundation marked its 25th anniversary and, more importantly, the beginning of its next 25 years, the Foundation and Systemiq partnered to explore what today's global uncertainty means for the future of food systems and for the impact we seek to drive. Together, we asked: how did we get here, what plausible futures may lie ahead, and how can progress be made on a shared agenda despite rising uncertainty and risk?

As part of that journey, we convened more than 70 leaders for a Symposium in Zurich in January 2026.

We brought together voices from civil society, academia, intergovernmental organisations, business, finance and philanthropy. The aim was not to agree on a single vision of the future. It was to reflect on plausible futures in ways that stretch conventional thinking, to identify practical areas where coordinated action could begin now, and to lay the groundwork for the partnerships that could bring those efforts to life.

This report builds on the momentum of the Zurich Symposium and on the broader reflection and learning that has unfolded over the past year, extending a wider invitation to align and take action.

In a world increasingly characterised by fragmentation and structural uncertainty, the trajectory of food systems will be determined by the strategic, financial, technological and political choices we make along the way – from which objectives get prioritised to how coordination evolves. By exploring plausible futures and identifying practical areas for action, this report offers an initial contribution towards the more deliberate coordination required to ensure food systems can navigate disruption, reduce risk and improve outcomes for people and planet.

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Executive summary

The global food system is not broken; it has been extraordinarily successful when judged against its original objectives. Built to deliver abundant, affordable calories at scale, it has fed billions, reduced famine risk and driven productivity gains through science, technology and trade. Few human systems have scaled so quickly or so effectively.

Yet the very objectives the system was built to deliver are now under strain. The capacity to provide abundant, affordable and stable food supplies can no longer be taken for granted, as yield growth is flattening in key regions, environmental degradation is undermining long-term productivity and diet-related disease is rising even as hunger persists. Food production is both a significant contributor to greenhouse gas emissions and highly exposed to climate shocks. Risks that accumulated quietly over decades are now surfacing as volatility, fragility and rising costs, threatening affordability, stability, and future supply itself. These pressures are not evenly distributed: farmers and fishers – particularly smallholders and coastal communities – are often the most exposed to climate, market and transition risks, while having the least capacity to absorb them.

The coming decade marks a clear inflection point for global food systems, unfolding in a fragmenting global order. Technological acceleration, health and demographic shifts, the impacts of the energy transition, migration and political contestation are transforming the context in which food systems operate. For decades, the industrialised food system has been built on trade liberalisation and agricultural specialisation, with food functioning as a globally traded commodity shaped by comparative advantage and cost efficiency. In today's geopolitical environment, however, as countries increasingly frame food security through the lens of national security, that model is being questioned. This is illustrated by China's most recent 15th Five-Year Plan where food security is framed as a core national security priority and outlines how China intends to become an agricultural power by leveraging modern and emerging technologies to boost domestic production and reduce reliance on imports.²

In parallel, the food system is also compounding the risks it now faces. Responsible for roughly one-third of global greenhouse gas emissions, the majority of freshwater withdrawals, and 90% of global deforestation, it is a primary driver of the environmental stress reshaping its own operating conditions.^{3,4,5,6} Deforestation and land conversion, overfishing, methane emissions and input-intensive production amplify climate and ecosystem disruption – pressures that feed back into yield volatility, water scarcity and supply shocks. System efficiency alone is no longer sufficient. Decision-makers must balance productivity with risk exposure, diversification and long-term system stability.

Preventing the system from cracking under mounting pressure requires greater clarity about what it must now deliver. The old system scaled because its objectives were simple and singular. Today, long-term resilience depends on navigating multiple goals at once: secure supply, affordability, health, environmental sustainability, livelihoods and resilience. Trade-offs are unavoidable. This makes prioritisation essential: non-negotiable objectives must be distinguished from those that can be phased over time, while effort is concentrated on interventions that generate co-benefits and unlock wider system change. Without a clearer hierarchy of both objectives and actions, volatility risks compounding and undermining the very outcomes the system was built to protect.

This moment therefore requires deliberate coordination among willing actors. Universal alignment is unlikely in a more fragmented world. But coalitions grounded in credible analysis and shared incentives can concentrate effort where it unlocks wider change, strengthen resilience where it matters most, and build momentum toward positive system tipping points even in the absence of full global consensus.

Decision-makers must balance productivity with risk exposure, diversification and long-term system stability.

Executive Summary (continued)

This report therefore highlights four high-confidence bets – interventions judged to have robust impact, potential and relevance across multiple plausible futures – that can serve as enabling foundations for transformation.

First: strengthen open, decision-grade data infrastructure. High-quality, accessible data on nature, production systems, risks and impacts is a strategic global public good. Without it, markets and policymakers are operating with only partial understanding.

Second: embed resilience into capital allocation by standardising how food-system risk is valued. Translating climate, nature and production risks into common metrics that can be understood and contextualised by finance professionals, such as Average Annual Loss, can help shift capital towards preventative investments in resilience.

Third: advance coherent national food system strategies within an interdependent global system.

A degree of global fragmentation is already underway, and the rules that have long governed food trade and cooperation are shifting. In this context, countries need clear national food system strategies that strengthen domestic food security and deliver visible benefits for the environment and citizen health – while recognising that food systems remain deeply interconnected through trade, ecosystems and shared climate risks.

Fourth: create dedicated spaces for macro-level dialogue and analysis on systemic risks, pathways and trade-offs. Integrating scenario thinking, economic modelling and structured trade-off analysis can help clarify difficult prioritisation decisions and better align policy signals with private-sector investment in a fragmented world.

There are no silver bullets, but there is a wider solution space than we often allow. The future will not be a choice between local or global, technology or tradition, plant-based or animal protein, regenerative or intensified production. It will require combining them thoughtfully and contextually.

The imperative now is to act with clarity and intent in shaping the next era of food. Resilience will not emerge by default. It must be built – through clearer priorities, stronger institutions and more deliberate coordination. This report is a starting point and an invitation to shape that shared transformation agenda together.

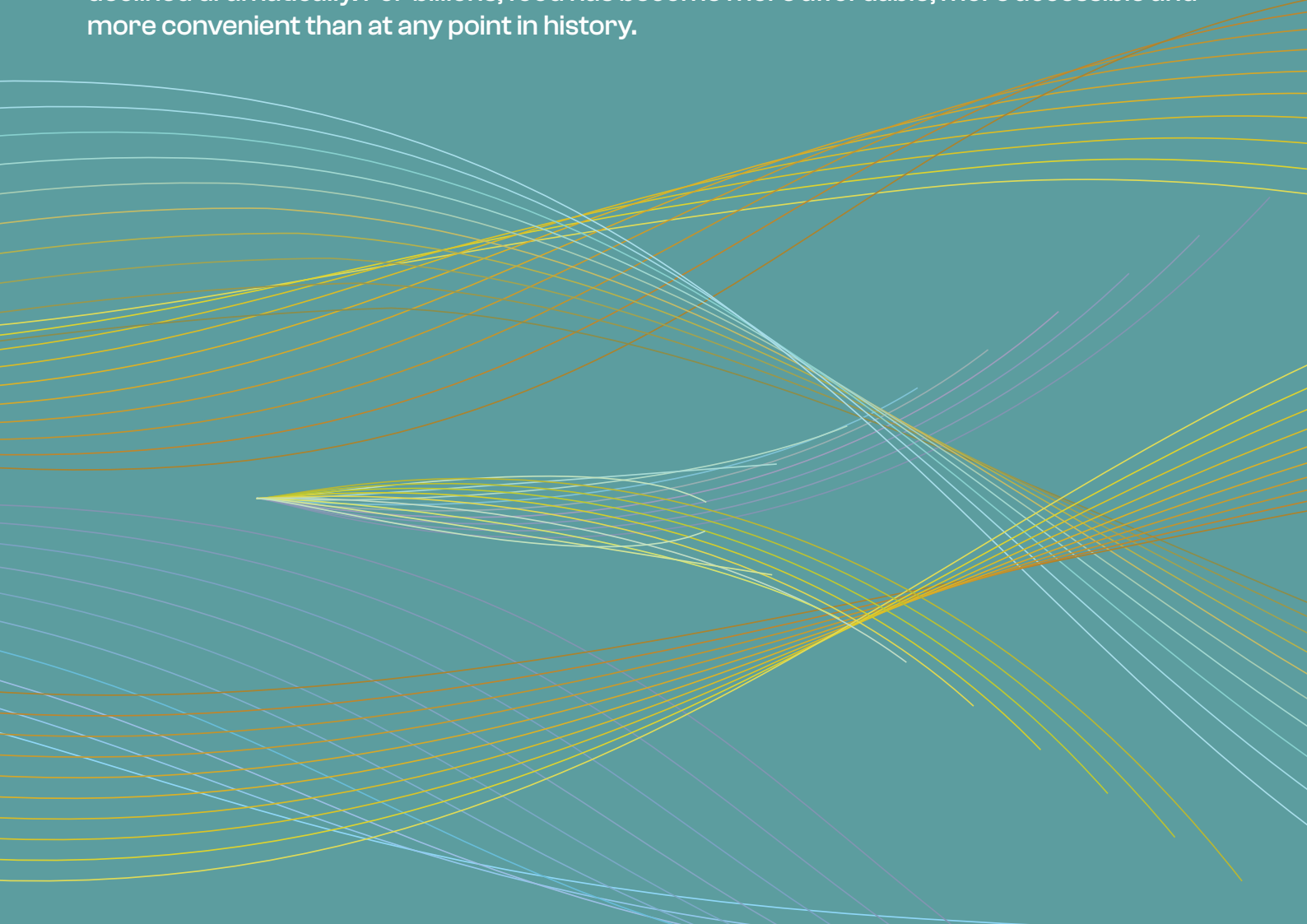


Part 1

How we got here – a clear look back

The food system is not broken. It is operating largely as it was designed to. By the standards of its original mission – producing large volumes of affordable calories to feed a rapidly growing global population – it has been remarkably successful. Since 1960, while representing a smaller share of global GDP, global agricultural production has more than tripled and its economic output more than quadrupled.^{7,8,9}

Average daily calorie availability has risen from roughly 2,100 kcal per person to nearly 2,900 kcal, even as the global population has increased by five billion.¹⁰ Famines have declined dramatically. For billions, food has become more affordable, more accessible and more convenient than at any point in history.



Part 1: How we got here – a clear look back

Over the past two centuries, the food system has undergone three reinforcing transformations that together have reshaped production, consumption and trade.

The first is agricultural industrialisation and financialisation. Beginning in the 19th century and accelerating after the 1940s, scientific advances in seeds, fertilisers, irrigation and mechanisation drove dramatic productivity gains. The Green Revolution extended these gains across parts of Asia and Latin America, tripling cereal production since 1960 and helping avert large-scale famine.¹¹ Yields rose faster than population, food prices fell in real terms, and an estimated 1.5 billion hectares of land were spared from cultivation due to productivity gains.¹² Abundance became technically possible.

Alongside industrialisation, food and agriculture supply chains have become increasingly financialised. As production scaled and trade expanded, food and agricultural outputs were progressively standardised and treated as commodities – priced, traded and hedged through futures markets rather than differentiated by place, practice or ecological context. Land itself became an asset class, attracting institutional capital seeking stable returns, while farmers grew more dependent on credit, insurance and volatile global price signals to operate. This financialisation has helped stabilise supply and manage risk in a growing, interconnected system.

The second transformation has reorganised how food is processed, distributed, marketed and consumed. As populations urbanised and incomes rose, supply chains globalised and consolidated. Supermarkets replaced local markets. Food manufacturing scaled. Shelf-stable, packaged and, later, ultra-processed products met the demands of urban life, dual-income households and time scarcity. Today, more than half of the calorie intake in countries such as the US and UK comes from ultra-processed foods.¹³ These products are affordable, safe, convenient and profitable. They are also engineered for taste and repeat consumption.

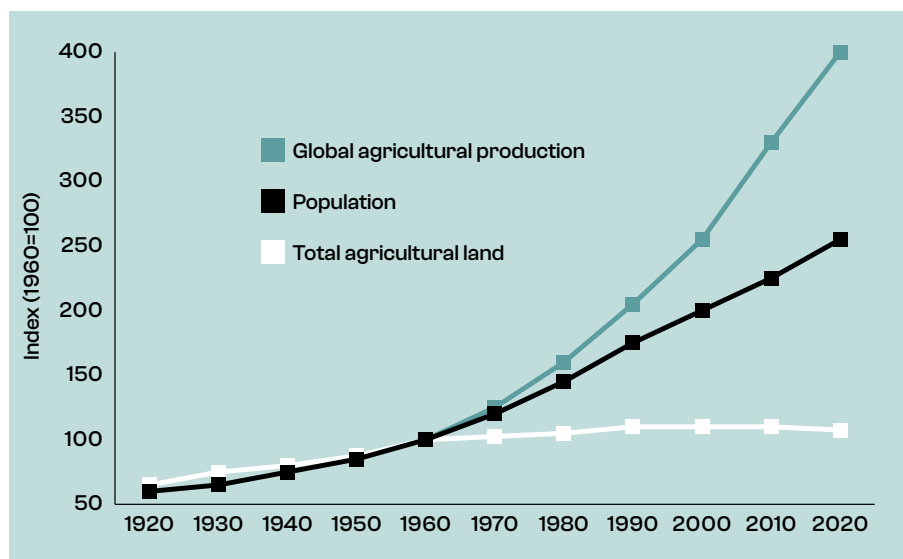


Figure 1: Evolution of population, agricultural production, and agricultural land relative to 1960 (adapted from OECD)¹⁴

Between 1960 and today, global meat production has increased more than fourfold

The third transformation has driven a significant rise in animal-based product consumption. Rising incomes, trade liberalisation and expanding feed crop production drove a global increase in animal protein consumption. Industrial livestock systems scaled rapidly, supported by cheap grain, antibiotics and vertically integrated supply chains. Meat, once an occasional luxury in many regions, became a daily staple. Between 1960 and today, global meat production has increased more than fourfold.¹⁵ For many households, higher protein consumption signals prosperity. For producers and investors, it signals growth.

The result is a system characterised by scale, efficiency and industrial integration. Agricultural supply chains have consolidated and globalised, optimised for a narrow set of staple crops and livestock species. Processing, logistics and retail infrastructure have been built to deliver consistency and low prices at scale. Financial instruments, global benchmarks and risk-management tools reinforce this model, prioritising volumes, cost reduction and commoditisation.

Over time, this production-first logic has become entrenched into structural lock-ins that now anchor the system to its current model. Capital assets have been built around monocultures, large-scale livestock operations and specialised processing facilities that are costly and complex to reconfigure. Public subsidies and procurement policies in many countries continue to favour high-input production and a narrow set of commodities. As a result, producers have specialised accordingly; combined with ageing demographics and low generational renewal, this has reduced their capacity to adapt and change. Financial markets treat agricultural goods as tradable financial commodities, reinforcing short-term price signals, scale and standardisation. Market power has consolidated among a small number of agribusiness, input, processing and retail firms, giving incumbents significant influence over supply, demand, policy and innovation pathways. At the same time, consumer norms have evolved around convenience, abundance and low prices, embedding demand patterns that reward industrial production models.








These lock-ins are shaping the future direction of the food system, while reinforcing the status quo. They bias adaptation toward reinforcing the existing model incrementally rather than transforming it. Financialisation narrows the set of options that are investable, privileging interventions that can be standardised, priced and scaled quickly, while making place-based, regenerative or resilience-oriented approaches harder to finance and harder to defend within conventional risk and return frameworks. As pressures mount, investment tends to flow towards efficiency gains within incumbent systems, geographic expansion into new production frontiers or consolidation to protect margins, reinforcing the very dynamics that created today's vulnerabilities. Declining fish stocks are met with technological intensification or the displacement of fleets into new waters, shifting extraction pressure rather than reducing it. Fertiliser use rises as soils degrade and yields plateau. Where restoring land productivity is costly or slow, agricultural production expands into natural ecosystems. Farms consolidate and monocultures scale further to maintain output and margins.

The very logic that powered the system's rise has accumulated risk. Efficiency, scale and specialisation delivered abundance, but have also concentrated exposure to climate volatility, resource constraints, geopolitical fragmentation and rising health burdens. A model built on assumptions of stable climates, cheap inputs, predictable trade flows, and an economic paradigm that treats social and environmental costs as externalities is now starting to operate under conditions that are less stable and less forgiving. As risks and shocks compound and interact, the system's adaptability is increasingly in question. The lock-ins that have reinforced the system may now limit how quickly it can adapt. As emerging pressures intensify, actors may be forced to reform these structures – or they may simply begin to fail. How the system responds to this mounting strain will shape what comes next.




As risks and shocks compound and interact, the system's adaptability is increasingly in question



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Historical drivers		Key datapoints
	Population growth	8.2 billion people live on Earth, up from 3 billion in 1960 ¹⁶
	Urbanisation	56% of the global population is urban, up from 34% in ¹⁷ 1960
	Subsidies and technology advancements	3x increase in global cereal yields over the past 60 years, enabled by government subsidies and public-private partnerships during the Green Revolution ¹⁸
	Economic growth and availability of private capital	8.7x increase of global GDP since 1960 ^{19,20}
	Free cross border trade, financialisation and specialisation	4x increase in global agricultural exports since 2000 ²¹ 20x increase in exchange-traded agricultural derivatives globally since 2000 ²²
	Consumer needs for affordability and convenience	1/3 of household food budget for home-cooked food in 2000, down from 1/2 in 1980 in the UK ²³ 2x increase in female labour participation rate since 1950 ²⁴
	Rising incomes	3x increase in GDP per capita (PPP-converted) since 1990 in low- and middle-income countries ²⁵ 1.6x increase in GDP per capita (PPP-converted) since 1960 in OECD countries ²⁶

Dominant features

	Industrialised and financialised supply chains	4 crops occupy 50% of the world's cropland – soyabeans, wheat, rice and maize ²⁷ 70–80% of global grain trade controlled by the top five food trading companies ²⁸ 75% of revenues of major food trading companies come from financial intermediation ²⁹ \$540 billion of annual support to agricultural producers globally (most of which is in high-income economies, China and India), equivalent to 15% of total production value ^{30, 31}
	Production systems geared towards ultra-processed foods	\$2 trillion in global retail value is generated by ultra-processed foods ³² 2x price per calorie for healthier foods in the UK compared to less healthy foods ³³ 44% of US adults aged 50–80 have symptoms of ultra-processed food addiction ³⁴
	Diets increasingly rich in animal proteins	2x increase in global per capita meat consumption (21x in China) since 1950 ³⁵ 75% of global agricultural land is used for livestock ³⁶ 39% of global cereal production is used for animal feed ³⁷



Lock-ins	How it creates inertia
Global system paradigm	
Global supply chain specialisation	Specialises production for exports, reinforcing monocultures and creating dependence on global supply chains for food
Financial commoditisation of agricultural goods	Standardises food into financially tradable commodities, limiting differentiation for sustainable practices and constraining investment in long-term resilience
Market dominance and political influence	Concentrates incumbents' market and political influence, maintaining the status quo
Short-termism and industrial logic	Prioritises volume, efficiency and short-term returns, entrenching industrial and input-intensive production models
Capital and finance	
Public financial incentives biased toward high-input production	Channels public funding to high-input farming and livestock systems, crowding out regenerative and diversified models
Private capital constrained by risk-aversion and short-termism	Locks farmers and businesses into conventional agricultural models and value chains
Lack of pricing for environmental and health risks and impacts	Sustains artificially low food costs and high demand for unsustainable products, with weak regulations failing to correct market failures
Dominant bias of yield maximisation for food security	Prioritises industrial yield increases as the main route to food security in policy and investment decisions
Land, infrastructure, and technologies	
Land tenure and ownership constraints	Undermines secure land access, discouraging long-term investment in sustainable farming and stewardship
Past investments and infrastructure	Locks farming and processing into specialised, expensive assets that make transitions logistically and financially prohibitive
Control of agricultural data and technologies	Consolidates ownership of digital tools and technologies, limiting open innovation and farmer autonomy
Education, training, and norms	
Specialised labour force and skills gaps	Ties workforce skills with conventional practices, limiting capacity for diversified food systems
Farmer demographics	Constrains transition as ageing farmers nearing retirement have lower adaptive capacity, reducing uptake of new practices while increasing exposure to climate and market shocks
Wide use of migratory labour	Creates cross-border dependencies, exposing food systems to geopolitical and labour market disruptions
Cultural norms of convenience and abundance	Normalises food waste and meat-heavy, ultra-processed, convenience diets, reinforcing demand for industrial production

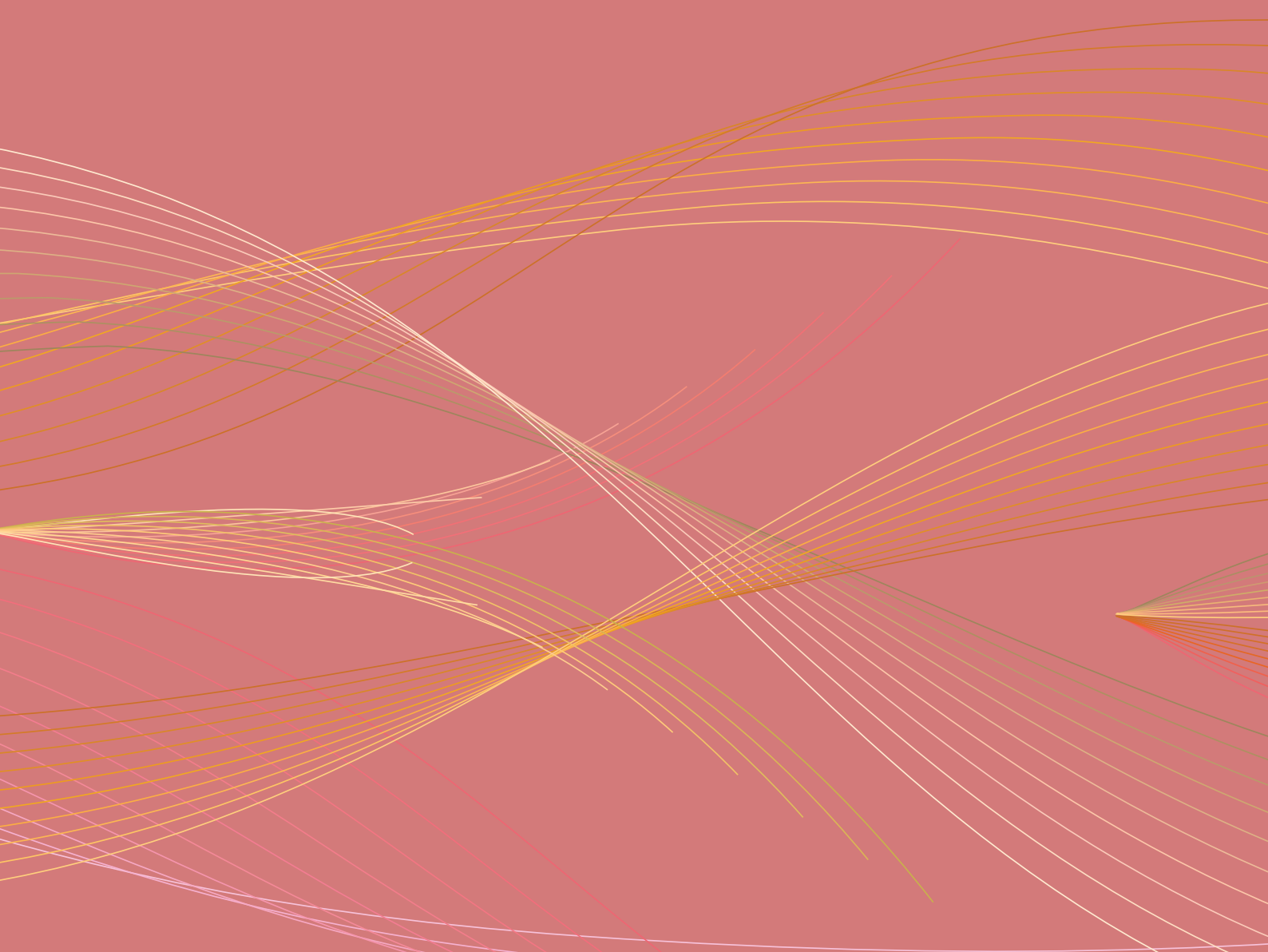


Part 2

What the future might hold – scenarios and signals

Emerging forces are pushing the system to an inflection point

A new set of drivers is beginning to reshape the food system. If the past century was defined by scale, efficiency and integration, the next decades will be shaped by disruption – as technology, geopolitics, health pressures and environmental risks intensify simultaneously. These forces are not incremental extensions of past trends. They are increasingly altering the operating conditions of the system itself.



Part 2: What the future might hold – scenarios and signals

Technological acceleration is expanding what is possible at speed.

Artificial intelligence, automation, renewable energy, gene editing and biomanufacturing are moving from pilot to scale often faster than regulatory and market institutions can adapt. Renewable sources are in many places the cheapest form of energy and account for roughly 30% of global electricity generation, reshaping the economics of production in energy-intensive food systems.^{38, 39} Artificial intelligence is poised to reshape food systems – from precision agriculture and optimised supply chains to accelerated crop innovation and the discovery of new proteins and food products.^{40, 41} At the same time, GLP-1 anti-obesity drugs are already reshaping food demand, with major food manufacturers reporting shifts in snack and ready-meal consumption.⁴² These technologies can lower costs and reduce resource intensity, but they can also entrench power, disrupt labour markets and rapidly reconfigure value chains.

Geopolitical and socioeconomic shifts are fragmenting what was once an increasingly integrated system.⁴³

Armed conflicts and related fatalities have more than tripled globally since the early 2000s, with around one billion people now living in fragile and conflict-affected economies.⁴⁴ Export restrictions and trade barriers surged following the war in Ukraine, and strategic stockpiling has become more common. China is intensifying its push for food self-reliance, reshaping global grain, soya, and fertiliser markets.⁴⁵ Food security is increasingly treated as a matter of national security rather than global interdependence. Demographic transitions such as ageing populations in Europe and East Asia and youth bulges in parts of Africa are also altering labour markets, migration flows and consumption patterns in ways that will shape food demand for decades.

Public health risks and shocks are exerting both sudden and structural pressure.

The COVID-19 pandemic exposed vulnerabilities in labour, logistics and just-in-time supply chains, prompting emergency state intervention at unprecedented scale. Beyond acute crises, slower-moving health pressures

are reshaping demand and regulation. Antimicrobial resistance is rising globally, linked in part to intensive livestock production and routine antibiotic use.⁴⁶ Endocrine-disrupting chemicals present in pesticides, packaging and food contact materials are increasingly associated with hormonal disruption, fertility loss and metabolic disorders, bringing greater scrutiny to packaged foods and chemical-intensive supply chains.⁴⁷ At the same time, poor diets contribute to one in five deaths globally,^{48, 49} obesity rates now exceed 40 percent among adults in the United States⁵⁰ and have been rising in China by one percentage point annually since the 1990s,⁵¹ imposing mounting economic and fiscal costs. Health is no longer a downstream outcome of the food system; it is becoming a central force shaping demand, regulation and investment.

Environmental risks are no longer distant projections; they are material and accelerating.

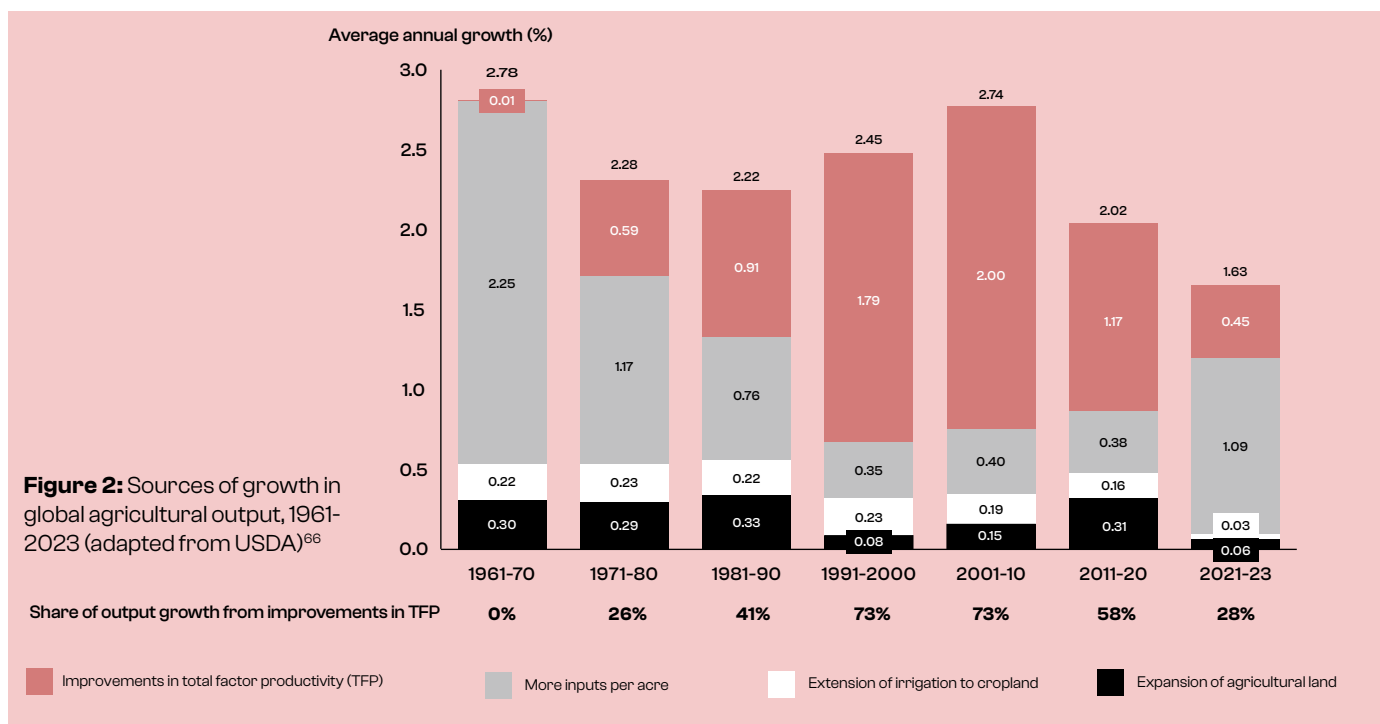
Extreme heat days are rising across major agricultural regions, and evidence shows that temperatures in some areas are approaching or exceeding physiological thresholds for key crops such as wheat and maize, negatively impacting yields.⁵² Extreme weather events are becoming more frequent, prolonged and severe globally posing significant risks to grain production,⁵³ while water scarcity is intensifying across South Asia, the Mediterranean and parts of the US Midwest.⁵⁴ Nearly one-third of the world's soils are moderately to highly degraded,⁵⁵ constraining long-term productivity, and pesticide resistance is spreading across key crop systems.⁵⁶ In marine ecosystems, warming, acidification and overfishing are reducing fish stocks that provide essential protein and micronutrients for billions.⁵⁷ Scientists now warn that several Earth system tipping elements, including major ice sheets, rainforest systems and ocean circulation patterns, may be approaching critical thresholds, beyond which abrupt and potentially irreversible changes could cascade through ecological and economic systems, posing systemic risks to food security and national stability.^{58, 59} Many of these impacts are arriving sooner and interacting more strongly than earlier models anticipated, compressing the window for adjustment.

Armed conflicts and related fatalities have more than tripled globally since the early 2000s

At the same time as these environmental and socioeconomic pressures are rising, the productivity momentum that underpinned past success is slowing. Between 1990 and 2020, most agricultural output growth came from improvements in productivity rather than intensification of inputs and expansion of land – yet we still lost 53 million hectares of tropical forests between 2010 and 2020.^{60, 61, 62} Global agricultural productivity growth has decelerated markedly from nearly

two percent per year in the 2000s to less than one since the 2010s – closer to what it was before 1980.⁶³ This slowdown is not only due to COVID-19, but also to climate pressures, soil and water constraints, diminishing returns from earlier technological gains and uneven investment in agricultural innovation.^{64, 65} The slowdown is especially troubling in Sub-Saharan Africa, where productivity growth has lagged despite substantial untapped yield potential, failing to meet a rapidly rising demand. As a result,

productivity growth now falls short of the two percent growth required to meet projected demand without renewed pressure on forests, water and other ecosystems, and while adapting to climate change. This creates a perfect storm: productivity must accelerate, yet producers are both the most exposed to emerging shocks and the least equipped to absorb or adapt to them, given tightening economics and the ageing farming and fishing communities.



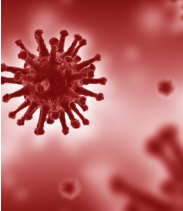



Taken together, the system’s slowing momentum and the emergence of new drivers mark an inflection point. The system is entering a period of heightened vulnerability in which long-standing assumptions can no longer be taken for granted. This convergence could accelerate deliberate redesign and innovation, or it could trigger more abrupt and disorderly adjustment. The trajectory is not predetermined; how actors respond to this moment will shape which pathways unfold.



¹ Productivity can be measured in terms of total factor productivity (TFP). TFP is an index that measures how efficiently all inputs (land, labour, capital and materials) are used to produce total agricultural output. Rising TFP means more output is produced with the same amount of inputs. In its conventional form, TFP reflects only marketed outputs and inputs, so environmental degradation is not captured unless it affects production. This means productivity can rise even as natural capital declines, although emerging approaches seek to integrate environmental pressures into productivity measurement.

Table 1: Emerging drivers are already impacting the system

Emerging drivers	Examples (non-exhaustive)	Key datapoints
 <p>Technologies</p>	<p>Renewable energy AI and data Automation Genetic tools GLP-1 anti-obesity drugs Biomanufacturing</p>	<ul style="list-style-type: none"> ▪ 2.7x expansion of global renewable capacity by 2030 (vs. 2022 levels)⁶⁷ ▪ \$140 billion projected global market size of AI in food processing by 2034 (CAGR 28%)⁶⁸ ▪ 30 million people projected to be on GLP-1 treatment in the US alone by 2030⁶⁹
 <p>Socioeconomic & geopolitical changes</p>	<p>Export bans and trade wars Sociopolitical unrest and migration Geopolitical conflicts and wars Financial crashes Global demographic shift Ageing populations</p>	<ul style="list-style-type: none"> ▪ 120 million people are currently forcibly displaced globally^{70,71} ▪ 3x increase in armed conflicts and related fatalities since early 2000s ▪ 60% decrease in number of births per 1,000 people in China compared to 2000, bringing births per woman down to 1.0 among the lowest in the world^{72,73}
 <p>Public health risks & shocks</p>	<p>Pandemics and epidemics Zoonotic disease outbreaks Antimicrobial resistance (AMR) Endocrine disruption Non-communicable diet-related diseases</p>	<ul style="list-style-type: none"> ▪ 3.8% decrease in GDP by 2050 caused by AMR⁷⁴ ▪ \$950 billion annual loss from livestock sector alone due to AMR by 2050⁷⁵ ▪ \$1.4–\$2.2 trillion annual healthcare costs due to toxic chemicals (phthalates, bisphenols, pesticides and PFAS) widely used across food systems⁷⁶
 <p>Environmental risks & shocks</p>	<p>Climate stress and shocks Biodiversity loss Water scarcity Desertification and soil degradation Pesticide resistance</p>	<ul style="list-style-type: none"> ▪ \$2.9 trillion losses in agriculture due to climate-related hazards since 1991⁷⁷ ▪ 99% of coral reef biodiversity could be lost under 2.5°C warming, threatening critical protein sources for 150+ million people in the Coral Triangle⁷⁸ ▪ 170 million hectares (55%) of irrigated cropland under high or very high water stress^{79,80}

Food systems face diverging futures

The coming decades could unfold in markedly different ways. Technological acceleration, geopolitical shifts, health pressures and environmental shocks do not point to a single destination. They create a range of plausible pathways, shaped by how governments, firms, communities and citizens respond. Whether actors reinforce existing models, adapt them incrementally or pursue more structural reform will determine how risks are managed, how opportunities are captured and who benefits.

In conditions like these, scenarios are not forecasts but tools for foresight. Foresight can be used to navigate complexity, align diverse stakeholders and improve decision-making under uncertainty by testing strategies against multiple plausible futures rather than relying on a single projection.⁸¹ Scenarios help surface hidden assumptions, depolarise debate and stress-test strategies before shocks occur. Used well, they enable leaders to prepare for disruption, adapt more quickly as conditions change and build resilience by designing policies and investments that remain viable across different futures, while also assembling a portfolio of interventions that are intentionally diversified across futures.

With this purpose, we developed four imagined but plausible scenarios to explore divergent futures for food systems. Starting from today's conditions, each scenario reflects a different governance logic and asks who leads and how change unfolds. Developed and refined in the months leading up to the Symposium, these scenarios span market-led adaptation, grassroots-led action, fragmented government intervention and coordinated government response. We briefly present the scenarios below. They can be found in full in the Annex. They are not ideal visions for 2050, nor the only futures that could emerge, but structured provocations to test assumptions, illuminate trade-offs and stimulate more deliberate decisions.

By grounding discussion in plausible rather than preferred futures, our intention is to help depolarise debate and disrupt entrenched patterns of thinking.

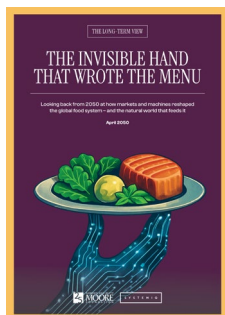
Starting from today's conditions rather than an idealised end-state shifts attention toward what is feasible under real-world constraints. It creates space to engage with difficult trade-offs, imperfect starting points, and the likelihood that progress will be uneven and at times disorderly.

While we have deliberately not accounted for them in scenarios, Earth system tipping points are increasingly material risks rather than distant possibilities.

Growing evidence suggests that Earth system tipping points and cascading failures are becoming more likely, with some potentially emerging as early as the 2030s, and would carry profound implications for food systems.⁹² The scenarios are intentionally framed around different governance pathways, rather than around varying degrees of environmental risks and impacts. While this focus helps show how institutions and coordination shape outcomes under stress, it also means that the full consequences of Earth system tipping points are not examined in depth. Even so, preparedness for such risks, and stronger coordination around global commons to mitigate them, is becoming increasingly critical. Countries, including the UK,⁹³ have indeed begun to frame biodiversity loss and climate disruption as matters of national and food security.

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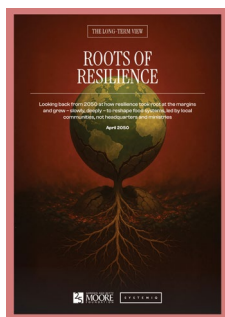




Market-led adaptation

Scenario in short: In response to rising climate, geopolitical and market volatility, food systems adapt primarily through private-sector innovation and scale rather than structural reform. Large firms deploy AI, cheap clean energy and capital to re-engineer production, logistics and diets, with data and IP increasingly becoming the main sources of control and concentration. Efficiency gains continue as the system absorbs some of the shocks, but resilience, distributional equity and public-good outcomes trail behind.

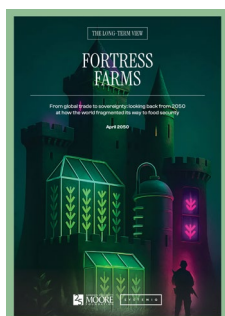
Scenario logic and key themes explored: This scenario extrapolates the political economy of the last few decades, in which markets remain the dominant organising force and governments largely set the guardrails rather than the direction of travel. It assumes that when faced with mounting volatility and environmental stress, the system doubles down on the tools that delivered past gains: scale, capital intensity and rapid technological innovation. The core question it explores is whether efficiency-led adaptation can keep pace with rising systemic risk.



Grassroots-led action

Scenario in short: As climate shocks, economic volatility and institutional gaps strain state and market capacity, local actors fill the void. Communities rebuild food systems through cooperatives, regenerative practices, peer-to-peer learning and locally rooted governance, with food treated as culture and commons rather than primarily as an efficiently traded commodity. These efforts strengthen local resilience but only where social cohesion and access to resources are high, resulting in uneven outcomes across regions. A strong focus on the local, however, constrains broader coordination, efficiency and scalability.

Scenario logic and key themes explored: This scenario assumes that repeated shocks gradually erode trust in large-scale institutions – both corporate and governmental – shifting the centre of adaptation towards local communities. Resilient, local solutions spread not out of ideology alone, but also out of necessity. The scenario therefore explores where decentralised resilience succeeds – and where the limits of grassroots-led action appear in a world of deep interdependence and shared ecological risks.



Fragmented government intervention

Scenario in short: In the face of sustained geopolitical tension, trade disruptions and repeated food shocks, governments increasingly turn inward. National food security becomes a strategic priority, driving protectionist policies, domestic production targets and state-led innovation agendas. Innovation continues, but largely within national or regional blocs rather than global markets. The result is a more fragmented food system: some countries stabilise supply through state capacity and investment, while others lack the resources or governance to do so and face persistent shortages and volatility.

Scenario logic and key themes explored: This scenario extends current geopolitical fragmentation into a world where food security is embedded within national security strategy. In response to shocks, rather than relying on global markets, governments respond by intensifying intervention – within their own borders or blocs. It explores a future in which the state regains strategic control over food systems, driving rapid reform where capacity exists. The core question is what opportunities arise from global fracture, and what risks and trade-offs it reinforces.



Coordinated government response

Scenario in short: Repeated global food crises in the late 2020s and early 2030s expose the limits of fragmented responses. Mounting food insecurity, price volatility and climate impacts prompt governments to strengthen cross-border coordination, initially through crisis response and eventually through more durable governance arrangements. Over time, shared rules and institutions emerge to align trade, finance and food system outcomes around resilience, equity and risk reduction. Coordination, however, remains largely reactive, and the transition proceeds more slowly and under tighter regulation – improving equity and risk management at the expense of speed and efficiency.

Scenario logic and key themes explored: This scenario imagines that repeated global crises eventually shift political incentives decisively in favour of cooperation. Governments increasingly recognise that systemic risks cannot be managed within national borders alone. Coordination therefore emerges incrementally, often through coalitions of the willing, and progressively reshapes global governance of trade, finance and nature. The core question is how coordination can emerge from division and crisis, and what costs and constraints arise when progress depends on cooperation.

To bring the scenarios to life, we have translated each into a set of stylised system metrics. While not model-based projections, these indicators reflect assumptions about how different governance logics would influence emissions, land use, biodiversity, diets, employment and poverty by mid-century. All metrics and rationales can be found in the Annex. Below are a few examples.

GHG emissions and deforestation:

Across the four futures, emissions decline in all cases but for very different reasons. In the market-led and fragmented government pathways, decarbonisation is largely a by-product of technological upgrading and energy shifts, and is partially offset by rising protein demand, land expansion, or crisis-driven deforestation. Grassroots-led transformation delivers deeper emissions cuts through diets shifting away from animal protein – often because food becomes more expensive,

choices narrow, and communities adapt consumption to what local ecosystems can reliably provide – yet lower productivity and uneven governance limit land-sparing gains. The most substantial reductions occur under coordinated government intervention, where carbon pricing, forest safeguards in trade, and aligned public finance deliberately reshape incentives. Deforestation follows a similar pattern: it slows everywhere, but only where rules are collectively enforced does it approach systemic reversal. The comparison suggests that while technology and local action can moderate pressures, sustained reductions in emissions and land conversion depend on governance that internalises environmental costs rather than reacting to them.

Food systems employment and GDP linked to food systems:

Across the four futures, food systems employment and their share of global GDP reflect different

economic logics rather than simple progress or decline. In the market-led pathway, automation and consolidation sharply reduce labour demand, and while productivity raises absolute value, food's share of global GDP remains broadly flat as other sectors grow just as quickly. In the grassroots scenario, food becomes more labour-intensive and economically central: employment rises and the sector's GDP share expands because other parts of the economy contract. Under fragmented government intervention, food is elevated as a strategic national priority, boosting its GDP share through state investment and protectionism, even as efficiency losses constrain broader growth. In the coordinated pathway, employment declines due to automation but is cushioned by rural investment, while food's absolute economic output increases but as a share of GDP remains stable given growth in other sectors.



Table 2
Scenarios comparison

Stylised data, illustrative

	2020s	Market-led adaptation		Grassroots-led action		Fragmented government intervention		Coordinated government response	
		2050	Trend (% change) ● Positive trend ● Negative trend	2050	Trend (% change) ● Positive trend ● Negative trend	2050	Trend (% change) ● Positive trend ● Negative trend	2050	Trend (% change) ● Positive trend ● Negative trend
GHG emissions (from food systems, billion metric tons CO ₂ eq per annum)	16.2 GtCO ₂ eq in 2022 ¹	12 GtCO ₂ eq	↓ 26%	10 GtCO ₂ eq	↓ 38%	12 GtCO ₂ eq	↓ 26%	8 GtCO ₂ eq	↓ 51%
Deforestation (hectares of forest loss due to agriculture per annum)	9 million ha in 2020 ²	6 million ha	↓ 33%	4 million ha	↓ 56%	5 million ha	↓ 44%	1 million ha	↓ 89%
Agroecology (% of global agricultural land under agroecology)	<5% ³	7%	↑ 40%	50%	↑ 900%	15%	↑ 200%	30%	↑ 500%
Biodiversity (Biodiversity Intactness Index)	76% 2000 - 2020 ⁴	65%	↓ 14%	70%	↓ 8%	70%	↓ 8%	80%	↑ 5%
Animal protein (% of total protein consumption)	37% ⁵	40%	↑ 8%	25%	↓ 32%	40%	↑ 8%	22%	↓ 41%
Global poverty (% population living below the international poverty line)	8.5% in 2024 ⁶	10%	↑ 18%	12%	↑ 41%	10%	↑ 18%	5%	↓ 41%
Food systems employment (% of global workforce employed in agrifood systems)	39% in 2021 ⁷	15%	↓ 62%	50%	↑ 28%	35%	↓ 10%	25%	↓ 36%
GDP linked to food systems (% of global GDP linked to food systems)	10% in 2019 ⁸	10%	-	25%	↑ 150%	20%	↑ 100%	10%	-
Obesity (% adult obesity)	16% in 2022 ⁹	20%	↑ 25%	15%	↓ 6%	15%	↓ 6%	20%	↑ 25%
Food insecurity (prevalence of undernourishment)	9.1% in 2023 ¹⁰	10%	↑ 10%	10%	↑ 10%	7%	↓ 23%	5%	↓ 45%
Access to healthy diets (% of population with economic access to a healthy diet)	65% in 2022 ¹¹	50%	↓ 23%	55%	↓ 15%	70%	↑ 8%	78%	↑ 20%

What we can learn from these scenarios

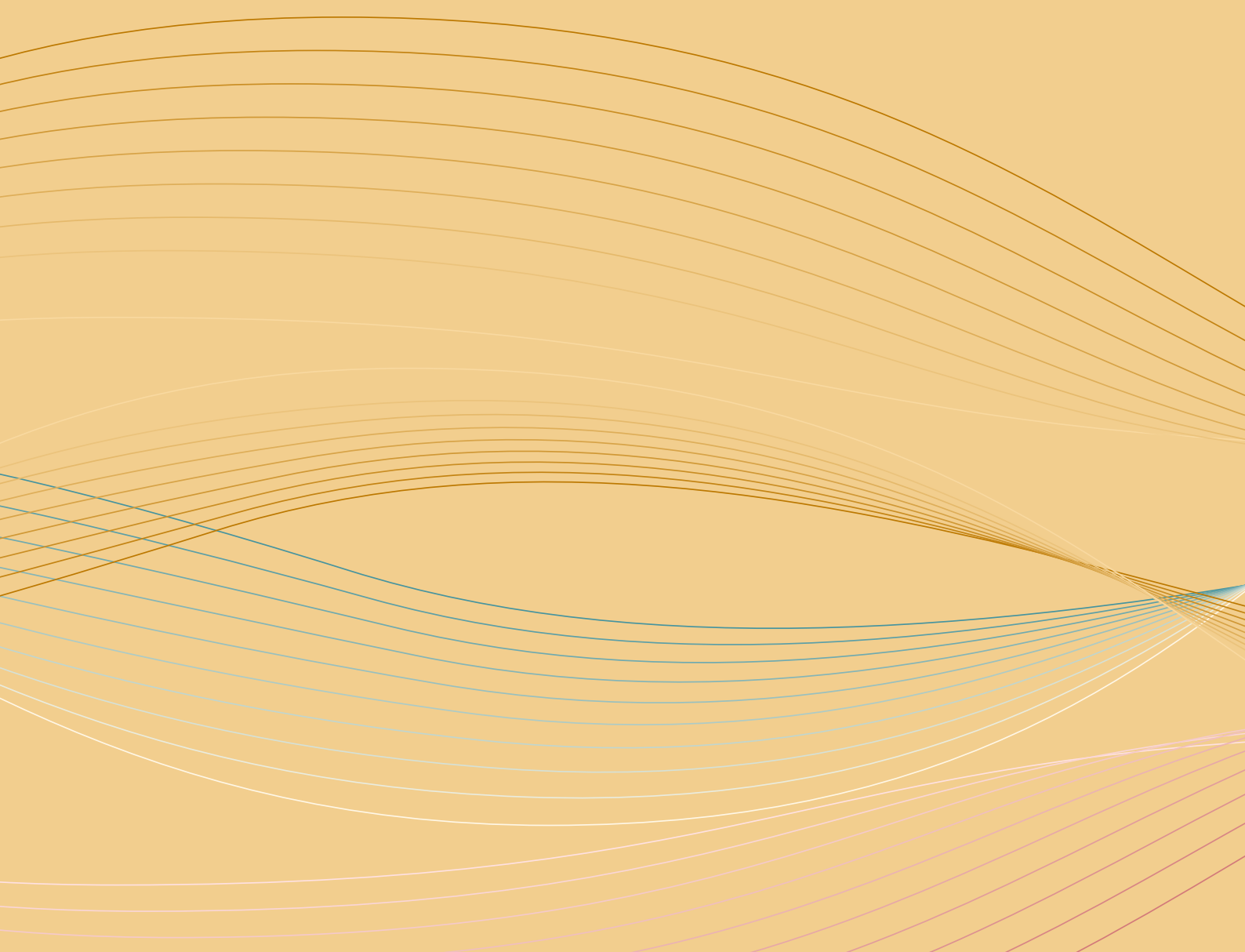
The scenarios are meant to explore possible pathways, not predict outcomes. Rather than pointing to a single preferred future, they clarify where uncertainty must be actively managed rather than resolved, and where early, coordinated action can expand future options and build common ground. Below are a few of our reflections from these scenarios. We invite you to draw your own.

- 1. External forces like geopolitics and technology will have a strong impact on food systems, but outcomes are not predetermined.** Multiple, interacting pressures are already shaping trajectories, yet the scenarios make clear that there is no single inevitable response. Different pathways remain plausible, and collective choices – by governments, markets and communities – will meaningfully influence how the change unfolds and which futures take shape. The rapid expansion of AI, for example, is reshaping control over data, decision-making and intellectual property across supply chains. Its benefits are unlikely to be distributed evenly: deploying AI at scale requires digital infrastructure, clean and reliable energy, technical capacity and access to high-quality data. Where these foundations are concentrated, AI may entrench market power and widen inequalities between companies and between countries. Where access is broadened, it could lower the cost of coordination, improve transparency and support more inclusive innovation.
- 2. What food systems can produce, where and how is increasingly shaped by access to low-cost, reliable clean energy.** From desalination and controlled-environment agriculture to precision fermentation and AI-enabled farming, energy is becoming a foundational enabler. Critically, it enables green ammonia and fertiliser production – shifting a core agricultural input away from fossil gas and geopolitically exposed supply chains, a vulnerability made stark by Russia's invasion of Ukraine and the recent conflict in Iran.⁸⁴ It is, however, rarely addressed as such in food system decision-making.
- 3. No single governance model guarantees success; what matters is the ability to adapt under pressure.** In a period of overlapping risks and geopolitical fragmentation, progress is less likely to emerge from fully coherent global solutions than from deliberate, pragmatic advances such as experimentation, coalitions of the willing, and strategies that adapt to remain viable across multiple futures. The actions and strategies that perform best are not those that eliminate uncertainty, but those that build mechanisms to learn, adjust and coordinate under pressure.
- 4. Resilience demands a reprioritisation of objectives.** The food system can no longer be organised around a narrow focus on maximising short-term yields and minimising costs. Health, ecological stability, livelihoods and systemic resilience must now be explicitly integrated into how success is defined. But broadening the lens does not mean flattening priorities. Some objectives constitute binding constraints on the food system's viability. Greater clarity about which objectives fall into this category is essential to prevent short-term optimisation from eroding long-term resilience.
- 5. Clearer priorities do not imply uniform pathways – we need a “yes, and” approach to solutions.** Even where objectives are clarified, the means of achieving them will differ across contexts. Agroecological practices and advanced technologies are not opposing choices; their relative weight will vary by context, and in many places hybrid, technology-enabled agroecological systems will offer the most durable pathway. Strong national strategies and constructive cross-border cooperation are not mutually exclusive; resilience depends on both. A resilient future will emerge not from a single dominant model, but from combining approaches pragmatically and tailoring them to place and circumstance.

Part 3

Reflections on the tensions and trade-offs of the food system

As explored above, for decades, the food system has been shaped by a relatively narrow set of objectives. Its organising logic prioritised delivering abundant, affordable and safe food at the lowest possible cost, with profitability driven by efficiency, scale and commoditisation. That focus helped unlock extraordinary productivity gains and expand access for billions.



Part 3: Reflections on the tensions and trade-offs of the food system

Under today’s conditions and emerging shifts, the system’s logic is beginning to undermine the objectives it was designed to achieve. Climate volatility, ecological decline, rising health burdens, geopolitical fragmentation and inequality are exposing the limits of a system optimised for scale and cost reduction rather than resilience. Food systems are not only exposed to these risks, they are actively contributing to them: accounting for roughly one-third of global greenhouse gas emissions,⁸⁵ including a significant share of methane emissions,⁸⁶ and driving land-use change that disrupts ecosystems and alters hydrological cycles on which production itself depends.^{87,88} A system that degrades its resource base, undermines human health or leaves producers unable to invest cannot sustain sufficiency, affordability or profitability over time.

System decisions must now account for a wider and more disciplined set of objectives to ensure long-term resilience. Delivering sufficient, safe and affordable food remains essential, but those goals can no longer be pursued in isolation from operating within ecological limits, supporting diets that promote long-term health, and creating economic conditions in which farmers and workers can invest in the future. Without this broader lens, efforts to optimise one objective risk undermining others – and, over time, eroding the foundations on which they depend. The next phase of food system evolution therefore requires not only integrating additional objectives, but also recognising how they interact and which set the system’s limits.

A system that degrades its resource base undermines human health

The table below sketches a possible reframing of system objectives, offered as a working illustration rather than a definitive blueprint.

Old system	New system
Food is...	
Sufficient	...and produced within planetary boundaries
Affordable	...and equitably valued and not wasted
Safe	...and healthy and nutritious
Convenient	...and culturally relevant
Optimised for productivity and financial efficiency	...and for long-term system resilience, factoring in human and natural capital

Table 3: Food system objectives – previous and future



Where objectives align, progress should be accelerated. Some interventions deliver benefits across health, sustainability and economic resilience simultaneously. Plant-rich dietary patterns, for example, can improve public health outcomes, reduce environmental pressure and lower costs for households. Targeted irrigation investments in parts of Sub-Saharan Africa can close yield gaps, strengthen food security and raise rural incomes. Farming practices that restore soil health can increase long-term productivity while reducing input dependence and vulnerability to climate shocks. Identifying and scaling such areas of alignment offers one of the most pragmatic routes to durable progress.

Priorities will vary across contexts, and they should. Context will inevitably shape where effort is concentrated and how trade-offs are managed. Yield gaps,

diet-related disease, biodiversity loss, ecosystem conversion and water scarcity do not carry equal weight everywhere. In parts of Sub-Saharan Africa, closing yield gaps and reducing undernutrition remain urgent to secure food access and rural livelihoods. In the United States and other high-income economies, addressing overconsumption and diet-related disease has become central to both public health and fiscal sustainability. In Brazil, halting deforestation and restoring degraded land are critical to maintaining ecosystem services and long-term agricultural productivity. In water-scarce regions of the Middle East, securing reliable production through water-efficient and controlled-environment systems carries greater weight. Designing for resilience therefore requires differentiated strategies aligned with local realities, even as shared constraints such as planetary boundaries bind the system as a whole.

Priorities will vary across contexts, and they should

While some win-wins exist, trade-offs are inevitable and must be managed deliberately – and not all trade-offs are equal. Some reflect hard physical limits; others reflect economic design choices. Distinguishing between the two is critical for effective prioritisation.

- 1. Physical trade-offs arise from finite natural resources and planetary boundaries.** Land, water, marine ecosystems and the atmosphere operate within limits. We cannot increase consumption of resource-intensive foods, scale crop-based first-generation biofuel production and restore ecosystems simultaneously without confronting real constraints. These trade-offs require explicit prioritisation and clarity about what takes precedence under scarcity.
- 2. Economic trade-offs, by contrast, often reflect misaligned incentives rather than immutable limits.** Healthy and sustainable food frequently appears less affordable because subsidies, pricing structures and market concentration favour input-intensive production and ultra-processed foods. In these cases, the constraint is institutional rather than biophysical, but institutional constraints are deeply embedded. Subsidy reforms are politically sensitive, capital markets prioritise short-term returns and incumbents benefit from existing rules. Reform is unlikely to emerge from universal consensus. Progress will instead depend on coordination among willing actors and targeted actions that trigger self-reinforcing change – positive tipping points that make further reform easier.⁶⁹

If trade-offs are unavoidable, the question becomes how to prioritise. Three complementary lenses can help guide decision-making: clarifying non-negotiable objectives, aligning action with risk timeframes and focusing effort on leverage points that unlock wider change.

1. Prioritise non-negotiable objectives.

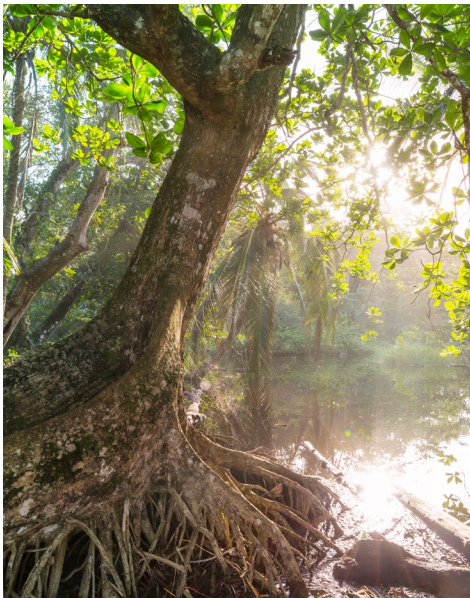
Some constraints, particularly those grounded in biophysical limits, set the outer boundaries within which the system must operate. Ensuring sufficient food production within planetary boundaries is foundational to long-term resilience – and survival. More specifically, respecting the land-use change planetary boundary, particularly by halting and reversing tropical deforestation, represents a binding system constraint. Other objectives, such as affordability or distributional outcomes, remain critical but are shaped by policy choices and market design. Clearer prioritisation requires distinguishing between what cannot be compromised and what can be reshaped through institutional reform.

2. Use risk timeframes as a compass for focus.

Political and investment cycles are short; systemic risks are not. Yet climate shocks, supply disruptions, geopolitical fragmentation and health impacts are increasingly arriving within those same near-term horizons. When crises compress into decision-making timeframes, they force rapid shifts in attention and capital. Anticipating where those pressures will emerge next – and acting before they crystallise – allows effort to be focused where it is most urgent, while ensuring that near-term responses are designed with long-term system resilience in mind, to avoid locking in irreversible damage.

3. Target positive tipping points to accelerate change.

Not all interventions carry equal systemic impact. Strategic focus on actions that can trigger self-reinforcing dynamics – positive tipping points – offers a pragmatic way forward. Coordinated moves by willing actors around procurement standards, finance, technology adoption or dietary shifts can lower costs, reshape incentives and make further reform easier over time.



Amazon dieback: a critical challenge for food system decision-making

Research indicates that at around 20–25% forest loss,⁹⁰ compounded by warming and fire dynamics, the Amazon could shift toward large-scale dieback. With deforestation currently near 17%, the margin for error is narrowing.⁹¹ The Amazon stores on the order of 200 gigatonnes of carbon. Even partial dieback in its most vulnerable regions could release around 30 gigatonnes, alter rainfall patterns and cause significant warming in the region – with potentially severe consequences for agricultural systems across this critical breadbasket.^{92,93}

The Amazon dieback risk illustrates how these lenses apply in practice. First, it represents a non-negotiable constraint: crossing this threshold would undermine both global climate stability and regional food production, with consequences far beyond the Amazon. Second, the proximity to this tipping point compresses decision timeframes, making immediate action critical to avoid locking in irreversible change. Third, it highlights a set of high-leverage interventions with system-wide effects, including strengthening legal protections for forests and Indigenous stewardship, enforcing deforestation-free commodity supply chains and mobilising finance for sustainable land use.⁹⁴

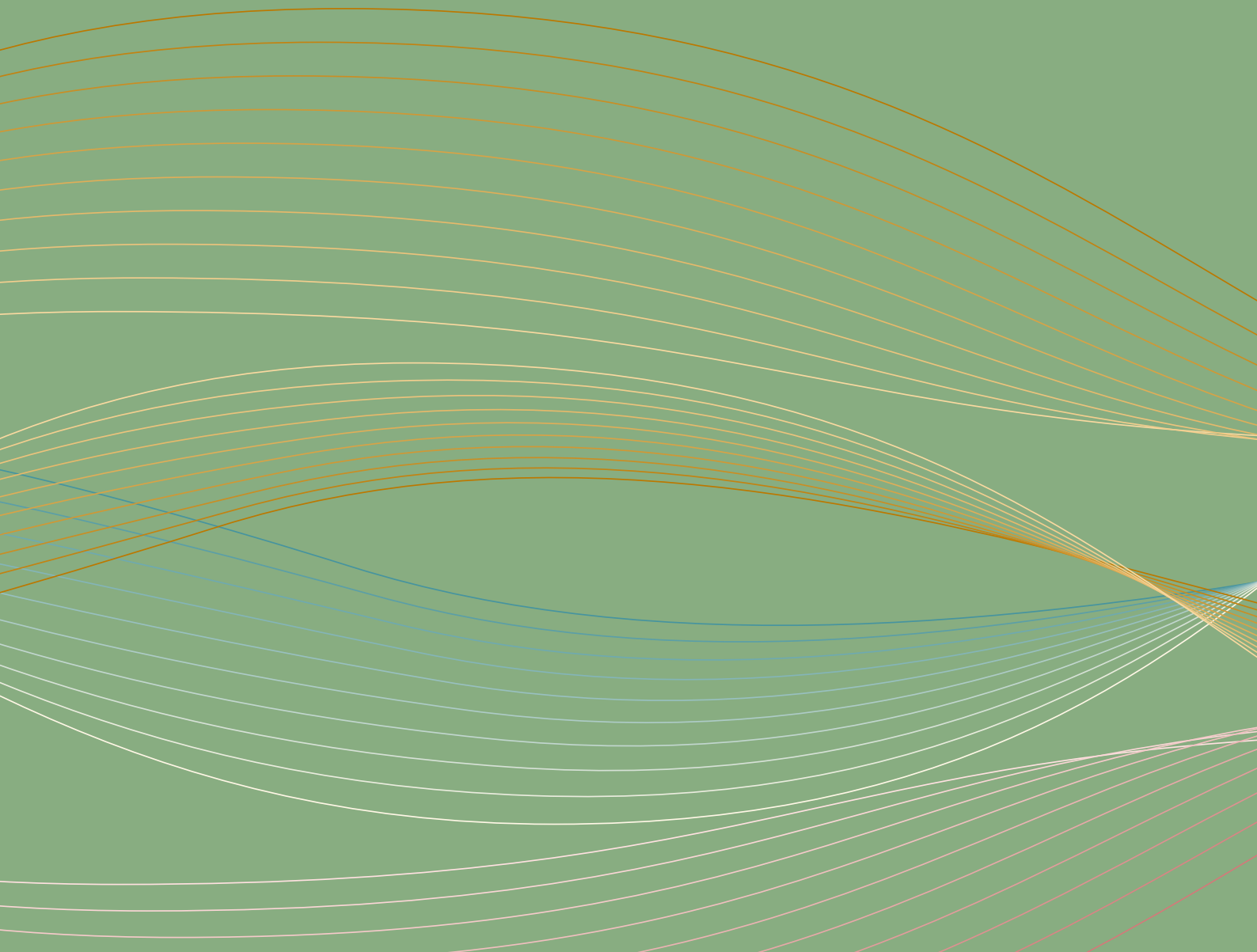
All of this points to a critical gap in how the food system manages trade-offs and navigates complexity. In the absence of shared analytical foundations and alignment-building processes, decisions are made within individual constraints and incentives, reinforcing fragmentation, short-termism, and systemic fragility. Closing this gap requires structured, collective sense-making to

assess trade-offs explicitly, determine which objectives must be prioritised, understand how risks evolve across time horizons, and identify where coordination can meaningfully expand the space of viable action. The reflections in this section are not a blueprint, but an invitation to help shape a shared transformation agenda grounded in clearer priorities and more deliberate coordination.

Part 4

Ideas and interventions – building a shared agenda

The shape of a shared transformation agenda will be determined by where we choose to concentrate effort, and by recognising that certain interventions can unlock change far beyond their immediate scope.



The complexity of today's food system cannot be addressed through isolated initiatives or single-objective reforms. What we believe is needed is a shared agenda that enables willing actors to focus effort where it can unlock wider progress. This section explores a set of pragmatic, high-confidence bets that can serve as foundations for collective action – interventions that are viable across multiple futures and capable of catalysing broader change if pursued in coordination.

We propose four high-confidence bets as enabling foundations for a shared agenda – not as a complete solution set. These priorities emerged from a collaborative process that generated and debated more than 100 ideas across policy, technology, finance, and governance. From this broader field, we identified a smaller set of interventions with outsized potential to unlock progress beyond their immediate scope. Each targets a structural leverage point in the system, where coordinated action could accelerate wider change and bring positive tipping dynamics within reach.

Together, they focus on:

1. Strengthening decision-grade data, metrics and systems
2. Improving the valuation of risk to inform capital flows
3. Enabling nationally grounded but globally coherent government action
4. Establishing shared analytical and coordination platforms that equip decision-makers to interpret systemic and local risks, assess trade-offs, and prioritise action

High-confidence bet #1: Open, decision-useful data infrastructure

Reliable, decision-grade data is foundational infrastructure for food-system transitions – yet it has historically been fragmented and proprietary. Food systems depend on soils, seas, water, biodiversity, climate stability and human health, but information about these dependencies and impacts is dispersed across private platforms, corporate systems and inconsistent public datasets. Much of the most granular and commercially valuable data, including farm-level production metrics, supply-chain traceability and input use, is controlled by a limited number of actors, constraining transparency and interoperability. The oceans present a stark case: fragmented monitoring and limited vessel tracking mean much of global fishing effort remains poorly observed, complicating efforts to

detect overfishing and manage marine ecosystems sustainably.^{95,96} The core challenge is that data is both scarce and fragmented across the value chain. Raw measurements from satellite imagery and ecological monitoring rarely translate into consistent, decision-useful outputs for investors, insurers, companies, and governments. Metadata standards differ, taxonomies are inconsistent, geospatial layers do not align, and modelling assumptions remain opaque. As a result, the same hectare of land or the same marine zone can generate conflicting risk assessments depending on the framework applied. Data is increasingly abundant but not interoperable, comparable or actionable, whether for producers or for other actors in the supply chain.

Demand for credible, structured data across the food system is growing rapidly. Producers need better, localised decision support to manage yields, inputs and risk. Companies require robust traceability and performance data to meet regulatory and supply chain resilience demands. Financial institutions need clearer visibility into climate and nature-related risks to inform lending, insurance and investment decisions. Governments need reliable evidence to guide policy, taxation and resilience planning. Yet growing demand alone does not create usable systems.

This high-confidence bet focuses on accelerating the shift toward high-integrity environmental and production data which is accessible, interoperable and comparable across actors and geographies. The opportunity is not to make all data open, nor to undermine proprietary advantage. Rather, it is to build shared digital rails – common standards, identifiers, and protocols – that allow data to move securely and meaningfully across systems. In this model, value shifts from controlling data to using data better: companies retain competitive datasets and insights, while benefiting from a larger, more reliable and interoperable

information ecosystem. By upgrading the underlying data architecture, this bet changes decisions across the system. It improves the quality of risk modelling and capital allocation as required in bet #2, strengthens national strategy design as required in bet #3, and enhances systemic analysis as required in bet #4. It also accelerates innovation by enabling entrepreneurs and researchers to build on open, standardised datasets, shifting business models from proprietary data control toward insight generation and practical implementation.





The value of this bet lies in making visibility itself a leverage point. Decision-makers cannot manage what they cannot see consistently. Data is needed to shape decisions: the more open, reliable and usable it is, the more farmers and other actors can see and evaluate the shared risks and trade-offs they face. It also mitigates a growing concentration risk: as AI becomes embedded in food systems, those who control the data and build the models are best positioned to capture market power. Treating foundational data layers as interoperable public infrastructure reduces the risk of informational monopolies and widens access to innovation capacity.

The data foundations required for systemic transition depend on shared, multi-stakeholder infrastructure – and momentum is already building. A growing ecosystem of public agencies, multilateral institutions, data providers, technology platforms, farmers' organisations and financial actors is beginning to assemble the core architecture. What is emerging is not a single system, but a set of interoperable building blocks that could form the backbone of a more connected and decision-grade data layer for food systems.

Several initiatives are already moving from concept to implementation. The Open Nature Intelligence Exchange (Onix) – a global, pre-competitive framework for farm- and field-level data exchange designed as a digital public good – is working to establish the shared digital rails that allow agricultural and land use data to move securely across public registries, private platforms and emerging technologies.^{97,98} In parallel, the Taskforce on Nature-related Financial Disclosures (TNFD) is advancing a Nature Data Public Facility to make decision-useful datasets accessible and connect environmental data providers with corporate and financial users.⁹⁹ Complementing these efforts,



Table 4: Examples of how open food system data infrastructure creates value

	Use case	Target user	Data infrastructure required	Value created	Example
	AI production advisory	Farmers and aquaculture producers	Soil or water quality data, weather and ocean conditions, field or farm IDs	Higher yields, lower input costs	A small-scale shrimp farmer in Vietnam uses AI combining water quality sensors, weather and satellite data to optimise feeding, stocking density and harvest timing.
	MRV for sustainable & regenerative production	Farmers and aquaculture producers, supply chain actors	Environmental outcomes, proxy practices implemented, field IDs	Access to premiums, climate & nature markets	A mid-sized coffee cooperative in Colombia uses satellite data and field-level records to verify regenerative practices, enabling farmers to access premium markets and climate finance with lower verification costs.
	Traceability & ecosystem compliance	Supply chain actors	Satellite data, field or vessel IDs	Market access, credible sustainability claims	A global cocoa trader links farm plots in West Africa to satellite monitoring systems, allowing it to prove its supply chain is deforestation-free and to maintain access to EU markets.
	Climate & nature risk modelling	Finance	Production data, local environmental risk data, field or farm IDs	Better risk pricing, improved capital allocation	An insurer models drought risk for crops and disease risk in aquaculture using production and environmental data to price policies and expand coverage.

the Initiative for Agriculture and Artificial Intelligence (IAAI) is developing an open agricultural data infrastructure across crops, farming systems and regions to enable AI models and agronomic tools tailored to smallholder producers.¹⁰⁰

Together, these efforts signal a shift: from fragmented experimentation towards the early formation of shared infrastructure. The window open to us now is to shape how these systems connect, scale and govern data flows. Sustained backing from governments, philanthropies and market actors will be critical to accelerate and align this emerging ecosystem. Actors across the system can engage in different ways: contributing by

sharing selected datasets, standards or methodologies in pre-competitive areas; adopting emerging standards – such as field or vessel identifiers and metadata frameworks – within existing systems; piloting interoperability and data-sharing models in specific geographies or value chains; and investing in the development of shared infrastructure, particularly in underserved regions.

The distributional stakes of how this infrastructure is built – by whom and for whom – are significant. Many of the regions most exposed to climate and food-system risk – particularly in Sub-Saharan Africa – also have the weakest environmental monitoring

and digital data infrastructure. Without deliberate investment in these regions' data infrastructure, a data-driven sector transformation risks reinforcing existing asymmetries, leaving the countries most exposed to climate and food insecurity least able to participate in a market that increasingly depends on AI and digital evidence.

Embedding open, decision-useful data as core infrastructure strengthens every other lever in the system. It lowers the cost of coordination, improves accountability, and increases the likelihood that capital, policy, and innovation can align around resilience.

High-confidence bet #2: Standardising risk valuation to redirect capital

Systemic food system risks are widely acknowledged but remain poorly priced.

Climate volatility, nature loss, water stress, supply-chain disruption, and health impacts are already generating material costs across food systems – from crop failures and land degradation to fish stock shifts, aquaculture disease outbreaks, marine ecosystem decline, and storm damage. Yet these risks are modelled unevenly, disclosed inconsistently, and only weakly embedded in financial decision-making. As a result, capital continues to flow in ways that amplify short and long-term risk, while resilient and nature-positive practices face higher costs of capital and limited access to finance.

This gap between actual risk and priced risk is now constraining transition.

Markets are beginning to respond through disclosure frameworks and risk analytics, but without common, decision-useful metrics, signals remain weak and fragmented. Different actors use different methodologies, time horizons, and definitions of risk, making accurate quantification and comparison impossible and coordination elusive. In this environment, resilience is locally and systemically under-valued.

This high-confidence bet focuses on standardising how food system risk is translated into comparable financial terms. This would enable capital markets to price and integrate climate and nature risks more consistently and mobilise investment toward prevention and resilience. Risk capital markets, their regulators, and credit rating agencies already offer a powerful precedent: metrics such as Average Annual Loss (AAL) and Probable Maximum Loss (PML) convert uncertain, volatile hazards into common financial measures that capture both frequent losses and tail risks in ways that allow comparison across different types of risk.¹⁰¹ Developed through catastrophe risk modelling since the early 1990s, these metrics introduced a critical shift from relying on just historical losses (what happened in the past) to quantifying current levels of risk (likelihood and financial impact) at current and future conditions and taking into account changing climate and exposure.¹⁰² This quantification techniques combine four disciplines: engineering, actuarial science, physical and human geography, and more recently climate science. By translating hazard, exposure, and vulnerability into forward-looking, comparable financial measures, they became the backbone of underwriting, capital allocation, and prudential regulation in the global re/insurance industry – helping move the sector from episodic crisis toward far greater resilience.¹⁰³

¹⁰¹ Extending this approach to food systems means combining three elements: the likelihood of hazards (e.g. droughts or storms), the exposure of assets (which food production systems, where), and their vulnerability (how much damage those assets incur under different hazards, e.g. how weather events translate into yield or stock losses). By simulating thousands of possible years, these models generate a distribution of losses from which AAL and PML are derived to capture both expected and extreme risks.



The critical shift was not improved prediction alone, but the ability to express risk in a form that financial institutions could price, compare, and trade risk to mobilise investors, as well as integrating it into core decision-making. Embedding these metrics across climate, nature, and supply-chain risks would allow risk and resilience to be priced consistently – shaping decisions where incentives are set: in premiums, credit terms, balance sheets, investments, and communities resilience.

The value of this approach lies in changing the economics of transition and thereby mobilising capital at scale.

When risks are measured, accounted, and priced consistently, resilient practices move from being perceived as niche or concessional to being recognised as risk reduction, value protection measures at both short and long-term scales. Conversely, business models that amplify risk face higher premiums, tighter credit conditions, and rising capital costs. Standardised metrics allow lenders, insurers, investors, and companies to compare their risk exposure across geographies and value chains, stress-

test strategies against current and future shocks, and differentiate between resilient and fragile assets. In practice, this enables banks to price loans informed by climate and nature risk exposure, insurers to design scalable products such as parametric cover linked to drought or marine heat thresholds, investors to fund resilient production systems and supply chains, and companies to support sourcing toward more resilient practices. Over time, these signals feed directly into credit decisions, insurance pricing, and investment strategies, shifting capital toward adaptation, diversification, and restoration – not primarily through regulation or voluntary commitments, but through core risk-informed financial decision-making.

This requires coordination across finance, industry, policy, and science.

Financial institutions (banks, insurers, reinsurers, asset managers), food and agriculture companies, scientists, data providers, alongside public actors that shape financial architecture must align around decision-grade metrics. The task is to translate existing science and risk analytics into credible, comparable AAL-

type indicators. Strong data infrastructure is essential: without interoperable, high-integrity data on climate, ecosystems, land and seascapes, and production systems, risk valuation cannot scale. A growing ecosystem is already emerging – from climate and hazard data platforms such as AgMIP (crop model intercomparison and yield projections),¹⁰⁴ to modelling engines such as CLIMADA (probabilistic climate risk modelling),¹⁰⁵ Oasis Loss Modelling Framework (catastrophe risk modelling),¹⁰⁶ and OpenQuake (a successful example of open catastrophe risk modelling infrastructure in another domain),¹⁰⁷ as well as integrated platforms such as OS-Climate (open climate data and analytics mesh)¹⁰⁸ – though these efforts are early stage, and not yet tailored to food system financial decision-making.

Embedding these metrics into financial architecture redirects capital at scale.

Integrated into credit assessment, insurance pricing, and investment strategy, standardised risk measures reposition resilience as core risk management and value protection. The transition is then accelerated through market logic – not in spite of it.



High-confidence bet #3: National food strategies in an interdependent world

National governments are re-emerging as decisive actors in food systems. Food security and affordability are being brought to the top of national agendas. In response, many countries are developing or revisiting national food system strategies to strengthen domestic resilience and reduce exposure to external shocks.

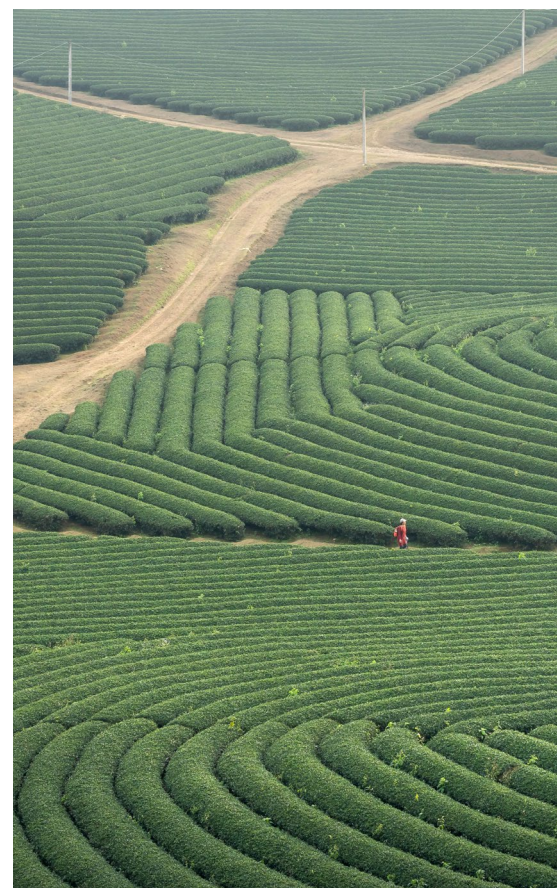
This shift is necessary, but it carries material risk. When pursued in isolation, national strategies can increase fragmentation, inefficiency, and environmental harm. Export restrictions, escalating domestic subsidies and inward-looking self-sufficiency drives may stabilise supply domestically in the short term, but amplify volatility, ecosystem pressure and political tension elsewhere. In a highly interconnected system, resilience pursued unilaterally can undermine resilience globally. Equally, resilience pursued through only a short-term domestic lens can erode its own foundations if it locks in ecological strain, fiscal burden or dependence on resource-intensive practices. This is particularly evident in aquatic food systems, where nationally driven expansion without international coordination can exacerbate pressure on shared marine ecosystems and migratory stocks.

The opportunity is therefore not simply for stronger national strategies, but for national strategies designed with global coherence in mind. Well-designed strategies can become powerful levers for system-level change: aligning policy, finance, procurement and standards; shaping demand and investment signals; and accelerating the transition toward more resilient, diversified production

systems on land and at sea. Poorly designed strategies risk locking in new vulnerabilities and zero-sum dynamics.

This high-confidence bet supports the development of integrated national food system strategies that are grounded in domestic realities and designed with global interdependence in mind. The aim is to help governments navigate trade-offs between self-reliance and interdependence, affordability and sustainability, and short-term political pressures and long-term resilience. While the starting point is nationally driven strategy, this approach also calls for collaboration among willing countries that share common risks, complementary strengths or mutual interests to exchange lessons and coordinate action. Working from a shared evidence base and a common understanding of system-level risks helps reduce fragmentation and clarify where coordination can deliver mutual benefit.

The value of this approach lies in three areas: i) strengthening domestic coherence, ii) aligning public and private actors and iii) enabling management of shared risks. First, it improves policy coherence within countries, bringing together agriculture, trade, climate, health and finance ministries through an integrated food system lens. Second, it strengthens alignment between public policy and private action, giving companies, financiers and insurers clearer long-term signals for investment, sourcing and risk management. Third, it enables collective management of transboundary risks such as climate impacts, biodiversity loss and price volatility that no country can address alone.



The aim is to help governments navigate trade-offs between self-reliance and interdependence

To be effective, this effort must be led at the highest levels of government and involve farming and fishing communities, major food system companies and financial institutions alongside public actors. Governments set direction and incentives; firms and financiers translate those signals into real-economy decisions. Given their systemic implications, these national strategies cannot sit solely within sectoral ministries of agriculture, fisheries or environment. They need to be anchored in the highest levels of government – including the President's or Prime Minister's office – and closely linked to finance ministries to align priorities, manage trade-offs and translate strategy into resource allocation.¹⁰⁹ Backed by appropriate financing tools, such as subsidy reforms, blended finance, guarantees and aligned procurement, national strategies can move from ambition to implementation. Crucially, these strategies must also address the distribution of risks and opportunities across actors along the value chain. Without explicit attention to a just transition for farmers and fishers, efforts to transform the system risk placing the greatest burden on those least able to absorb it, undermining both political feasibility and long-term resilience.

There is a growing number of countries beginning to develop national food strategies or elements of one, signalling a shift and providing an initial foundation for more coherent, system-wide action. France announced in February 2026 its 2030 food, nutrition and climate strategy, setting targets to shift diets, reduce environmental impacts and better align agricultural production with public health outcomes.¹¹⁰ While the independent 2019 UK National Food Strategy¹¹¹ was not adopted by the government at the time, the current government has taken forward key elements, launching in March a Land Use Framework to guide how land is allocated across food production, nature restoration and climate objectives.¹¹² China's 15th Five-Year Plan, also published in March, reinforces food security as a core national priority, with a focus on boosting domestic production, technological innovation, and reducing import dependence.¹¹³ In 2021, Japan's MIDORI Strategy for Sustainable Food Systems set out a long-term transition toward sustainable agriculture, including reduced chemical inputs and expanded organic production.¹¹⁴ In 2023, Denmark launched its Action Plan for Plant-based Foods,¹¹⁵ complemented by its 2024 climate and agriculture policy which set plans for the world's first tax on agricultural climate emissions.^{116, 117, 118}

These examples are not blueprints, but signals of a broader shift: food systems are rising on national agendas and increasingly being approached as a strategic, cross-sector priority. National food strategies are only a starting point, but getting them right – both for domestic realities and global interdependence – will be critical to avoid locking in environmental damage, shifting pressures across borders, or exacerbating vulnerabilities in food-insecure regions.

The objective is not uniformity, but holistic, coherent national strategies that are designed with an awareness of global interdependence. When countries take domestic resilience, health, land use and farmer viability seriously, and build in cooperation where it can mitigate shared risks, their strategies become more durable and economically credible. Where interests align, collaboration among willing countries can extend the impact of national strategies – unlocking efficiencies, strengthening supply relationships and accelerating innovation that no country could achieve alone. Strengthening the analytical foundations needed to understand the systemic risks and trade-offs that shape these strategies is a critical next step.



High-confidence bet #4: Institutions for systemic risk and trade-off assessment and coordination

Complex systems require credible institutions to make sense of risk, trade-offs and long-term pathways.

In finance, bodies such as the Financial Stability Board exist to identify systemic vulnerabilities, translate complex risk into decision-relevant insight and support more coordinated responses across actors. The global food system lacks an equivalent forum: a space where senior decision-makers can jointly assess how different objectives, risks and transition pathways interact, and what this implies for strategy, capital allocation and coordination over time.

Today's food system fragmentation reflects more than political disagreement; it reflects analytical fragmentation.

As this report has shown, food system actors face growing uncertainty, contested priorities and accelerating physical and transition risks. Yet decisions continue to be made in fragmented ways, guided by partial analysis, short-time horizons and uncoordinated signals from markets and policy. Without a shared, analytically grounded reference point, even well-intentioned action risks reinforcing misalignment rather than reducing it.

One possible response to this gap is a senior-level working group on food systems transitions. It could develop on the model of the Energy Transitions Commission¹⁹ – an industry-governed, analytically rigorous platform that helps leading food companies and financial institutions make sense of how the food system transition is likely to unfold and what that means in practice for priorities, sequencing and collaboration. Its purpose is not advocacy or target-setting, but disciplined sense-making: translating complex system dynamics into a small number of coherent, evidence-based futures that make trade-offs explicit and comparable.

The distinctive value of such a group lies in three areas: i) clarifying system trade-offs, ii) aligning incentives across actors and iii) strengthening evidence-based policymaking.

First, it would clarify objectives and trade-offs by synthesising the best available modelling and analysis into decision-grade insight on how different priorities – such as affordability, nutrition, emissions reduction, land and marine resource use, livelihoods, and resilience – interact under real-world constraints. Second, it would support alignment between real-economy and financial actors, helping firms, banks and insurers anticipate how risks, costs and incentives are likely to shift, and where coordinated action is required versus where markets can deliver change independently. Third, it would strengthen engagement with policymakers by providing a credible analytical reference point that informs policy design without becoming an advocacy platform.

Participation and independence are critical to such a group's impact. It must involve those actors whose decisions most materially shape system outcomes: senior leaders from across the agri-food value chain (upstream production, processing, retail and food service), alongside banks, insurers, and other financial institutions with significant exposure to food- and nature-related risks. Its credibility would depend on having strong safeguards for analytical independence, an internationally-respected independent chair, and a clear separation between analysis and public positioning.

A complementary institutional track focuses on public risk management.

Alongside that working group, there is a case for a Food Systems Stability Board (FSSB): a high-level platform modelled loosely on the Financial Stability Board, designed to assess vulnerabilities across the global food system before they cascade into crisis. First proposed in the

A Food Systems Stability Board would fill a structural gap



aftermath of COVID-19, the idea was to move beyond fragmented early-warning tools toward integrated risk assessment – examining how climate shocks, trade restrictions, input dependencies, financial exposures and geopolitical tensions interact across borders and commodities.¹²⁰ A Food Systems Stability Board would fill a structural gap: comparing systemic risks, stress-testing food systems against compound shocks, and encouraging countries to develop shared risk assessments and contingency plans – linking to the previous high-confidence bet on national food strategies.

Such a body would not require universal buy-in from the outset.

Although initially conceived in a more cooperative moment, the rationale is still strong in today's more fragmented landscape. Full global consensus may be unrealistic; progress could begin with a coalition of willing governments – for example through the G20 or groupings of major producing and consuming countries across the global South and North – building common risk dashboards, coordinating crisis protocols and gradually expanding participation. In a world of rising interdependence and rising tension, such a mechanism would anchor food security within the logic of collective stability rather than reactive crisis management.

Though distinct in function, the working group and FSSB serve a shared purpose.

Together, they shift food systems from reactive crisis management toward more deliberate, coordinated management of systemic risk in a fragmented world. By strengthening shared analysis, improving comparability of risks and trade-offs and embedding systemic thinking into financial and public decision-making, they make the consequences of action – and inaction – more visible and harder to ignore. In doing so, they support more resilient strategies, better-aligned capital allocation and more effective collective action in an era defined by increased fragmentation.

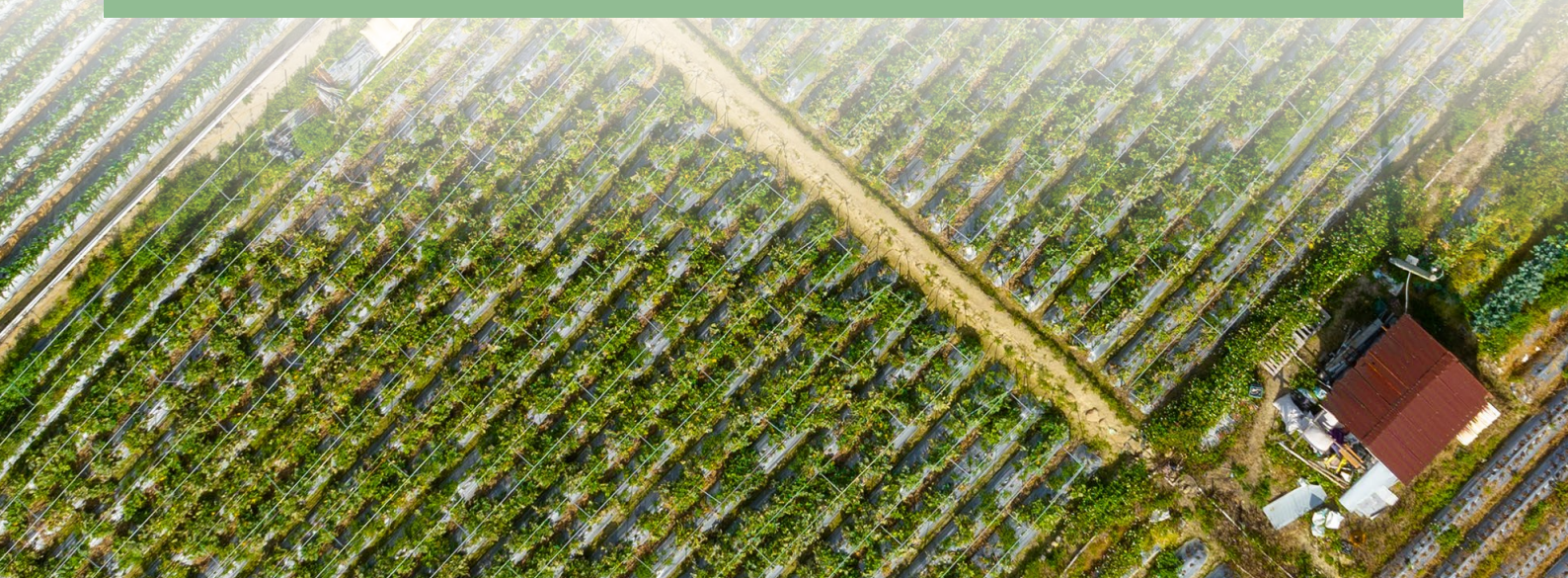
How these bets reinforce one another across futures

Solutions must be robust across multiple governance logics. The scenarios in Part 2 span market-led adaptation, grassroots-led systems, fragmented state intervention and more coordinated global responses. In such a landscape, credible interventions cannot rely on a single political economy configuration. They must be adoptable by market actors, operationalised by governments and advanced by coalitions of the willing – even in the absence of universal consensus.

The four high-confidence bets meet that test because they strengthen system foundations rather than depending on a single political configuration. Open, interoperable data improves transparency whether markets dominate or states intervene. Standardised risk valuation works through financial logic even in the absence of sweeping regulation. National strategies embedded in a global context allow coordination to deepen through alliances of the willing rather than universal agreement. Analytical platforms such as the senior-level working group and the FSSB provide shared reference points that reduce fragmentation even when geopolitical tensions persist.

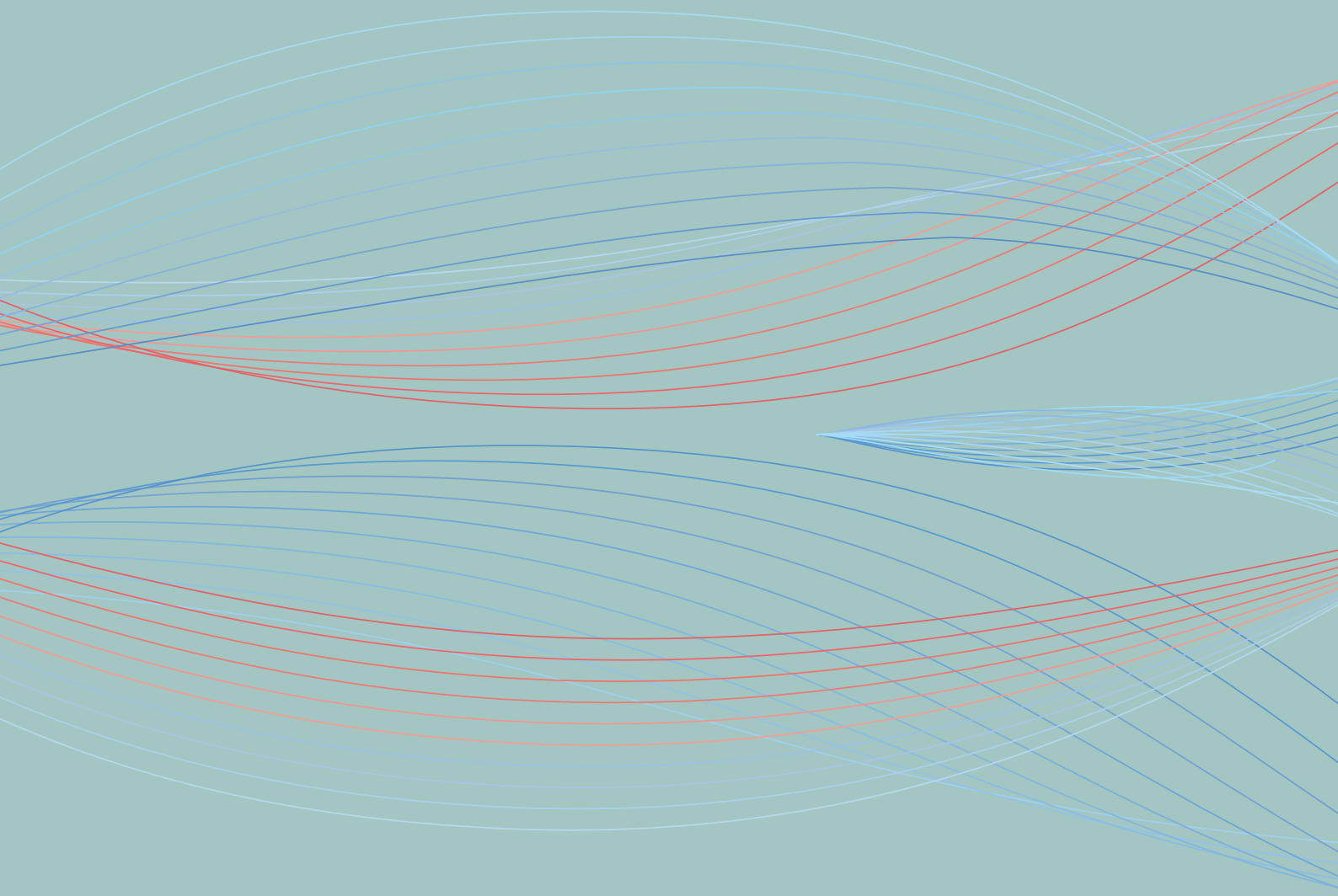
These four bets are not the only interventions that matter. Diversifying production, scaling green ammonia and precision agriculture, climate-resilient seeds and dietary shifts are all essential. So too are reforms to trade rules, blended finance vehicles, procurement mandates and innovation policy. But without shared data foundations, credible risk pricing, nationally coherent strategies and institutions capable of interpreting systemic trade-offs, many of these efforts will remain fragmented or sub-scale.

The purpose of this shared agenda is therefore not to narrow ambition, but to concentrate effort on leverage points that make wider progress more likely. In an era of compounding shocks and geopolitical strain, progress is unlikely to emerge from grand designs alone. It will come from pragmatic alignment among willing actors, building coordination where possible, and strengthening the structural foundations that allow resilience, innovation and cooperation to reinforce one another over time.



Part 5

Summary and next steps



Part 5: Summary and next steps

This report set out to strengthen collective clarity at a moment of structural change – not to prescribe a single pathway, but to sharpen how we understand risk, trade-offs and the choices that will shape the food system's next phase.

- Part 1:** we looked back at how the current system was built – optimised for scale, efficiency and cost – and how that success now exposes new vulnerabilities under climate stress, ecological strain and geopolitical fragmentation.
- Part 2:** we explored how emerging forces are expanding the range of plausible futures and are reshaping the system's operating conditions.
- Part 3:** we examined the tensions that must now be managed: biophysical limits, complex and at times competing objectives, shifting risk horizons, and the need to focus effort where it can unlock wider change.
- Part 4:** we translated those reflections into four enabling bets – practical leverage points to strengthen data infrastructure, improve risk valuation, support coherent national strategies and build institutions capable of assessing systemic trade-offs.

The throughline is clear: resilience will not emerge by default. It will depend on clearer priorities, stronger analytical foundations and more deliberate coordination – especially in a period when geopolitical fracture is weakening the multilateral glue that once held system-level cooperation together. In a more divided world, coordination will not happen organically; it must be built intentionally, among actors willing to lead.

In that spirit, the Gordon and Betty Moore Foundation and Systemiq are advancing two immediate strands of work as early contributions to this shared transformation agenda.

The first focuses on China's food future and its potential implications for global food systems. Insights from the futures work presented in this report pointed repeatedly to one emerging signal of change: the possibility that China may apply its industrial playbook – previously used in sectors such as solar and electric vehicles – to food and protein systems. With the recent release of China's 15th Five-Year Plan, which elevates food security and biomanufacturing within the country's strategic agenda, these signals have become particularly salient. Given China's scale and central role in global agricultural markets, even incremental

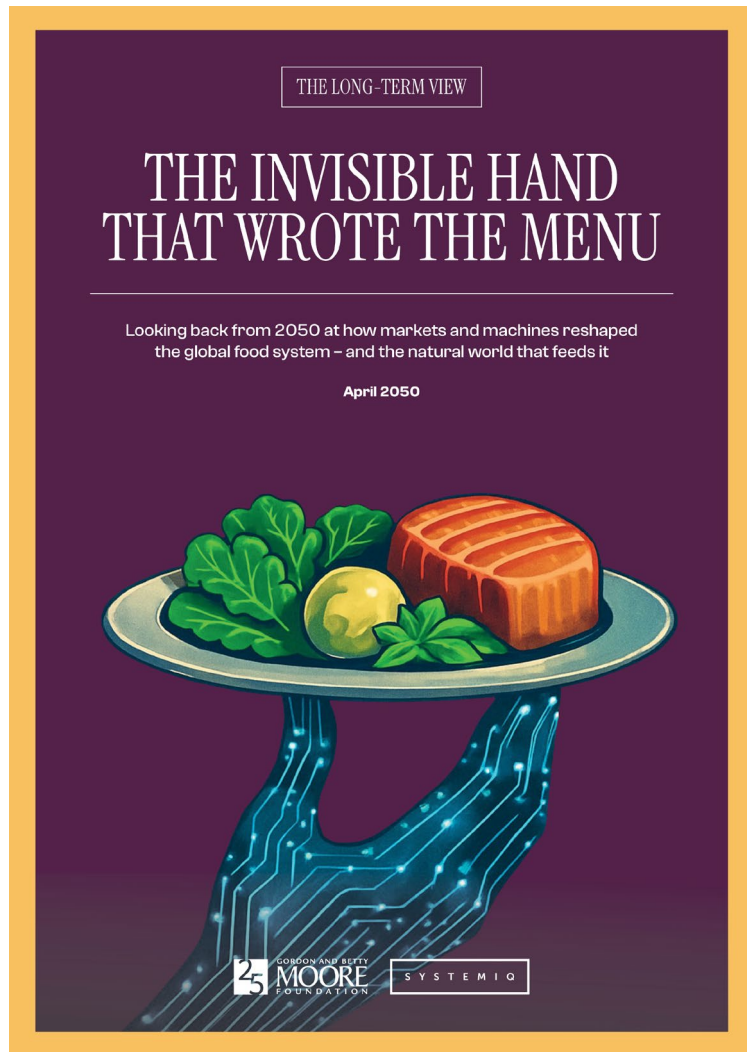
shifts could reshape commodity demand, land use and trade dynamics. To explore these implications, we undertook a dedicated analysis of China's evolving food strategy and its potential global impacts.

The second strand focuses on strengthening understanding of systemic risks and trade-offs across the global food system – an idea explored in this report's fourth high-confidence bet. To help address the current fragmentation of analysis and decision-making, we are exploring the establishment of a senior-level working group: an independent, analytically rigorous platform designed to help companies and financial institutions better understand food-system risks, clarify trade-offs and align long-term strategy with resilience. By providing a shared analytical foundation, the aim is to support more coordinated and informed decision-making in a period of growing uncertainty.

These efforts are only a starting point. The ambition is broader: to catalyse a more coordinated, decision-ready approach to food system transformation. We hope this report – and the work that follows – encourages others to engage, innovate and accelerate progress toward a more resilient and durable system.

The throughline is clear: resilience will not emerge by default.

Annex I: Four plausible scenarios



1: The Invisible Hand That Wrote The Menu

Looking back from 2050 at how markets and machines reshaped the global food system – and the natural world that feeds it

A QUARTER century ago, the global food system teetered on the edge of fragmentation. Trade wars, climate shocks, and public health crises were mounting, and calls for state-led reform grew louder. But governments hesitated. What followed instead was a cascade of market-driven adaptation – led not by ministries, but by megafirms, startups, and algorithms. This is the story of how technology and private capital reengineered how the world grows, moves, and eats its food.

The turning point came in 2033, when joint breakthroughs in ultra-efficient solar cells and low-cost battery storage sent energy prices into freefall. What followed was more than a green energy revolution – it was a reshaping of food systems from the grid up. Technologies like bioreactors, indoor farms, water desalination, and AI-managed precision agriculture, long constrained by energy costs, became scalable and profitable. But the clean energy surge had a shadow: soaring

demand for critical raw minerals drove rapid expansion of mining in poorly regulated regions, bringing new deforestation and labour abuses even as rising circularity softened some of the damage. The transition powered new tools – but it was far from clean or fair for everyone.

At the same time, AI was driving a transformation of its own. Behind the scenes, AI evolved from a tool of optimisation into a discovery engine. It mapped the genomic architecture of seeds, microbes, and ingredients; accelerated protein discovery and strain design; and collapsed the timelines for seed improvement and product development from years to weeks.

40%

of China's protein demand came from domestic alternative sources by the mid-2040s.



What changed was not the system's logic, but its tools.

With abundant energy and AI, vertical farms and bioreactor-based production flourished, especially in climate-vulnerable and densely populated countries. China led the way, investing heavily in alternative feeds, fermentation technologies, and cultivated meats to reduce import dependency. By 2050, it met 50% of its protein demand from domestic alternative sources – cheap, shelf-stable, and algorithmically optimized.

Land-based farming adapted too. Precision agriculture, powered by AI and cheap renewable energy – much of it generated directly on farms through agri-PV – along with green ammonia fertilizers, became standard across industrial farms. Automated machinery, gene-edited crops, and sensor-rich soil management stabilized yields despite escalating climate shocks. Yet these gains skewed to those who could afford them. Smallholders were squeezed. Land was consolidated. But not all resilience came from money and machines. A parallel shift

unfolded as elements of agroecology – once dismissed as fringe – were co-opted and scaled by mainstream producers. Intercropping, diversified rotations, and low-input systems gained traction, not from consumer pressure or romantic ideals, but because they helped farms hedge against volatile weather and input costs. Paired with AI-driven planting tools and hyper-local weather prediction, this “agroecology lite” became a quiet engine of adaptation. Purists called it greenwashing. Investors called it smart risk management. The soil, at least, seemed to benefit.

The seas followed a similar pattern. With wild fisheries increasingly unstable, aquaculture expanded, supported by AI-driven monitoring, automated husbandry systems, and cheap renewable energy. Innovation in feeds – from plant-based ingredients to insects, microalgae, and microbial single-cell proteins – steadily reduced reliance on wild fish inputs. But as on land, the gains flowed mainly to large operators, deepening the divide between industrial aquaculture and struggling coastal fisheries.

Ultra-processed foods (UPFs) continued to dominate – but evolved. A new wave of “premium UPFs,” tailored to obesity drugs and hyper-personalized nutrition plans, flooded wealthy markets. GLP-1-friendly product lines became a staple. In affluent segments, consumers exercised choice as an expression of optimisation and identity; elsewhere, “choice” was largely shaped by price and promotion – with the most affordable calories still the least nutritious.

Animal protein demand kept rising with incomes. Intensive livestock systems grew more efficient and tightly monitored, reducing antibiotic use and disease outbreaks. Cheap renewable energy also lowered production costs for precision-fermented feed ingredients, making amino acids and microbial proteins competitive with soy and fishmeal. Alternative proteins, especially cultivated meat and fish analogues, met much of the new demand. Technology helped contain risk – but did not erase it.



Climate shocks persisted. The “double drought” of 2034, which hit the US Midwest and China simultaneously, was a turning point. Markets adjusted. Indoor farms scaled. Bioreactors surged. Global trade shifted – from grains and oilseeds to bioreactor feedstocks and data. Countries with abundant renewable capacity became exporters of green ammonia, biomanufactured inputs and ingredients, and produce grown in controlled environments – new pillars of food security built directly on cheap power. Supply chains bent, but did not break.

Control of the system shifted, too. Big Ag faded from headlines. In their place: Big Tech found its way into food – firms that own the data, algorithms, and IP behind modern food production. They do not just sell and ship food – they design it, optimize it, and often, own its means of creation. Their data platforms helped strengthen traceability and claims verification, though rapid advances in AI simultaneously made fraudulent claims easier to generate and harder to detect.

As AI expanded what firms could quantify, natural capital began to be priced and managed like any other asset class. Companies invested in mangroves, wetlands, and other ecological buffers that reduced climate risk to their supply chains – often more cheaply than man-made defences. But the same metrics that made nature investable also narrowed how it was valued: what was easy to measure was what attracted capital. As demand for bioresources grew – whether for feedstocks, biomaterials, or bioenergy – investment tilted toward projects that maximised carbon or harvestable volume, not ecological integrity. Some countries used the bioeconomy boom to restore degraded land and bring it back into production, meeting rising demand without expanding into intact ecosystems. But where governance was weak and ‘sustainable biomass’ loosely defined, it instead drove monocultures, habitat loss, and growing strain on water and soils.

Governments, for the most part, remained on the sidelines – reactive rather than directive – with domestic policies continuing the short-termist logic of servicing markets rather than reshaping them. Some embraced progressive tech policies like CRISPR for drought-resilient crops or strain development for biomanufacturing, but these moves reinforced market-led trajectories rather than redirected them. Multilateral treaties on climate and nature resurfaced in speeches and summits – but with little enforcement, they served more as symbols than systems. A few exceptions emerged where corporate and geopolitical interests aligned, such as the Global Alliance to End Wildlife Crime – but these remained the exception, not the rule.

By 2050, food is smarter, faster, and more efficient. But not fairer and not evenly resilient. Environmental concerns matter – but mostly as a hedge against disruption. GHG emissions and land conversion are lower than they were in the 2020s, tempered by synthetic and indoor production, but still beyond planetary boundaries, while oceans remain depleted. As climate volatility intensified, markets adapted with technology, yet the resilience this created remained uneven, leaving many beyond the reach of the invisible hand. Billions still eat what they can afford, not what they need. The system adapted but the outcome is not optimal. The invisible hand stayed in charge – steady as ever, for better or worse.

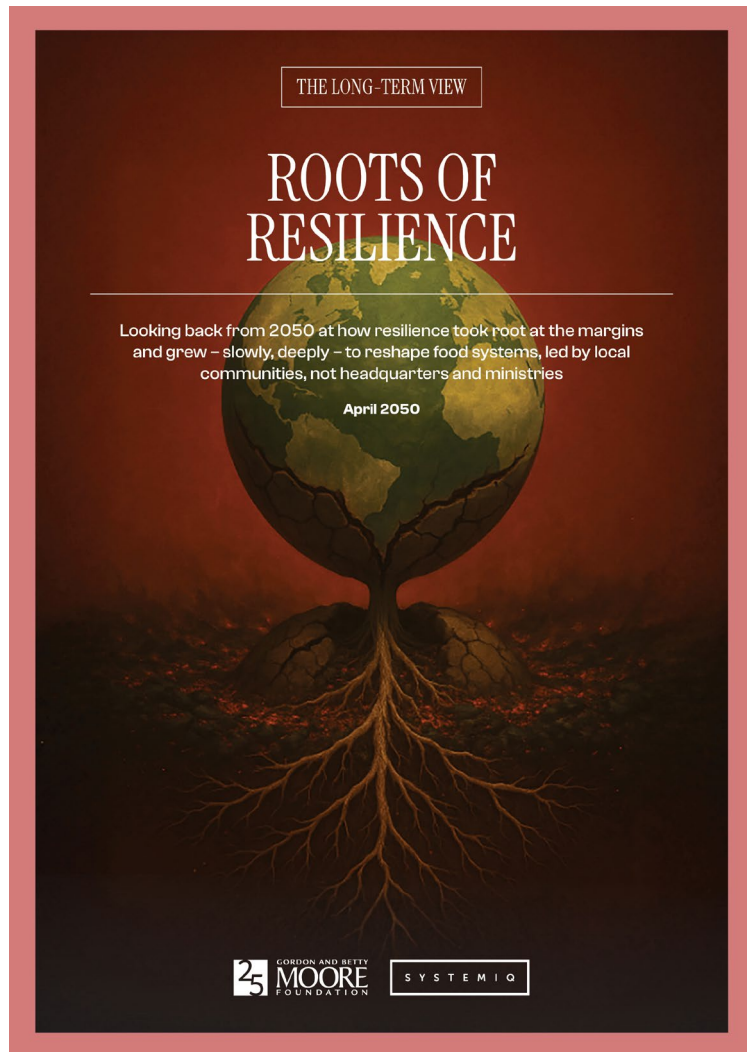


Market-led adaptation: Food system dashboard

Stylised data, illustrative

	2020s	2050	Trend (% change)	
			● Positive trend ● Negative trend	
GHG emissions (from food systems, billion metric tons CO ₂ eq per annum)	16.2 GtCO ₂ eq in 2022 ¹	12 GtCO ₂ eq	↓ 26%	Efficiency gains offset by rising protein demand and high-energy tech. Cultivated meat scaled, but overall emissions remain high.
Deforestation (hectares of forest loss due to agriculture per annum)	9 million ha in 2020 ²	6 million ha	↓ 33%	Agricultural productivity gains, alt protein, indoor farming reduced pressure, but commodity expansion for growing food and bioresource demand (and critical raw minerals) continues in weak governance zones.
Agroecology (% of global agricultural land under agroecology)	<5% ³	7%	↑ 40%	Corporate need for climate-resilient supply chains drove the growth. Deep agroecology is limited to high-end markets and small in scale, while shallow agroecology is more widespread, but often seen as greenwashing.
Biodiversity (Biodiversity Intactness Index)	76% 2000 - 2020 ⁴	65%	↓ 14%	Some local gains, global losses. Biodiversity suffered from weak nature protection.
Animal protein (% of total protein consumption)	37% ⁵	40%	↑ 8%	Technology makes alternative proteins cheaper and more accessible, reducing reliance on traditional animal sources. However, demand for meat continues rising with incomes, particularly in emerging economies.
Global poverty (% population living below the international poverty line)	8.5% in 2024 ⁶	10%	↑ 18%	Productivity gains favored agribusiness and tech investors, but smallholders and informal workers are left behind.
Food systems employment (% of global workforce employed in agrifood systems)	39% in 2021 ⁷	15%	↓ 62%	Automation and consolidation reduce on-farm and processing jobs. Rural labor markets shrink as urban services expand.
GDP linked to food systems (% of global GDP linked to food systems)	10% in 2019 ⁸	10%	-	Productivity and tech raise absolute value in food systems, but equally rapid growth elsewhere keeps the sector's share of global GDP flat.
Obesity (% adult obesity)	16% in 2022 ⁹	20%	↑ 25%	Cheap UPFs dominate diets of the poor, but GLP-1 curb obesity in wealthy markets. Combined with demographic shifts, the overall trend deteriorates.
Food insecurity (prevalence of undernourishment)	9.1% in 2023 ¹⁰	10%	↑ 10%	Calorie access improves through tech and trade, but affordability shocks and regional volatility persist. Climate stresses lead to local shortages.
Access to healthy diets (% of population with economic access to a healthy diet)	65% in 2022 ¹¹	50%	↓ 23%	Nutrient-dense foods remain unaffordable for many. Innovations target premium markets, widening nutritional inequality.

Sources: [1] FAO (2024a); [2] FAO (2020), 10 million ha per year average 2015-2020; UN (2022), 90% of deforestation is driven by agricultural expansion; [3] Land area farmed under the FAO agroecology principles is not measured; According to FiBL (2025), 2.1% of global agricultural land was managed organically in 2023; [4] Liu, Wu & Liu (2025); [5] Smith et al (2024); [6] World Bank (2024); [7] FAO (2024b); [8] Food and Land Use Coalition (2019); [9] WHO (2024); [10] FAO (2024); [11] FAO (2024)



2: Roots of Resilience

Looking back from 2050 at how resilience took root at the margins and grew – slowly, deeply – to reshape food systems, led by local communities, not headquarters and ministries

THE 2020s and 2030s left deep scars. Record-breaking heatwaves scorched nearly every corner of the globe. Wars dragged on for years, prolonged by the vanity of ageing leaders clinging to legacy. Cuts to subsidies and food aid during the 5-year Long Recession sparked protests that swept from the US to Brazil, from the EU to India. Farmers blocked highways from Punjab to Paris. Youth strikers demanded more than targets; they demanded a seat at the table. While the world reeled from climate and public health shocks, migration, political volatility, and inflationary waves, something deeper was also taking hold.

Like root systems, change often begins out of sight. Roots spread slowly, underground, and unnoticed. But they do more than hold up trees – they link species and feed ecosystems. In that way, they are not unlike communities. As markets promised abundance but delivered hunger, and governments promised stability but preserved inequality, the roots of change kept

growing and communities moved from coping to creating. They did not topple institutions – they grew around them. The roots of change rerouted trust and power – and became conduits of resilience. What slowly took place was not quite a revolution. It was a quiet contagion.

In the late 2020s, in Ukraine – its farms bombed, its ports blockaded – life pushed back through the soil. With centralized institutions weakened, a different kind of rebuilding took hold. Farmers shared soil data and cropping strategies through open-source platforms, building a peer-to-peer web of agroecological learning. Community-owned solar-powered cold-chain and distribution hubs emerged in repurposed railway depots and warehouses, serving as the connective tissue between small farms and urban dwellers. Ukraine did not rebuild what was lost – it grew something different. The world took note.

Born in the wake of the Long Recession of 2029-2034 and inspired by Ukraine's reinvention, local food movements emerged between young farmers and urban youth from Brasília to Bangkok, Nairobi to New Orleans.



They were not just protesting; they were redesigning. They built regional co-ops and launched digital markets linking producers and eaters directly. This was not charity or boutique organics – it was a deliberate effort to make local food the backbone of daily diets. Meanwhile, the global AI boom had hollowed out many white-collar roles, pushing people toward work algorithms could not replace. More hands turned to the soil and the water – a return to crafts of farming that AI could guide but never perform. By the time COVID-37 shuttered global supply chains for months, many networks were already in place. While supermarket shelves emptied, these hubs fed cities and safeguarded culturally rooted foods. The pandemic did not create the movement, but it proved it.

Thereafter, like the hidden filaments of a mycelial network, three strands of change spread beneath the surface – one carrying voice, the second carrying knowledge, the third carrying culture.

The first strand reshaped governance itself. After COVID-37, the state did not disappear – but in many places, it learned to listen differently. Governments shifted toward more open, place-based governance. Citizens' assemblies from Wales to West Bengal rewrote regional food and nature strategies. In Pará and Palawan, young farmer and fisher cooperatives and local ecologists sat with regional authorities to co-write resilience plans rooted in place. Finance gradually localised: solidarity lending circles and community-based insurance

schemes resurfaced as practical tools for sharing risk as large finance and insurance institutions withdrew. Yet these mechanisms still faltered when entire regions were hit at once, prompting some national or bioregional governments to step in as backstop reinsurers to spread losses across communities. Governance took root locally, braided from the resources and reach of the state with the trust and knowledge of communities.

The second strand rewired knowledge. Technology and intelligence no longer flowed only from corporate R&D labs, but from collective, decentralized peer-to-peer exchange. Growers trained AI tools on their own weather logs, soil tests, and reef biodiversity surveys. These were pooled into open "nature intelligence" platforms that did not just boost yields – they accelerated the shift to agroecology and guided nature restoration projects that brought back seagrass meadows, oyster reefs, wetlands, and pollinator corridors.

The third strand renewed food culture. Agriculture and diets returned to their roots in meaning and place. As global staples faltered in fractured supply chains during COVID-37, local foods endured: Sahelian millet, Appalachian beans, Andean tubers. Kelp forests and oyster beds tended by coastal cooperatives. They fed bodies and identity. As conglomerates lost influence, marketing budgets shrank and shelf-space battles faded. Availability, seasonality, and proximity shaped diets more than promotions. Choices narrowed within places – fewer imported staples, fewer out-of-

season luxuries – but diversified across places as distinct regional food systems re-emerged. Much of the shift was born of necessity after repeated supply disruptions, but it hardened into preference: consumers rewarded what their regions could grow or harvest, redirecting demand and capital toward local producers. Demand no longer flowed primarily through global brands, but through networks of trust, proximity, and shared stewardship. Food became less a commodity, more a commons.

Across regions, the three strands met in a single challenge: living within the limits of local bioresources. Communities set rules on harvesting, water use, and rotational grazing; growers shared data to judge what ecosystems could regenerate; and diets shifted toward what local soils, forests, and waters could reliably provide. Organic waste, seaweed, and fishery byproducts were cycled back into farms and ponds, turning necessity into circularity. Resilience took shape through these trade-offs – messy, negotiated, and grounded in place.

But the pattern was not even. Community-owned microgrids, powered by wind, water, sun, and biodigestion kept the lights on in many places – but capacity was finite, and energy rationing became part of daily life, limiting energy-intensive industry. Remote rural areas stayed isolated by patchy connectivity and poor roads. Few regions could sustain the scale needed for cheap meat or lab-grown analogues; most met their protein needs with local pulses, nuts, small pelagic fish, or bivalves.



Diets narrowed in choice but shrank in carbon footprint. But as production localized, ecological pressures surfaced: reduced efficiency and the drive for self-sufficiency left too little land truly untouched, with lower yields pushing cultivation into nearby high-biodiversity areas. Where climate stress stripped resources and trust, forests fell to fire and chainsaw, and armed groups moved in. And with limited global coordination, pests crossed borders unchecked, while droughts in one region emptied rivers, driving price spikes and migration in another. In some regions, "local" hardened into exclusion, turning self-reliance into a gate that shut out migrants and the displaced. Climate and water stress pushed

tens of millions from their homes – farmers from salinized deltas, herders from desertifying rangelands, coastal families from flooded plains. Many found no durable resettlement, lingering in vast, under-resourced camps in border regions and peri-urban settlements where food security remained precarious. Yet even there, displaced communities improvised: container gardens, cooperative kitchens, small-scale aquaculture, and informal markets stitched together fragile forms of resilience. Migration became not a temporary shock but a structural feature of the food system reshaping demand, labour availability, and political stability across regions.

In some places, adaptation to climate change was forced – through displacement and loss. In others, it was deliberately built through local governance seeking to strengthen resilience. Diets shifted accordingly: in richer regions consumption still strained land and climate, but across much of the world food systems settled into lower-impact patterns out of necessity. Choice narrowed within places, yet diversity expanded across them. The result was a system that traded efficiency for local resilience.

By 2050, the world looked less like a machine and more like a living mosaic – mycelial threads binding diverse pieces into something whole. Food systems not uniform, but relational. The roots of resilience were not laid in policy halls or P&L statements, but in networks grown from the ground up. Trust, renewed. Power, re-patterned. Governance, re-routed. It was not the future we planned for, but one we learned to cultivate.



Grassroots-led action: Food system dashboard

Stylised data, illustrative

	2020s	2050	Trend (% change)	
			● Positive trend ● Negative trend	
GHG emissions (from food systems, billion metric tons CO ₂ eq per annum)	16.2 GtCO ₂ eq in 2022 ¹	10 GtCO ₂ eq	↓ 38%	Localized production and dietary shifts towards plant proteins reduced overall food system emissions, offsetting efficiency losses from smaller-scale, agroecological farming.
Deforestation (hectares of forest loss due to agriculture per annum)	9 million ha in 2020 ²	4 million ha	↓ 56%	While some communities actively restored forests, others – lacking strong governance – succumbed to armed groups driving deforestation for illegal mining and timber or expanding degraded farmland.
Agroecology (% of global agricultural land under agroecology)	<5% ³	50%	↑ 900%	Localization of agriculture and diets, combined with youth returning to farming, drove widespread agroecology often by necessity due to scarce industrial inputs, and not always achieving high yields.
Biodiversity (Biodiversity Intactness Index)	76% 2000 - 2020 ⁴	70%	↓ 8%	Many communities invested in ecosystem protection and restoration, but land fragmentation worsened, and agroecology often fell short of sparing sufficient intact habitat for nature.
Animal protein (% of total protein consumption)	37% ⁵	25%	↓ 32%	With meat analogs failing to scale, diets shifted towards pulses, beans, and other local plant proteins – driven by affordability, necessity, and renewed cultural value – while livestock production persisted at smaller scales.
Global poverty (% population living below the international poverty line)	8.5% in 2024 ⁶	12%	↑ 41%	In wealthier regions, many voluntarily adopted more modest, local lifestyles, but poverty deepened most in areas hit by climate shocks and conflict.
Food systems employment (% of global workforce employed in agrifood systems)	39% in 2021 ⁷	50%	↑ 28%	Initially due to the rise of AI displacing other sectors, and later from the need to meet essential community food needs, a significant portion of the global workforce became directly involved in agrifood systems.
GDP linked to food systems (% of global GDP linked to food systems)	10% in 2019 ⁸	25%	↑ 150%	With food security a strategic local priority, the sector's share of global GDP grew – not because it expanded dramatically, but because overall GDP contracted as other sectors declined.
Obesity (% adult obesity)	16% in 2022 ⁹	15%	↓ 6%	Greater physical activity in farming and fishing, coupled with diets lower in animal protein and ultra-processed foods—and in some cases limited calorie availability—helped stabilize obesity rates.
Food insecurity (prevalence of undernourishment)	9.1% in 2023 ¹⁰	10%	↑ 10%	While many communities met nutritional needs through local production, others fell short—conflicts, climate extremes, and isolation exposed the limits of localism under systemic shocks.
Access to healthy diets (% of population with economic access to a healthy diet)	65% in 2022 ¹¹	55%	↓ 15%	With food taking a larger share of household budgets, some relied heavily on starchy staples at the expense of dietary diversity—driven by both economic constraints and limited local crop variety.



3: Fortress Farms

From global trade to sovereignty: looking back from 2050 at how the world fragmented its way to food security

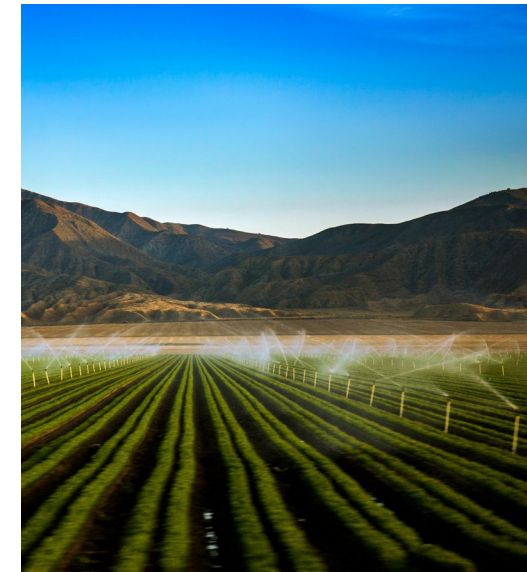
THE fracture began not so quietly, with Trump, tariffs, and tempers. By 2035, it was official: the era of global food trade was over. Trade routes dried up. Multilateralism broke down. And when two large agri-commodity trading companies filed for bankruptcy in 2036, it marked the symbolic death of the global agribusiness age.

What rose in its place was a world of food fortresses – state-managed, innovation-driven, and fiercely inward-looking. In the face of climate shocks, export bans, and geopolitical mistrust, governments took charge of feeding their own. Innovation did not slow, but it splintered. Sovereign food tech became the new space race.

China went furthest – and fastest. What began with US-China trade frictions and price disputes with Brazil in 2025 gradually forced Beijing to diversify away from its two dominant suppliers. After innovation in the private sector, with China's largest pig farming companies adopting and proving low-soy feeds, Beijing had its first clear proof that domestic innovation could

meaningfully reduce dependence on imported soy. This led China to rethink its entire protein strategy, from how it fed herds to how it fed people. China's 15th Five-Year Plan (2026-2030) and the accompanying subsidies, low-interest loans, and public R&D, supercharged the shift. China's protein production transformed far faster than the rest of the world expected, echoing the country's earlier breakthroughs in solar PV and electric vehicles, and sending shockwaves through global supply chains. The breakthrough in biomanufacturing quickly rippled outward – from livestock feed to agri-inputs to alternative meat. China's push for sovereignty was more aggressive and abrupt than anywhere else, but its logic soon spread as governments everywhere lost confidence in global cooperation amid the geopolitical turmoil of the 2020s and 2030s.

Elsewhere, the transition accelerated in different ways. In the US, agricultural policy swung decidedly protectionist, with federal support for vertical farms, solar-powered irrigation



systems across the Southwest, and AI platforms that accelerated the discovery of novel proteins and metabolic-support ingredients tailored to the country's growing GLP-1 user base.

In Europe, demographic pressures and ecological strain pushed transformation even further. Losing farmers to retirement and confronting persistent labour shortages, the EU expanded indoor horticulture and robot-enabled aquaculture and agroforestry, subsidising food production grown with AI and renewables. At the same time, rising food insecurity and environmental decline led Brussels to legislate reductions in animal protein and scale up regional agroecological landscapes. Legumes became central to northern European rotations, supporting dietary shifts and reducing import dependence. Strict quotas and marine reserves enabled the gradual recovery of regional fisheries. By 2050, Europe fed itself more sustainably, rebuilding pockets of ecological capital along the way.

In the Global South, the picture was more uneven. Where expensive technologies failed to reach, agroecology took root – not as a nostalgic return, but as a pragmatic response to volatile weather, rising input costs, and institutional gaps. From West African farmer cooperatives to Andean agrobiodiversity farmer peer-to-peer hubs, local knowledge networks revived polycultures, soil regeneration, and seed sovereignty, increasing food security without relying on costly tech stacks.

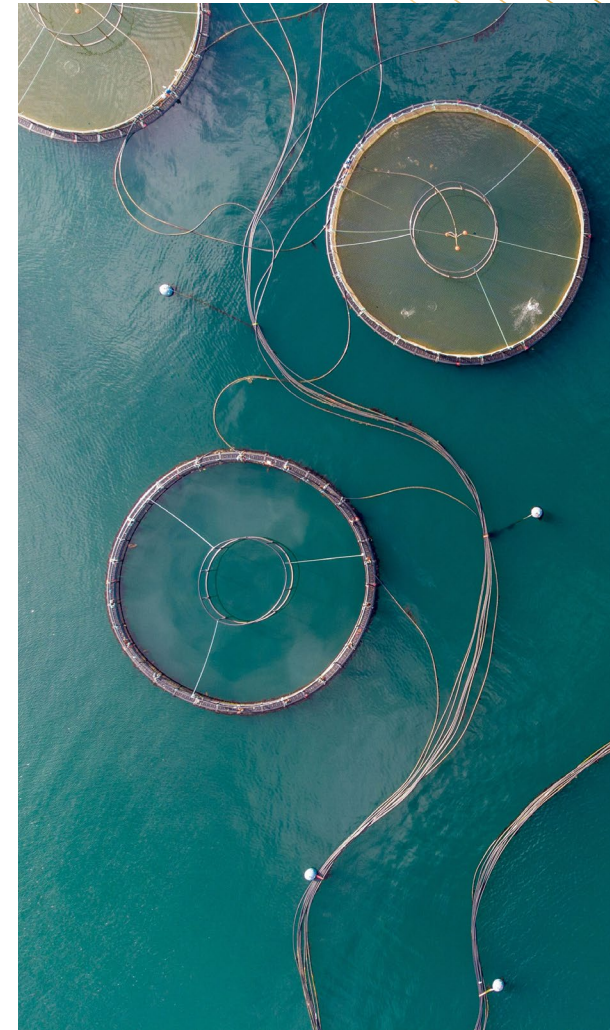
When the world split, capital split with it. International lenders fled volatile farm and fisheries portfolios, and reinsurers priced climate shocks out of reach. Governments filled the void. State banks channelled cheap credit to strategic local crops and biomanufacturing inputs, while parametric insurance schemes replaced global risk pools. These programmes kept producers afloat but created stark divides: wealthier states built robust risk-pooling systems, whereas lower-income countries relied on thin public budgets or compulsory self-insurance tied to state procurement. Food security became as much a fiscal feat as a technical one.

Across all regions, public health became an unavoidable pressure point. With ageing populations, shrinking labour pools, and rising obesity- and non-communicable-disease-related costs eroding productivity, governments could no longer treat nutrition as a secondary concern – it became a strategic economic variable. In the US, employers began covering GLP-1 drugs to protect workforce capacity as talent shortages deepened, and the medications reshaped food demand: diets shifted toward high-protein, low-calorie, low-sugar foods that supported weight loss and metabolic stability. AI discovery engines designed novel proteins, flavours, and metabolic-support ingredients optimised for GLP-1 users, while marketing increasingly flowed through AI health advisors rather than traditional advertising. China quietly restricted unhealthy UPFs and redirected subsidies

toward reformulated, lower-calorie lines to curb escalating healthcare burdens. Alarmed by The Lancet's UPF 2025 series, Europe and Brazil tightened labelling rules and taxed high-sugar products, driving a gradual decline in UPF consumption and production. In a world where each region depended more heavily on its own people to sustain its economy, keeping populations healthy became as important as keeping supply chains functioning.

As regions diverged in their agricultural strategies, one force cut across borders more than any other: the rapid spread of cheap renewable energy. A technological breakthrough in 2033 made solar power and battery storage inexpensive, modular, and easy to deploy. Instead of restoring global integration, it enabled countries to double down on self-reliance in food. Saudi Arabia and the UAE built desalination-powered food zones – vast indoor farms cooled by solar energy and irrigated from the sea. In East Africa, decentralised microgrids powered climate-controlled greenhouses and aquaculture systems less vulnerable to weather extremes, local fertiliser production, and small-scale processing hubs.

Yet this transition came with its own dependencies. The surge in solar, battery, and electrolysis technologies drove unprecedented demand for lithium, nickel, copper, and rare earths. Not all nations could meet their critical-mineral needs at home, keeping trade alive even as food routes collapsed. But the drive to



reduce import dependence also pushed some governments to open up ecologically sensitive regions for mining, extending the footprint of sovereignty into high-biodiversity frontiers.

But critical raw minerals were only part of the picture; the struggle to manage land and bioresources under fragmentation proved just as consequential for nature. Despite policies to curb obesity and overconsumption and the rise of more efficient protein systems, many governments still leaned heavily on their land and seas to supply bioresources – food, feedstocks, fibres, fuels, and materials – needed for domestic sovereignty. In regions with weak governance or limited capacity, this led to intensified expansion into high-biodiversity landscapes and seas, and the steady erosion of ecosystems that once

depended on shared stewardship. And without global standards or trusted reporting, private nature finance flowed toward jurisdictions with the cleanest data and strongest enforcement, not toward the biomes most at risk. As a result, while some ecosystems thrived, vast transboundary systems such as the Congo Basin and the high seas continued to degrade in the absence of coordination. The world ended up with pockets of well-funded restoration surrounded by regions still in decline.

Climate and water stress proved among the most destabilizing forces of all. As degraded soils, collapsing fisheries, and depleted aquifers rendered once-productive regions unviable, tens of millions were displaced. Rather than renewing multilateralism, these movements deepened fragmentation. Borders tightened,

asylum narrowed, and food security policy fused with national security doctrine. Camps and informal settlements swelled at frontiers, while selective labour migration became a strategic tool for wealthier states. Mobility did not reconnect the world – it reinforced the fortress.

As governments turned inward in the 2020s, many leaned on short-term fixes to secure food supplies. They converted more land to agriculture and intensified input use. Over time, as they realised the negative impacts of these fixes, longer-term strategies began to take hold in some countries, from resilient and climate-smart farming systems to protein diversification that reduced pressure on land.

By 2050 the system is somewhat less carbon-intensive than it was in the 2020s, but it remains beyond ecological limits and its impacts are felt unevenly. The food system is indeed more resilient in some places, more precarious in others. The world feeds itself – but not together. Food is safer, more local, and tightly managed. But innovation without cooperation has a cost: duplication, exclusion, and chronic inefficiency. And like all fortresses, today's food systems offer security – at the cost of unity. Defended, but divided.



Fragmented government intervention: Food system dashboard

Stylised data, illustrative

	2020s	2050	Trend (% change)	
			● Positive trend ● Negative trend	
GHG emissions (from food systems, billion metric tons CO ₂ eq per annum)	16.2 GtCO ₂ eq in 2022 ¹	12 GtCO ₂ eq	↓ 26%	The race to climate resilience led to some decarbonization. Some countries cut emissions via sustainable intensification and alt protein, but food crisis-driven deforestation stalls global decarbonization.
Deforestation (hectares of forest loss due to agriculture per annum)	9 million ha in 2020 ²	5 million ha	↓ 44%	Food and resource nationalism drives land conversion; protections vary widely across borders with some countries boosting reforestation because they now value local nature more than agricultural exports.
Agroecology (% of global agricultural land under agroecology)	<5% ³	15%	↑ 200%	A growing number of climate-vulnerable countries incentivize agroecology to increase resilience to climate shocks and ensure stable food security. Other countries prioritize industrial farming and maximize productivity.
Biodiversity (Biodiversity Intactness Index)	76% 2000 - 2020 ⁴	70%	↓ 8%	Some regions invest in ecosystem protection, but land fragmentation worsens. Disconnected governance fails to halt habitat loss at scale.
Animal protein (% of total protein consumption)	37% ⁵	40%	↑ 8%	Some regions make policy shifts toward sustainable or lower-meat diets, but others double down on livestock. Fragmented action leads to a patchwork: substitution happens in some regions and not others.
Global poverty (% population living below the international poverty line)	8.5% in 2024 ⁶	10%	↑ 18%	Some governments reduce poverty through safety nets and public investment, but fragile states fell behind, and inequality widens across blocs.
Food systems employment (% of global workforce employed in agrifood systems)	39% in 2021 ⁷	35%	↓ 10%	Automation reduced labor intensity, local agroecology increases labor intensification in some areas and food nationalism drives economic and strategic importance of food and agriculture-related jobs.
GDP linked to food systems (% of global GDP linked to food systems)	10% in 2019 ⁸	20%	↑ 100%	Food nationalism turned food systems into strategic priorities, boosting investments and deprioritizing other less urgent sectors. Major economic efficiency losses due to breakdown in trade.
Obesity (% adult obesity)	16% in 2022 ⁹	15%	↓ 6%	Nutritional policy gained traction in some blocs (e.g., EU, China), and in food insecure countries food rations helped curb obesity.
Food insecurity (prevalence of undernourishment)	9.1% in 2023 ¹⁰	7%	↓ 23%	National food strategies improved calorie access in many regions. Yet volatility and state capacity gaps keeps millions food insecure.
Access to healthy diets (% of population with economic access to a healthy diet)	65% in 2022 ¹¹	70%	↑ 8%	Some states subsidize fruits, vegetables, and fortified foods. Others lacked scale or efficiency, limiting universal access.



4: The Longest Supper

Looking back from 2050 at how governments shared the table – and rewrote the fate of food and nature

THE world did not unite over values. It united over fear. In the late 2020s and early 2030s, a series of overlapping shocks – crop failures in the US Midwest and China, heatwaves in Australia, India, and Europe that killed both people and livestock – forced the world's hand. Grain shortages from 2029 to 2033 triggered mass migration but also the largest coordinated food aid deployment of the modern era. The machinery of multilateralism, long dormant, began grinding back into motion.

From that chaos emerged the architecture of today's food system – one no longer driven solely by market logic or national silos, but by a renewed effort at coordinated government leadership. Slowly, new regional and cross-regional blocs formed or solidified. An early hint of what was possible had come even before the grain crises fully broke: at COP30, when the Tropical Forests Forever Facility (TFFF) – launched just as global cooperation was fraying – nonetheless managed to unite more than 50 forest countries behind a long-term, performance-based conservation

fund. At the time, it looked like an outlier; in hindsight, it was a precursor.

In the years that followed, cooperation widened. The African Food Compact, the South Asia Resilience Alliance, and the Brazil-China-EU Healthy Diet Accord – later championed by the G20 – created platforms for collective action. The UN's World Food Convention of 2035 laid the groundwork for a new global food governance framework, spawning the Food Systems Stability Board (FSSB) – loosely modelled on its financial counterpart from 2009. The FSSB took on the unglamorous but essential task of monitoring systemic risk. It tracked climate shocks, price volatility, trade restrictions, and supply chain concentration – then issued early warnings and convened governments to act. By 2045, its dashboard had become a quiet reference point for sovereign lending, trade terms, and even private investment strategies.

Private capital and innovation did not vanish – but were recalibrated. Guardrails emerged across jurisdictions, targeting monopolies in AI and data, seeds, and junk foods.



New frameworks made it so that if a technology could not reach the bottom 50%, it could not scale rapidly. As a result, xxxgene editing and synthetic biology advanced – but under tight scrutiny, and far slower than private investors had hoped.

Multilateralism did not just resurface – it restructured. The IMF began tying access to finance to subsidy

repurposing plans, encouraging governments to phase down harmful support and scale up regenerative production and sustainable use of marine resources. The World Bank updated its lending frameworks: countries with credible plans for subsidy reform, or deforestation-free and overfishing-free commodity supply chains gained preferential terms. Meanwhile, concessional climate finance – through institutions like the Green Climate Fund – became a key channel for supporting food system transformation in climate-vulnerable countries, linking finance access to progress on nutrition, resilience, and emissions. Concessional capital was essential while markets ignored the value of natural and human capital; but once these were embedded in trade rules and investment decisions – because they proved critical to supply-chain resilience – commercial lenders could finally price them in, allowing sustainable commodity finance to become an instrument of change at scale.

Countries of the African Food Compact, for example, made agroecology a pillar of their investment strategies, recognizing its potential to reduce input dependency, build drought resilience, and strengthen rural livelihoods. By 2045, agroecological systems covered 1/3 of the region's agricultural land, supported by public extension services and farmer peer-to-peer learning networks.

Technology found new purpose through public coordination. Instead of billion-dollar food tech unicorns, the real breakthroughs came through global cooperative innovation.

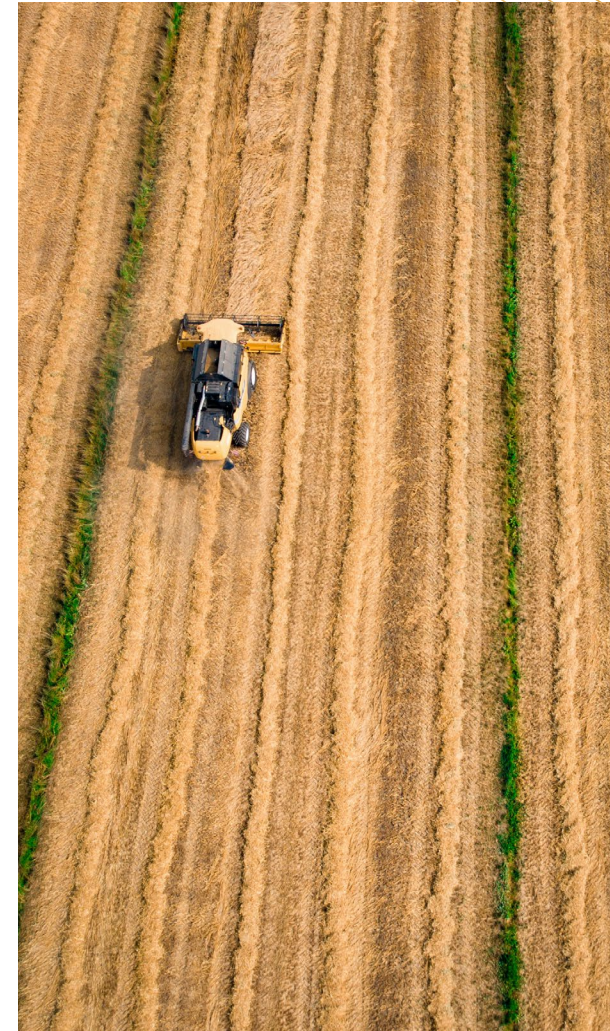
The innovation curve is gentler, but broader. A global infrastructure of open-access food and climate data helped farmers and fisheries adapt to shocks and enabled real-time supply chain transparency. Carbon pricing, deforestation disclosure, and nutrition standards became embedded in trade agreements and upheld through reformed World Trade Organization rules. It did not end trade – but it changed the rules. A new level playing field emerged, rewarding low-carbon, regenerative producers.

But the new architecture of rules and data needed something more: resources to help farmers actually meet the standards being set. What began in late 2020s as a small export levy on selected commodities in Latin America – a so-called "1% Fund," modelled loosely on levy structures long used in sectors like steel and mining – slowly expanded across major exporting regions and, by the 2040s, had become a standard fixture of global commodity governance. Its logic was disarmingly simple: Codex Planetarius, a new set of minimum environmental standards modelled on Codex Alimentarius, could only work if the farmers at the bottom of the performance curve had the means to improve. The levy created a pooled transition fund that channelled resources to the highest-impact 20% of producers – those driving most soil degradation, water pollution, deforestation, and overfishing but also the least able to bear the cost of compliance. It was not a race to the top, but a slow, collective climb toward a shared environmental floor. Over time, the mechanism helped previously

excluded food producers adopt basic digital monitoring, regenerative practices on land and at seas, and low-cost inputs, reducing systemic risk without collapsing local livelihoods.

One of the system's quiet enablers was energy. Breakthroughs in solar and battery storage in the early 2030s brought abundant, cheap power – used not just for mobility and computing, but for farming. Across the Middle East and North Africa, solar-powered desalination corridors enabled regional food independence. In Sub-Saharan Africa, decentralized microgrids powered controlled-environment agriculture and aquaculture, green fertilizer production, and local processing hubs. Energy abundance helped lift long-standing infrastructure constraints and buffer food production against climate volatility – once governance and coordination caught up.

But abundant clean energy brought new pressures – and early missteps. The first wave of mineral demand triggered rushed extraction, including destructive deep-sea mining projects that governments later admitted had caused irreversible ecosystem loss. At the same time, rising demand for biomass as fuel for cars and aviation, and as feedstock for plastic alternatives, pushed some regions into overharvesting and land conversion. Only after these failures did coordination catch up. In the late 2030s, governments finally converged on a set of shared rules: mineral recycling mandates and coordinated stockpiles to ease supply volatility, and global biomass standards that



prioritised residues and the ocean bioeconomy to limit expansion into intact ecosystems. These measures did not erase earlier damage, but they prevented cascading crises and brought both mineral and bioresource use back within ecological limits.

Nature governance followed similar patterns – slow to start, and only taking shape once crisis finally forced clarity. A 2039 international ruling that held a deep-sea mining consortium liable for ecocide in the Arctic catalysed a wave of reform. Through the 2040s, more than fifty countries granted legal rights to key ecosystems and agreed on shared definitions to recognise those rights across borders. This enabled coordinated restoration

funding, nature-as-infrastructure investment, and formal roles for Indigenous and local guardianship. But progress remained uneven. Several major economies still reject ecocide statutes, allowing firms to operate under weaker rules, and court-ordered remediation rarely covers the full cost of damage.

Ultimately, building a more coordinated system did not make its trade-offs disappear. The objectives were never simple. Governments aimed to balance food security, health, and environmental sustainability – but trade-offs were inevitable. Citizens pushed back when some foods became pricier. Over time, governments responded not only by shifting subsidies, but by reshaping the food

environment itself. Advertising restrictions on unhealthy products tightened; reformulation standards steadily reduced harmful ingredients; public procurement and fiscal policy made plant-forward, climate-smart options the default in schools, hospitals, and urban retail. Ultra-processed foods did not disappear, but most were reengineered to compete on nutritional performance rather than indulgence alone. Today, healthier and lower-carbon foods are often simply cheaper. Consumer choice did not vanish – but it operates within guardrails designed to align individual incentives with collective goals.

By 2050, the global food system is more cohesive – and arguably more just. But it is not utopia. While climate shocks were the catalyst for coordination, they still test its limits. Shared rules, standards, investment, have gradually bent the trajectory of emissions, deforestation, and ecosystem decline, though recovery came slowly and never fully outran the damage already set in motion. Bureaucracy lagged behind urgency.

When everyone has a seat at the table, the meal is slow to serve. Consensus fed fairness, but starved speed. Still, the meal – however delayed – is finally being shared. The world eats more equally. Just not more easily.



Coordinated government response: Food system dashboard

Stylised data, illustrative

	2020s	2050	Trend (% change)	
			● Positive trend ● Negative trend	
GHG emissions (from food systems, billion metric tons CO ₂ e per annum)	16.2 GtCO ₂ e in 2022 ¹	8 GtCO ₂ e	↓ 51%	Global carbon pricing, methane accounting, and off-take agreements drive steady cuts. Governments aligned incentives with long-term decarbonization.
Deforestation (hectares of forest loss due to agriculture per annum)	9 million ha in 2020 ²	1 million ha	↓ 89%	Trade deals include forest safeguards. Ecosystem payments and Indigenous stewardship expanded globally, but progress is slow, and deforestation still exists, notably from mining critical raw minerals.
Agroecology (% of global agricultural land under agroecology)	<5% ³	30%	↑ 500%	Multilateral climate finance helped derisk farmers' transition. Conditional finance on subsidy reform plans boosted global uptake.
Biodiversity (Biodiversity Intactness Index)	76% 2000 - 2020 ⁴	80%	↑ 5%	Coordinated investments in restoration, protected areas, and agroecology halt and reverse biodiversity loss.
Animal protein (% of total protein consumption)	37% ⁵	22%	↓ 41%	Policy aligns across nations to shift dietary norms and incentivize plant-based or alternative proteins e.g., through public procurement reform, protein taxes and ecosystem service payments.
Global poverty (% population living below the international poverty line)	8.5% in 2024 ⁶	5%	↓ 41%	Cash transfers, co-op models, and rural investments boost livelihoods. Global food governance helps stabilize prices and redistribute profits and incomes more equally.
Food systems employment (% of global workforce employed in agrifood systems)	39% in 2021 ⁷	25%	↓ 36%	Automation reduce headcounts. Training, cooperatives, and services expand inclusive rural employment to counter job loss.
GDP linked to food systems (% of global GDP linked to food systems)	10% in 2019 ⁸	10%	-	Public investment and reforms raise value added in food systems, but broad-based growth across other sectors keeps the sector's share of global GDP stable.
Obesity (% adult obesity)	16% in 2022 ⁹	20%	↑ 25%	Unhealthy foods are taxed and reformulated across regions. Obesity rise slowly, curbed by coordinated public health and GLP-1 access.
Food insecurity (prevalence of undernourishment)	9.1% in 2023 ¹⁰	5%	↓ 45%	Climate-resilient crops and safety nets improve food access. Regional compacts and global treaties reduce undernourishment through coordinated support.
Access to healthy diets (% of population with economic access to a healthy diet)	65% in 2022 ¹¹	78%	↑ 20%	Healthy diets are subsidized, standardized, and prioritized across supply chains. Coordinated procurement and education make nutritious food more accessible.

Annex II: Look back to look forward: a futures thinking framework

The framework presented here brings together the core terms that help us look back at how today’s system took shape and also to look forward to the forces, futures and choices that will define the decades ahead.

Look back

How today’s food system came to look and behave the way it does is the result of a long arc of forces, patterns and reinforcing dynamics. Understanding its historical drivers, the dominant features those forces produced, and the lock-ins that now keep the system on its current path gives us a shared basis for analysing how we got here and why change can be so hard. The key terms below support that shared understanding.

Historical drivers

Historical drivers are the long-term social, economic and technological forces that shaped today’s food system – from population growth and rapid urbanisation to agricultural innovation, expanding capital, global trade, rising incomes and demand for affordable convenience. These forces drove the system’s industrialisation and globalisation, laying the groundwork for the dominant features and structures we see today.

Dominant features

Dominant features are the defining characteristics of today’s food system, such as industrialised and financialised supply chains, production systems centred on ultra-processed foods and

diets high in animal protein. These features emerged from decades of historical drivers and now shape how the system functions and where its impacts fall.

Lock-ins

Lock-ins are the structural mechanisms that keep the current system in place and make change costly or slow. They include policy and subsidy incentives, financial structures, existing farming and supply chain infrastructure, market concentration, cultural norms and workforce skills tied to conventional practices. Together, they reinforce inertia and limit the system’s ability to adapt quickly and build resilience as environmental, economic and public-health pressures intensify.

Look forward

The coming decades will be shaped by forces that are already beginning to pull the food system in new and sometimes competing directions. Understanding the emerging drivers behind this change and the future scenarios they make plausible helps us understand what may lie ahead, and which action areas and solution ideas offer meaningful opportunities to steer the system toward better outcomes. The terms that follow offer a simple framework

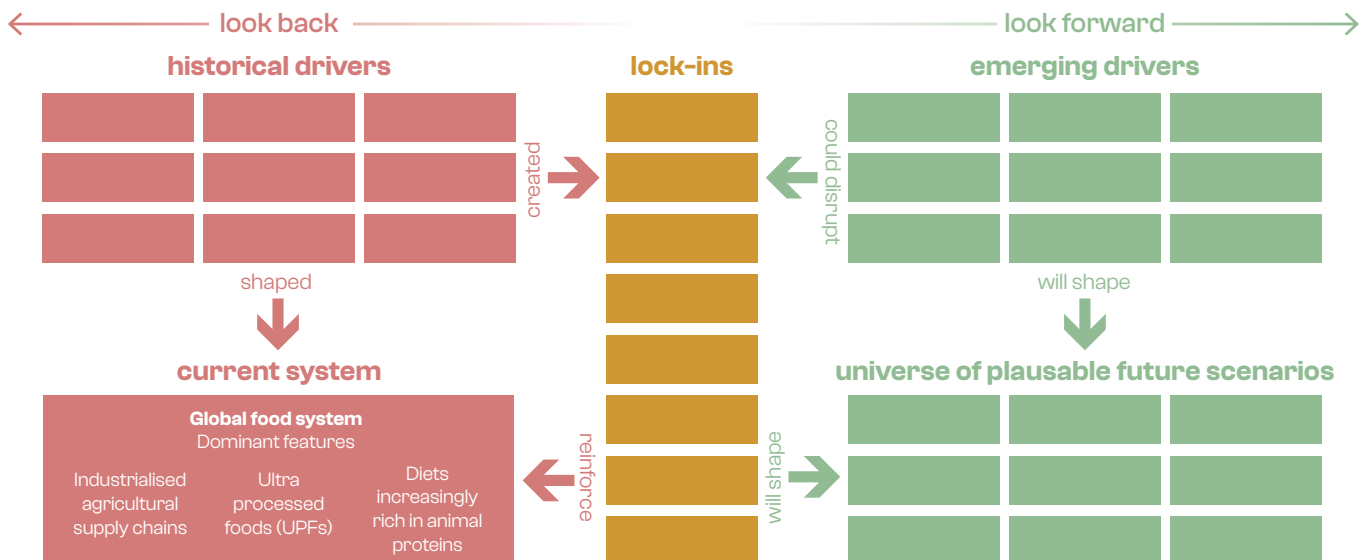
for making sense of uncertain futures and where we can act.

Emerging drivers

Emerging drivers are the new and rapidly evolving forces, such as technological breakthroughs, climate pressures, demographic shifts, changing health needs and geopolitical tensions, that are reshaping how food is produced, traded and consumed. Many originate outside the food system but have profound impacts on its structure and outcomes. These drivers can disrupt established patterns and create both risks and opportunities for transformation.

Future scenarios

Future scenarios are intentionally fictional but plausible narratives that explore different ways the food system could evolve by 2050. Each scenario draws on real trends and system pressures to illustrate how the food system could realistically diverge. They are built to reveal blind spots, challenge assumptions and help leaders test how their strategies hold up under different future conditions. Scenarios are not predictions or ideal visions, but tools to identify priority action areas and potential solutions.



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